DRAFT ENVIRONMENTAL IMPACT ASSESSMENT
&
ENVIRONMENTAL MANAGEMENT PLAN

For

"Construction of a road tunnel for NH-148E with its approach and connection to NH-248BB in NCT of Delhi".



Project Proponent:

NATIONAL HIGHWAYS AUTHORITY OF INDIA

(Ministry of Road Transport &Highways, Government of India)

Environmental Consultant:

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Undertaking

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ABBREVIATIONS

AAQ	Ambient Air Quality
ANL	Ambient Noise Level
BOD	Biochemical Oxygen Demand
CPCB	Central Pollution Control Board
CGWB	Central Ground Water Board
CF	Conservator of Forest
CO	Carbon Monoxide
COD	Chemical Oxygen Demand
CoI	Corridor of Impact
CPR	Community Property Resource
DFO	Divisional Forest Officer
DJB	Delhi Jal Board
DDA	Delhi Development Authority
EAC	Expert Appraisal Committee
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
ESZ	Eco-sensitive Zone
EPC	Engineering Procurement Construction
ERoW	Existing Right of Way
GoI	Government of India
GO	Government Order
GW	Ground Water
IMD	India Meteorological Department
IRC	Indian Roads Congress
IS	Indian Standard
LHS	Left Hand Side
Leq	Equivalent Continuous Noise Level
MoEF&CC	Ministry of Environment, Forest and Climate Change
MoRTH	Ministry of Road Transport and Highway
NBWL	National Board of Wildlife
NHAI	National Highway Authority of India
NAAQS	National Ambient Air Quality Standards
NGO	Non-Governmental Organizations
NH	National Highway
NoC	No-objection Certificate
PIU	Project Implementation Unit
PAF	Project Affected Family
PAH	Project Affected Household
PAP	Project Affected Person
PD	Project Director
PM	Particulate Matter
PPP	Public Private Partnership
PRoW	Proposed Right of Way
PUC	Pollution Under Control
R&R	Resettlement and Rehabilitation
RAP	Resettlement Action Plan
RF	Reserved Forest
RHS	Right Hand Side
RoW	Right of Way
SPCB	State Pollution Control Board
SW	Surface Water
SH	State Highways
TDS	Total Dissolved Solids
ToR	Term of Reference
VUP	Vehicular Underpass

EXECUTIVE SUMMARY

E.1 INTRODUCTION

The Ministry of Road Transport and Highways (MoRTH), Government of India has proposed "Bharatmala Pariyojana" an Umbrella scheme of road development project through National Highways Authority of India (NHAI), National Highway, Industrial Development Corporation Ltd (NHIDCL) and State Public Works Departments (PWD). NHAI is engaged in the development of National Highways and as part of this endeavour, the Authority has decided to undertake the Economic Corridors, Inter-Corridors, Feeder Routes primarily to improve freight movement in the Country under Bharatmala Pariyojana Programme. Bharatmala Pariyojana focuses on optimizing efficiency of freight and passenger movement across the country by bridging critical infrastructure gaps through effective interventions like development of Economic Corridors, Inter Corridors and Feeder Routes, National Corridor Efficiency Improvement, Border and International connectivity roads, Coastal and Port connectivity roads and Green-field expressways.

The proposed project is a part of the Bharat Mala Project which has been envisaged as an umbrella program under the Ministry of Road Transport and Highways. The project involves constructions or improvement of national highways/ newly declared National Highways with an aim to improve road connectivity to border areas, backward areas, religious and tourist sites.

Delhi being National Capital generates and attracts huge quantum of traffic not only from within Delhi but also from surrounding region. In order to cater to this regional traffic, Inner and Outer ring roads were planned in 1962, of which only inner ring road could be completed whereas outer ring road is still not a full ring. Additionally, non-Delhi destined traffic i.e. traffic to/from North Indian States (which includes Punjab, Northern Haryana, Jammu & Kashmir) to remaining Indian states (which includes Rajasthan, Southern Haryana, Gujarat, Maharashtra) has to pass through Delhi due to absence of alternate network. This leads to heavy congestion on the existing ring roads.

The National Highways Authority of India has been assigned the work of "Construction of a road tunnel for NH-148E with its approach and connection to NH-248BB in NCT of Delhi."

The total length of the project is 4.983 Km with a PRoW of 45m. The main objective of the proposed project is decongestion of traffic. The proposed tunnel is completely Greenfield / underground and hence will have negligible impact on environment.

E 2. BRIEF ABOUT THE PROJECT AND ITS LOCATION

The project starts from Near Shivmurti Interchange NH-8 proposed Ch. 0+000 and ends at Nelson Mandela Marg at Vasant Kunj with Chattarpur-Mahipalpur Road proposed Ch. 4+983.

The proposed underground Tunnel is passing through New Delhi & South Delhi district in the NCT of Delhi. The main objective of the project is that NH-48 carries very heavy traffic to Chattarpur/ Vasant

Kunj from Gurugram creates a heavy congestion at Mahipalpur due to very narrow city road, traffic to and from Delhi airport and Mahipalpur Rangpuri market.

The salient features of the proposed project are presented in **Table No. E-1** below.

Table No E-1: Salient features of the project

1.	Project Name	Construction of a road tunnel for NH-148E with its approach and connection to NH-248BB in NCT of Delhi.
2.	Location of the sub project road	The project NH-148AE starts from Shiv murti Interchange Ch. 0.000 Km (Dwarka Expressway Package-1(UER/II/NH248BB) at NH-48 and ends at Nelson Mandela Marg Ch. 4.983 Km in Vasant Kunj in New Delhi.
3.	Total design length of the project	4.983 Km
	3.1 Tunnel Length	4.305 Km
	3.2 Approach Ramp	0.004 Km
	3.3 At Grade	0.074 Km
	3.4 New Proposed Flyover	0.668 Km
4.	Geographical Location	Start 28°31'55.31"N, 77°06'27.34"E End 28°31'44.78"N, 77°8'53.20"E
5.	Start Point	NH-8 Near Shivmurti Interchange
6.	End Point	Nelson Mandela Marg Vasant Kunj
7.	Project Category (as under EIA Notification, 2006)	Category-A
8.	Total Civil cost	3426.38 Cr
9.	Total Capital Project Cost (including Civil, Utility Shifting and Forest, Environment)	4089.09 Cr
10.	**Resource Requirement**	
	i. Reinforcement	17,213.42 Tons
	ii. Concrete	**Item** / **Estimated Qty (m3)** Dry lean Cement Concrete (DLCC) / 14865.05 Plain Cement Concrete (PCC) / 33360 M50 / 48409 M35 / 7714
	iii. Water	**Thematic area** / **Quantity (m3/day)** Road construction (tunnel) / 300 KLD

		Road making Local surface/ground water	20 KLD
		Dust suppression	60 KLD
		Others (including drinking and domestic purposes)	50 KLD
		Total	420 KLD
		15% Contingency	63 KLD
		Total	483 KLD
	iv. Estimated Manpower requirement (Skilled and unskilled)	400 – 450 per day	
11.	Transportation		
	i. Muck Disposal	1221trp per day	
	ii. Concrete	88025 m^3	
	iii. Segments (To be estimate TBM contractor)	10563 Nos	
12.	Power of Consumption		
	i. DG Set during construction phase	3 Nos x 750 KVA	
	ii. TBM Capacity	7371758 KWH	
13.	Terrain	Plain & rolling	
14.	Existing right of way (ERoW)	0-45 m.	
15.	Proposed Right of Way	30-45 m	
16.	Carriageway	10.5 m (3.5m + 3.5m + 3.5m)	
17.	Design Speed	80 Km/hr	
18.	Safety Measure	New Jersey Crash Barriers	
19.	Flyover	1 Nos	
20.	Proposed Toll Plaza	1 Nos (Ch 4+900)	
	Feature of EIA importance		
21.	Type of Mode	EPC	
22.	Location of Proposed Project Name	Construction of a road tunnel for NH-148E with its approach and connection to NH-248BB in NCT of Delhi.	
23.	Jurisdiction		

Sl No.	State	District	Village
1	NCT of Delhi	New Delhi	Sarnaka
2		New Delhi	Rajokari
3		New Delhi	Ranggurl
4		New Delhi	Masoodpur
5		South Delhi	Mehrauli

24.	Seismic Zone	Zone IV
25.	Forest Land Diversion	Forest land involving 5.8257 ha falling under Southern Ridge Reserved Forest and 1.6888 ha falling under Deemed Forest will be diverted. The Project involves 417 trees cutting at the exit point and U-turn Modification. **Permission for the same has been granted by Hon'ble** Supreme Court via diary no.(s) 34870/2023 in W.P. (Civil) no. 467/1985 listed date on 18.10.2023 (Copy Attached as **Annexure II).**
26.	Water bodies Impacted	None
27.	Existing trees within ROW	417 at the exit point near Nelson Mandela Marg and modification of U-turn are given in **Annexure III.**
28.	Compensatory Plantation	Approx. 4170 (ten times of total trees to be felled) shall be planted as compensatory plantation.
29.	Wildlife Sanctuaries	NIL
30.	Nos of Structure Affected	NIL
31.	Total Area of Land Acquisition	Land Acquisition would not be required due to the project is an underground Tunnel

E.3 DESCRIPTION OF ENVIRONMENT

Study Area:

The base-line data has been collected for Core Zone (Corridor of Impact (COI)), an area covering 500 m on both sides of the proposed alignment and 10 km buffer zone for prominent environmental attributes like Ambient Air quality, Noise Level, Water quality and Soil profile. Primary and Secondary data has also been collected for other environmental attributes for the preparation of EIA/EMP report. The baseline study for the project was conducted during the months from March 2022 to May 2022 (Summer Season)

Baseline Study:

The findings of the baseline environmental status on land (topography, geology, soil quality, land use pattern), meteorology (Temperature, Relative Humidity, rainfall, wind speed, wind rose), air (ambient air quality- PM_{10}, $PM_{2.5}$, SO_2, NO_x and CO), water (surface & ground water), noise level, ecological environment (terrestrial and aquatic flora & fauna), socio-economic conditions (demographic profile and households' condition) were presented and interpreted with reference to environmental standards.

Meteorology:

The study area is located in New Delhi and South Delhi. The climate of district is mainly influenced by its inland position and prevalence of air of the continental type during major part of the year. Extreme

dryness with intensely hot summer and cold winter are characteristics of the climate. The cold season starts towards the latter half of November when both day and night temperatures drop rapidly with the advance of the season. January is the coldest month with the mean daily maximum temperature at 21.3°C and the mean daily minimum temperature at 7.3°C. May and June are the hottest months. In May and June, maximum temperature may sometimes reach 46 or 47°C.

Air Environment:

Ambient air quality monitoring has been done at 8 locations. Specific station-wise Ambient Air Quality (AAQ) data for PM 2.5, PM 10, SO2, NO2 and CO as recorded during the months from March 2022 to May 2022. The minimum and maximum values of, PM2.5, PM10, So2, NO2 and CO analyzed along the proposed project tunnel are 82.4(µg/m3) to 120.6(µg/m3), 111.5(µg/m3) to 216.5(µg/m3), 10(µg/m3) to 19.5(µg/m3), 17.8 (µg/m3) to 34.6 (µg/m3) and 0.69 (mg/m3) to 1.92 (mg/m3) respectively. All the parameters have been analyzed and show that all the parameters are well below the National Ambient Air quality standards, 2009.

Water Environment:

The development of any region is based on the availability of sufficient water resources, as developmental activities require water for irrigation, domestic and other purposes. 08 Ground water samples have been taken along the proposed project highway/tunnel. The pH varies from 7.3 to 7.4, Total dissolved solids vary from 325.6– 344.0 mg/l, and Total Hardness as CaCO3 varies from 116.5 – 161.0 mg/l, whereas no surface water body is presented near the alignment. All physical and general parameters were compared with the desirable and permissible limits as per IS10500:2012 for ground water and it is interpreted that all results are within Permissible limits and water can be used for drinking purpose.

Noise Environment:

Ambient noise level monitoring has been done at 8 locations along the proposed Expressway. The hourly recorded noise level at various locations in the study area shows fluctuations because of change in traffic movement, construction activities and other man-made sources. The noise levels vary from 52.4 to 59.7 dB (A) during daytime and whereas during night time the noise level varies from 43.7 dB to 51.0 dB (A), which are within the prescribed norms as defined in Noise standards, 200.

Soil Environment:

Soil sampling has been done at 8 locations near to the proposed highway. The pH of the soil samples ranged from 7.19 to 7.30 during the study period, indicating that soils are slightly neutral to slightly alkaline in nature. The soil Electrical Conductivity (EC) also varies from 18.6 µs/cm to 24 µs/cm. These parameters indicate that soils are neutral in reaction and having average EC. The Nitrogen content ranges from 2.88 kg/ha to 5.81 kg/ha, Bulk density ranges from 2.88 kg/ha to 5.81 kg/ha and Zinc content ranged from 1.88 mg/kg to 2.02 mg/kg during the study period. Based on soil analysis

data it is concluded that soil is rich in nutrient. The availability of Nutrients for the plant growth in the study area is good.

Ecological Environment:

The forest crop is dominant plants present in the study area were *Acacia nilotica, A. leucophloea, A. catechu and A. modesta, Capparis separia, C. decidua, Tribulus terrestris, Zizyphusoenoplia, Croton sparsiflorus, Tephrocia purpurea, Prosopis juliflore* etc. The major fauna species present in the study area are includes Nilgai, Jungle Cat, Small Indian Civet, Ruddy Mongoose and Small Indian Mongoose, Rufous Tailed hare, Per lizard cat etc. The detail list of flora and fauna in the project area has been provided in EIA/MP report.

The proposed alignment does not pass through any Wildlife Sanctuary/National Park and its eco sensitive zone.

Socio Economic Environment:

The primary purpose of socio-economic analysis is to provide an overview of the State's, socio-economic status and the relative status of the Project Influence Area (PIA) within the State.

The project alignment passes through New Delhi and South Delhi district in the state of Delhi.

District New Delhi

New Delhi with a density of 4,057 persons per km^2. According to the provisional results of the 2011 national census, New Delhi has a population of 1,42,004, making it one of most populated UT. The district occupies the eighth place in terms of area as it shares 2.4 per cent of the total area of the State. The district is fully urban. In terms of Population, it occupies the fourth position and shares 0.8 percent population of the State. It has no villages. No uninhabited villages of the State fall in this district. It's two tehsils are totally urban. In terms of density, it occupies the eighth position in the State. The Sex Ratio of the district is only 822 and it occupies 9th place amongst all the nine districts.

District South Delhi

South Delhi with a density of 11,060 persons per km^2. According to the provisional results of the 2011 national census, New Delhi has a population of 27,31,929, making it one of most populated UT. The district occupies the third place in terms of area as it shares 16.7 per cent of the total area of the State. In terms of Population, it occupies the fourth position and shares 16.3 percent population of the State. No uninhabited villages of the State fall in this district. It has only 3 villages and its two tehsil are totally urban. In terms of density, it occupies the sixth place in the State. The Sex Ratio of the district is only 862 and it occupies 7th place amongst all the nine districts.

E.4 IMPACTS AND MITIGATION MEASURES

The potential impact and their mitigation measures during of the Pre-Construction, Construction & Operation Phase have been presented in **Table No. 10.2**.

Table No. 5.2c : Potential impacts and their mitigation measures suggested for the proposed project

Pre-Construction Or No.	Activities	Potential Impacts	Significance criteria for determining significant impact (e.g., any impacts triggering of land, impact irreversible, the likelihood of exceeding available and disaster or donor requirement or international commitments)	Mitigation Measures	Responsibility
1.	Land Acquisition	• Loss of land, structure, standing crops, trees, and other assets • Removal and relocation of utilities and services • Property Valuation (CCK/ sq. m. • Removal and relocation of Cultural and Religious Properties	Insignificant	There is no land acquisition is required for tunnel purpose. It is underground, thus no structure of any type is going to impact due to construction of underground tunnel.	NHAC & Contractor
2.	Site preparation	• Conversion of existing land into construction site as per design, removal of standing crop, felling of trees and removals of top soils	Significant	• As far as practical, maximum efforts shall be made to minimize the number of trees proposed to be felled for locating of engineering designs • Trees shall be removed from the Corridor of Impact	NHAC & Contractor

		• Air, noise & water pollution		(CtE) and consumption order before the commencement of construction. Prior Permission shall be obtained from the concerned authority for the intake/taking. • There is no crop which are going to affect due to construction of underground tunnel. • Construction of tunnel is underground will not affect the soil except erosion & soil crack • Ambient Air Quality monitoring will be carried out by the contractor as per the Environmental Monitoring Program and in accordance with the general and specific conditions as stipulated in Environment clearance letter, CTE and CTO.	
C	Procurement of machinery (Construction Vehicles, equipment and machinery for casting plant, site, mix Plants, & Batching Plants)	• Disruption to traffic flow and disturbance to sensitive receptors and nearby community including road accident • Air, noise & water pollution	Significant	• Crushers, hot mix plants, and casting and batching plants shall comply with the requirements and specifications of the current enforced control legislation and specifications. Consent / NOC for all such plants shall be submitted. • Casting yard, batching plant, crushers, hot mix plants shall be located at least >500m (1km) away from residential settlements, hotels, welfare and commercial establishments preferably in the downwind direction. • The Contractor shall submit a detailed layout plan for all such sites and seek prior approval of Engineer-in-charge of supervision Consultant before entering into a formal agreement with a landowner for setting-up such sites. Actions by Supervision Consultant and NHAI against any non-compliance shall be borne by the Contractor at his own risks. • Arrangements to minimize dust pollution through the provision of windbreaks, water spray, road dirty units, and dust encapsulation shall be provided at all such sites. • All such legislation by the Contractor shall be	Contractor

				allowed till all the requisite legal clearances are obtained from the competent authority and the same is submitted to the Nodal and the Supervision Consultant. • Noise limits for construction plant and equipment that are to be procured such as compressors, rollers, hand tools, concrete mixers, dozers, excavators, dumpers etc. shall not exceed 75 dB (A), when measured at one-meter distance from the edge of the equipment in free field, as specified in the Environment (Protection) Rules, 1986. • The Contractor shall maintain a record of Pollution-under Control (PUC) certificate for all vehicles and machinery used during the contract period, which shall be produced to the RWSI and the Supervision Consultant for verification whenever required.	
7	Consents, permits, clearances, NOCs, etc.	Failure to obtain necessary consents, permits, NOCs, etc. can result in design revisions and/or stoppage of works.	Significant	• Obtain all necessary consents (including CTE by casting yard, CTE/CTO permit, consensus, NOCs, etc. prior to start of civil works). • Ensure that all necessary approvals for contractors to be obtained by contractor are in place before start of construction. • Acknowledge in writing to RWSI and provide record on compliance (Consent order, Permit, Clauses). • Non overlap of the necessary permissions/licenses/permits that have to be obtained.	Contractor
8	Raw material sourcing	• Extraction of materials can disrupt nature land contours and vegetation resulting in accelerated erosion, disturbance to natural drainage patterns, ponding and water logging, and water pollution.	Significant	• Arrangement for locating the source of supply of materials for the Tunnel construction as well as compliance with environmental requirements, as applicable, shall be the sole responsibility of the Contractor. • In any obligation, To the extent possible, the Contractor shall explore the possibilities of utilizing	Contractor

		• Increase in traffic load on existing infrastructure and increase road accident.		the City with the construction schedule as specified in the Notification 2021 on use of fly ash. • To prevent loading of temporary structures, water shall be sprayed and covered with tarp before. • Contractor shall prepare traffic management and get it approved by MMRDA and local authority.	
8.	Development of Construction dumpyard and construction activities	Improper storage and availability of storage space leads to soil erosion, air and water pollution.	Significant and reversible	• Dust suppressing measures with sprinkling of water should be taken for concrete used for transport. • The location for dumpyard for construction materials shall be identified at least 500 m from settlement or water body.	Contractor
9.	Construction of labour camp	Risk of social conflict	Significant	• Construction camps shall not be provided within 500m from the railway settlements to avoid nuisance and stress over the infrastructure facilities with the local community. • Contractor as per provision rules shall carry out negotiations with the landowners/ private for obtaining their consent for temporary use of labour camp. Contractor shall submit labour camp.	Contractor
10.	Accessibility approach road	Traffic problems and inconvenience to project locations and nearby road	Significant	• The construction on ramp is underground will not affect any existing road and path. However, in case if any road blockages it is ensured and provide safe and convenient passage for vehicles, pedestrians, etc. by providing temporary connecting road.	Contractor

Construction Phase

Sl. No.	Activities	Potential Impacts	Significance	Mitigation Measures	Responsibility
1.	Tunnel Construction	• Use of toxic slurry and other chemicals. • Drainage inside tunnel	Significance	• Use non-toxic slurry and additives and minimize impact of these materials to reduce risk of impact on ground water quality. • Ensure that pressure applied to tunneling and ground treatment is controlled to prevent excessive pressure that will drive the slurry out of the desired range increasing the risk of water pollution. • The Contractor will pass all drainage water from the tunnel through a settlement tank. • If the drainage water meets existing water standards it can be considered for recycle in any operations required during the construction phase.	Contractor
2.	Sprouting, shaping and preservation of Hillside & Muck Disposal	• Land use change and loss of productive ag. soil. • Trigger erosion, earthwork and soil and its movement	Significant	• Construction of terrace is undergone to minimize of top soil in the adjacent. However top soil may affect as entry and exit point of tunnel, so the top soil from construction road shall be stripped to a specified depth of 150 mm and stored in stockpiles for reuse. • Structure shall be arranged such that the slope does not exceed 1:2 (vertical to horizontal), and height is restricted to 15. If soil is stored for long time, provide silt screens to prevent erosion. • The muck generated due to excavation of tunnel will disposed off at said designated site at Delhi-Meerut Expressway.	Contractor
3.	Auxiliary activities, construction machinery and equipment, of electricity	Depletion of resources and land ground water contamination, siltation and contamination of surface water, nuisance to public, deterioration of local ambient air and noise quality	Significant	• Requisite permissions shall be obtained for abstraction of groundwater if required. • Contractor must use STP water from near STP. • There is no river in nearby project area. So, no	Contractor

				effect on surface water is anticipated. • Diesel Generator set shall be placed on a cement concrete platform with oil and grease trap to control the oil ingress into saltwater bodies. • All equipment operators, drivers, and maintenance personnel will be trained in immediate response for spill containment and localized cleanup. • Hazardous waste such as wastewater which has oil sludge, waste rubber from DG set and vehicles shall be disposed of through authorized recycler. Prior authorization from SPCB should be obtained for the storage and disposal. • Water quality to be monitored periodically as per the monitoring plan (once in six months). • Ensure storm water drain all around periphery of casting and batching plant including regular cleaning and maintenance. • Contractor shall prepare traffic management and diversion plan duly approved by RMC. • Ensure that batching and asphalt mixing plants and crushers shall be located at downwind direction of any nearby receptor settlement. • Submit PUC certificates for all vehicles, equipment machinery that are being used for the project. • Ensure regular water sprinkling and encapsulation of dust source by erection of screen/barriers. Also water shall also be sprayed on haul road and where is required. • Vehicle delivering materials shall be covered. Dry bulk in loaders shall be provided to prevent spillage. • Monitor workers on quality and comply with the	

				monitoring. • Noise Limits for construction equipment used in the projects such as compactors, Dozers, Front loaders, concrete mixers, cranes (moveable), vibrators and saws which are ascribed 75 dB (measured at manufacturer distance from the edge of equipment to the sites here), as specified in the Environment (Protection) Rules 1986. • At the construction sites within 100 m of the nearest habitation, noisy construction work such as crushing, concrete mixing, blasting shall be stopped during the night time (between 6.00 pm to 6.00am).	
6	Environment Health and Safety	• Failure in safety measures leads to accidents • Occupational hazards • Stoppage of site work and risk of litigation	Significant	• Contractor shall appoint a qualified EHS personnel at the start of the project to conduct training, audit, EMP implementation, monitoring and EHS compliance. • CoC offices shall prepare an annual training calendar targeting workers, supervisors, middle and senior management. • Project managers and workers shall be imparted regular training on EMP implementation including waste management, general site safety, standard operating procedures for accident prevention, emergency preparedness plan, first aid training, use of personal protective equipments, for construction works. • Site shall violate a work permit system for working at heights, working in confined spaces, and hot jobs. • Signage board shall be used to ensure EHS advisement. • Provide extinguishers at electrical installation, DG set etc., along with Sand Buckets. • Proper ventilation plan shall be prepared for smooth flow of traffic.	Contractor

				- Site shall prepare accident prevention plan - Prepare Standard Operating Procedures for the management of C&D waste and municipal waste - Prepare Standard Operating Procedures for hate speech, grievance redressal, gender equity and sexual harassment - Protective gadgets and clothing to workers engaged in noise breaking activities and workers shall be awared of sufficiently with intervals - Exposure to workers exposed to hourly noise (should not exceed 85 dB (A)) and workers working in crushing composition (it considered noising operation) - Develop Standard Operating Procedures for monitoring, reporting and capacity building. - The Contractor shall not employ any persons below the age of 18 years for any work.	
2	Labour/ employee welfare	- Exploitation of labour - Gender inequity and violence - Social security, health, hygiene	Significant	- Apply and obtain labour licenses under contract and migrant labour act - Maintain Wage Register - Maintain a register of attendance and muster at the site - Site ensure that workers' working hours should not exceed more than nine hours a day or forty-eight hours a week - Provide a day of rest every week - Proportional engagement of women to total human resource engagement - Engage women labour from different castes/class provide equal remuneration, provide separate toilet facilities for women workers - Contractor shall ensure that all workers engaged in	Contractor

				site construction must have insurance, same is applicable to sub-contractors. • In every establishment where 50 or more women or ordinarily employed as workers/labour there shall be provided two rooms of reasonable dimensions for the use of their children under the age of 6 years. One of such rooms should be used as a play room for the children and the other as bedroom for the children. For this purpose, the contractor shall supply adequate number of toys and games in the play room including bed in the sleeping room. The standard of construction and maintenance of the crèches as per the condition specified in the BOCW act. • Every migrant workmen shall be registered and entitled for allowance, benefits etc., as prescribed in the rule. • No female migrant workmen shall be employed by any contractor before 6 a.m. or after 7 p.m. • Provide canteen facility for the use of workers in case the number workers are more than 250 (BOCW Rule). • Contractor shall provide accommodation, adequate sanitation and water supply.	
5.	Labour Camp Management	Location of Construction labour camps		• Camps must be located at least 500m away from settlement areas. • The location, layout and basic facility providers of each labour camp shall be submitted and approved by NHAI/ IE before their construction.	
		No Construction		• The Contractor shall provide, each and maintain necessary (temporary) resident living accommodation and ancillary facilities during the progress of work. • Contractor shall provide electricity, water supply and	

				area are sanitized to the best. • Contractor shall ensure sanitation to labour camp once a week and ensure safety precautions are followed.	
		Potable Water Sanitation and Sewage System		• Ensure sufficient water availability for drinking, cooking, and washing. • Supply of sufficient quantity of potable water (as per IS) in every accommodation complex or worksite and easily accessible places and regular maintenance of such facilities. • Regular Testing of water shall be done as per the parameters prescribed in IS:10500:1991. • Compliance with EMP shall be reported & shall be inspected the MoUs camp periodically to ensure compliance of the EMP. • The Contractor shall ensure that- • The sewage system for the camp are designed, built and operated in such a fashion that no health hazards occur and no pollution to the air, groundwater or adjacent watercourses take place. • Adequate and sufficient number of toilets /bathrooms for men provided in permanent and women are to be provided. • Adequate water supply is to be provided in all rooms and outside. • STP of suitable capacity shall be installed to manage sewage generation and to maintain sanitation condition of camp site.	
		Waste Disposal		• The contractor shall provide garbage bins in the camps and ensure that these are regularly emptied and disposed of.	

7	Community Relations	Community Grievance Process	Significant	- Contractor shall establish a community grievance redressal system to address the public complaints and inconveniences. To make it effective contractor shall also establish an information dissemination mechanism to inform different stakeholders - Spot follow up of complaints recorded in complaints register to assess whether the complaints had been closed or not - Public meetings to assess whether appropriate information is being provided to communities and whether sufficient information collected from communities	
8	Archaeological artefacts	Chance finds or discovery of any archaeological artefacts, treasures etc during excavation	Insignificant	- There are no Archaeological structures present near project area	Project Proponent & site in charge
9	Traffic management	Traffic safety and flow management	Significant	- The Traffic Control Plans shall contain details of temporary diversions, traffic safety arrangements, night safety measures, speed limit, signage, barriers, and flagmen for traffic control etc.	Contractor
10	Ecology And Biodiversity (Flora & Fauna) Aquatic Ecology	Tree Cutting	Significant	- Conservatory efforts/encroachment: Proper care of saplings must be taken, as the saplings don't die all or are eaten by cattle.	Contractor under supervision of forest department
					Contractor
		- Impact on the habitats and wildlife	Significant	- The construction of tunnel is below the ground level will not affect any habitation and wildlife - Vibrations like noise and vibration due to construction equipments and T&M may cause problem. So employed and well-maintained equipment and designs should be used to minimize the noise and vibration during construction	

				- There is no evidence of any surface water threatened nearby project area. So no effect on aquatic life.	
11	Labour & Employee Welfare & Safety	Risk of social conflicts due to religious, cultural or ethnic differences or gender-based violence.	Significant	- Contractor should ensure that workers' working hours should not exceed more than nine hours a day or forty-eight hours a week and wage register must be maintained. - Provide a day of rest every week. - No female workmen shall be employed by any workman before 6 a.m. or after 7 p.m. Also have provision under employment contract to adhere POSH rules 2013. - The standard of construction and maintenance of the colonies may be such as may be specified by Govt. Act - To ensure safety, health and hygiene of workers, the contractor shall develop and implement site specific health and safety plan and prepare a detail Standard operating procedures (SOPs) for each activities which has potential to trigger injury and accidents	

Operation phase

Sr. No.	Activities	Potential Impact	Significance	Mitigation Measures	Responsibility
1	Energy conservation measures	Loss of natural resources	Significant	- Use energy efficient electrical equipment - Full horizontal cut off glass lens luminaires are installed at 0o uplift. These luminaires, in addition to reducing sky glow, help to minimize visual intrusion within open landscape. - Where possible use lower lamp heights. - To prevent future pollution issues prohibit the use of sodium light (HPS or LPS/SOX) and use LED lights.	Adani & Contractor

				with a "neutral" solar temperature of 25[illegible]	
2	Emergency Response	Incidents in tunnel	Significant	• Emergency Response system shall be provided inside the tunnel for ventilation. • Phone booth at regular interval shall be provided • Tunnel escape route shall be provided in case of emergency • Phone booth for accidental reporting and ambulance services with minimum response time for rescue of any accident victims, if possible. • Install warning signs.	NHAI & CONTRACTOR
3	Traffic Management	Traffic congestion and Traffic safety	Significant	• Maintenance of all unnecessary boards and signage to keep road user aware for direction and other instructions • Regular maintenance and cleaning of assets such as signboards, bus stops, shelter, etc. shall be undertaken. • Spill prevention and control and emergency response system • Towaway facility for the breakdown vehicles if possible.	NHAI / Site in-charge

E.5 ANALYSIS OF ALTERNATIVES

Three alternative alignments have been considered.

OPTION 1.

The alignment starts from the proposed Shiv Murti Interchange and point via a tunnel which traverses for a length of 2 Km through southern ridge. The tunnel exits 700m before the end point of Nelson Mandela Marg and then a 594 m ramp and 74 m at grade surface road merges with the Nelson Mandela Marg end point. Salient Features of the Alignment are as follows:

- Total Length- 4083 m
- Tunnel Length-4306 m
- Approach Ramp to Tunnel End Portal- 594 m
- At Grade Surface Road- 74 m

Pros and Cons of option 1 are as follows:

Pros	Cons
• No Impact on Rangpuri Farm House and Ridge Forest Area • No land acquisition is proposed • Least Impact on Existing Utilities • No traffic hassles during construction period	• Long Tunnel Length will lead to increase in cost

OPTION -2

The alignment starts at the same point as discussed in earlier options after Shivmurti interchange with a tunnel which traverses beneath the Rangpuri Farm House Area and Rangpuri forest. The tunnel ends at Nelson Mandela Marg on the existing road and the approach ramps from tunnel will meet the existing road at a gradient of 3.3% before the Vasant Kunj Flyover Red light. This option does not involve any land acquisition but the construction on existing Nelson Mandela Marg which is coming on the end approaches of tunnel will lead to shifting of utilities, traffic hassles during construction as the Nelson Mandela Marg serves as the only connecting road to 4 nos. of DDA housing societies (Ganga, Yamuna, Narmada and Saraswati).

Salient Features of the Alignment are as follows:

- Total Length- 4783 m
- Tunnel Length- 4100 m
- Approach Ramp to Tunnel End Portal- 600 m

- At Grade Surface Road- 69 m

Pros and Cons of Option-2 are as follows:

Pros	Cons
• No Impact on Rangpuri Farm House and Ridge Forest Area • No Land Acquisition	• Long Tunnel Length will lead to increase in cost • Utility Shifting- A number of utilities i.e., IGL gas pipelines, HT Line, Water and Sewer Network are present at the existing Nelson Mandela Road which needs to be shifted. • Traffic Hassles during Construction as the Nelson Mandela Marg serves as the only connecting road to 4 nos of DDA housing societies.

OPTION-3

The proposed alignment is similar to that proposed in Option-3, only the tunnel exits after the Rangpuri Ridge Forest Area reducing the tunnel length to 2800 m and then a 600 m approach ramp and 702 m at grade surface road merges with the Nelson Mandela Marg end point.

In addition to this newly proposed alignment, modifications in existing Nelson Mandela Junction are required to make the junction signal free and smooth flow of traffic. This will include blocking of right movement at the junction and providing a guided U Turn at the existing traffic light near Spinal Injury hospital towards Mahipalpur end. Apart from this, an additional flyover parallel to existing flyover at Nelson Mandela Junction would also be required. Strengthening and upgrading of Nelson Mandela Marg from the dead end till Junction has also been proposed in order to make it similar to the newly proposed green field alignment. For the local societies, the two service lanes have been proposed which will be cater both ways traffic. No direct flow of traffic on the main 6 lanes carriageway is recommended.

Salient Features of the Alignment are as follows:

- Total Length- 4102 m
- Tunnel Length- 2800 m
- Approach Ramp to Tunnel End Portal- 600 m
- At Grade Surface Road- 702 m
- Up-gradation of Nelson Mandela Marg with 2 lanes service roads on both sides for local societies.
- New flyover parallel to existing flyover at Nelson Mandela Junction – 400m length

- Two lanes Guided U turn at traffic lights towards Mahipalpur near Sainal Injury Hospital
- Restricting right turn at Nelson Mandela Junction.

Pros and Cons of Option-3 are as follows:

Pros	Cons
• No Impact on Rangpuri Farm House and Ridge Forest Area • Least Tunnel Length will lead to decrease in project cost • Least Impact on Existing Utilities • No traffic hassles • Smooth traffic flow in and around Nelson Mandela Junction	• Least Land Acquisition- 7.812 Ha considering (1302 m length and 60m width of ROW) • Land Acquisition at one Farm House near the end point

OPTION-3.1 EXTEN SION

The proposed alignment is similar to that proposed in Option-3.1 extension, in which the tunnel exits after the Rangpuri Ridge Forest Area reducing the tunnel length to 2800 m and then a 600 m approach ramp is provided. After exiting the tunnel, a 1700m long viaduct is provided which passes on the Nelson Mandela Marg and crosses from above the Vasant Kunj Flyover. The flyover ends before the U turn on the Vasant Kunj Mall Road.

Salient Features of the Alignment are as follows:

- Total Length- 5111 m
- Tunnel Length- 2800 m
- Approach Ramp to Tunnel End Portal- 600 m
- Viaduct Length- 1700 m
- Approach Ramp to Viaduct- 700m
- At Grade Surface Road- 311 m

Pros and Cons of Option-3.1 Ext are as follows: Pros

Pros	Cons
• No Impact on Rangpuri Farm House and Ridge Forest Area • Traffic coming out from tunnel towards Nelson Mandela will be through movement via the elevated viaduct	• Additional viaduct will lead to more capital cost • Land Acquisition- 7.812 Ha considering (1302 m length and 60m width of ROW) • Land Acquisition at one Farm House near the

	end point • Shifting of HT Line (3 Nos. of HT)

E.6 ENVIRONMENTAL MONITORING PROGRAMME

The Environmental Monitoring Programs are also suggested to provide information on which management decisions may be taken during construction and operational phase. The objective of this program is to evaluate the efficiency of mitigation and enhancement measures, updating the actions & impacts of baseline data and adaptation of additional mitigation measures. Total cost for environment monitoring plan is **Rs. 1,50,00,000**

E.7 ADDITIONAL STUDIES

E.7.1 Public Consultation & Public Hearing

As per the EIA notification dated 14th September 2006, vide section 7(f) related to public hearing, the draft EIA/EMP report is being submitted to the Delhi Pollution Control Committee (DPCC) for conducting public hearings in South Delhi district in the state of Delhi.

E.7.2 Social Impact Assessment

The proposed project is underground tunnel does not going to affect any structure. The Tunnel passes through the Ridge Forest area, there is no private land involve in the project. Hence No Social Impact Assessment is required. There is no land acquisition required for the project.

E.7.3 Road Safety Features

Indian Road Congress (IRC) codes will be followed in proposing and designing road safety features. Pavement markings will be done for traffic lane line, edge lines and hatching. The marking will be with hot applied thermoplastics materials. The pavement markings will be reinforced with raised RR pavement markers and will be provided for median and shoulder edge longitudinal lines and hatch markings. Tunnel lightings including high masts will be provided at intersections in order to improve the night time visibility.

All the urban locations as well grade separated structure locations will be provided lighting arrangements.

In addition to avoid the accidents inside and outside the tunnel & for the smooth and safe flow of traffic it is required to provide the various safety features for the tunnel. In accordance to IRC: SP: 91, the tunnel is classified as long tunnel and therefore require ventilation system and associated MEP systems along with other facilities suitable to all possible tunnel operations modes.

The following section establishes design criteria of mechanical & electrical systems for Tunnel.

- Ventilation System
- Emergency Power supply System

- Fire Fighting system
- Lighting System
- Traffic Management and Controls Systems (TMCS) etc
- Noise & Vibration

The Detailed study is given in Chapter-7 of EIA report.

E.8 PROJECT BENEFITS

As NH-48 carries very heavy traffic to Chattarpur/Vasant Kunj from Gurugram creates a heavy congestion at Mahipalpur due to very narrow city road, traffic to and from Delhi airport and Mahipalpur/Rangpuri market. Since, the road bears heavy traffic and have very heavy settlement enroute, heavy congestion along this route occurs during the peak hours of the day. Widening along this route is almost difficult due to heavy settlement, and therefore, it was proposed to connect NH-248BB with NH-148NE at Nelson Mandela Marg to avoid this congestion. The proposed alignment is a green field alignment and enroute posh area of Wastend Green and across the Rangpuri Ridge.

The advantages of this project are as follows:

- Easy flow of traffic from Dwarka Expressway to Nelson Mandela Marg which remain heavily congested areas in Mahipalpur and Rangpuri. No major congestions on NH-48 in peak hours.
- Availability of 6 lane road at Nelson Mandela Marg meets the design configuration of tunnel that has also been proposed a 6-lane tunnel. Traffic flow would be easy without any major hassles.
- No land is being acquired for the construction of underground tunnel. However, Forest land of approx. 7.5145 ha of land will be diverted around the Southern ridge and deemed forest area. Permission for which has already been applied through FCA proposal no. **FP/DL/OTHER/ 468849/2024 dated 22.01.2024.**
- It will create a short distance route that will take less travel time, and hence, resolve traffic congestions problem at the aforesaid places. In addition, it will improve local ambient air quality and reduction in carbon footprints during entire life cycle of the project.
- The project also does not trigger displacement, no structure are going to impact due to construction of underground tunnel, however, some public utility will be impacted at the Nelson Mandela area which is the exit point of the proposed Tunnel.
- And being a Greenfield project, it will envisage very less impact upon the environment.

E.9 ENVIRONMENTAL MANAGEMENT PLAN (EMP)

The Environmental Management Plan is prepared for avoidance, mitigation and management of the negative impacts of the project. It also covers remedial measures require to be taken EMP includes the list of all the project related activities, their impacts at different stages of project during

construction phase and operational phase on environment and remedial measures to be undertaken to mitigate these impacts.

Total cost for environment management plan (including environmental monitoring plan) for the project is **Rs. 77.65 Cr.**

E.10 FINDINGS & CONCLUSSION

The Draft EIA report for this proposed project has been prepared after thorough interaction with the engineering section of the DPR consultant and contractor so that the negative impacts on the environment and human population could be avoided as far as possible. Some of the important findings of the study are as follows. -

1. There will be insignificant loss of bio-diversity as no rare plant or animal species are going to be affected by the present project.
2. The proposed alignment is not passing through any Sanctuary or National Park.
3. Precautionary measures such as Health & Safety, Proper Ventilation System, Mechanical & Electrical arrangement and emergency response system etc. have been proposed to mitigate the impact during construction and operation.
4. No monuments protected by the Archaeological Survey of India (ASI) are located within the ROW of proposed project.
5. The most important factors, which need continuous attention and assessment during the construction phase, are the ambient air quality, health & safety, muck disposal and the noise & vibration level. A proper mitigation plan is prepared and will be implemented during the construction phase to maintain the Air & Noise Environment. Muck will be disposed at identified site and Health & safety plan is prepared.
6. Approximately 417 numbers of trees are recorded in corridor of impact to mitigate the impact the impact.
7. There are no structures recorded within the corridor of impact of proposed tunnel. However, the proposed project will definitely have some positive impact on the socio-economic environment of the people of surrounding area experiencing development in the area in specific and state and nation as a whole.

CHAPTER-1: INTRODUCTION

1.1 PROJECT BACKGROUND

The Ministry of Road Transport and Highways (MoRTH), Government of India has proposed "Bharatmala Pariyojana" an Umbrella scheme of road development project through National Highways Authority of India (NHAI), National Highway, Industrial Development Corporation Ltd (NHIDCL) and State Public Works Departments (PWD). NHAI is engaged in the development of National Highways and as part of this endeavour, the Authority has decided to undertake the Economic Corridors, Inter-Corridors, Feeder Routes primarily to improve freight movement in the Country under Bharatmala Pariyojana Programme. Bharatmala Pariyojana focuses on optimizing efficiency of freight and passenger movement across the country by bridging critical infrastructure gaps through effective interventions like development of Economic Corridors, Inter Corridors and Feeder Routes, National Corridor Efficiency Improvement, Border and International connectivity roads, Coastal and Port connectivity roads and Green-field expressways.

The proposed project is a part of the Bharat Mala Project which has been envisaged as an umbrella program under the Ministry of Road Transport and Highways. The project involves constructions or improvement of national highways/ newly declared National Highways with an aim to improve road connectivity to border areas, backward areas, religious and tourist sites.

Delhi being National Capital generates and attracts huge quantum of traffic not only from within Delhi but also from surrounding region. In order to cater to this regional traffic, Inner and Outer ring roads were planned in 1962, of which only inner ring road could be completed whereas outer ring road is still not a full ring. Additionally, non-Delhi destined traffic i.e. traffic to/from North Indian States (which includes Punjab, Northern Haryana, Jammu & Kashmir) to remaining Indian states (which includes Rajasthan, Southern Haryana, Gujarat, Maharashtra) has to pass through Delhi due to absence of alternate network. This leads to heavy congestion on the existing ring roads.

The National Highways Authority of India has been assigned the work of "Construction of a Road tunnel for NH-148E with its approach and connection to NH-248BB and existing Delhi internal roads in the State of Delhi."

The total length of the project is 4.983 Km with a PRoW of 45m. The main objective of the proposed project is decongestion of traffic. The proposed tunnel is completely Greenfield / underground and hence will have negligible impact on environment.

1.2 CONSULTANCY APPOINTMENT:

M/s SMEC International Pty. Ltd in association with Anandjiwala Technical Consultancy has been appointed as lead Consultants vide letter no **PIU/DWE/20/02/1924 dated 29th October 2020** to carry out the Detailed Project Report (DPR) from proposed Near Shivmurti Interchange NH-8 (Dwarka Expressway Package-1) to Nelson Mandela Marg.

The project involves study and detailed design of the most feasible alignment with twin tunnel arrangement with approach ramps and surface roads to merge into the planned alignment. The contract with NHAI was signed on 12th January 2021.The scope and principal objectives of the consultancy services is contained in the Terms of Reference (TOR) of the consultancy services, which is part of the contract agreement. The services were commenced with effect from 12th January 2021.

Further, DPR Consultants has assigned Ambiental Global Private Ltd. a NABET accredited consultant to obtain Environmental Clearance from MoEF&CC including preparation of the Environmental Impact Assessment report and Environmental Management Plan for the above referred project.

1.3 IDENTIFICATION OF PROJECT AND PROJECT PROPONENT

The Ministry of Road Transport and Highways (MoRTH), Government of India (GoI), is the apex body for formulation and administration of the rules, regulations and laws relating to road transport, and transport research, in order to increase the mobility and efficiency of the road transport system in India. Road transport is a critical infrastructure for economic development of the country.

The National Highways Authority of India (NHAI) is a nodal agency of the Ministry of Road Transport and Highways. The NHAI was created through the promulgation of the National Highways Authority of India Act, 1988. In February 1995, the Authority was formally made an autonomous body. It is responsible for the development, maintenance and management of National Highways.

The NHAI is developing NH-248BB (Dwarka Expressway) and have proposed to connect this NH with existing Nelson Mandela Road through NH 148AE to reduce the traffic congestion at Mahipalpur/ Rangpuri. Further, an interchange has been proposed to connect NH 248BB with NH 48 and NH 148AE. A connection to Indira Gandhi International Airport has also been proposed from this interchange.

A Term of Reference (ToR) has been granted by MoEF&CC vide letter No. 10/6/2022-IA.111 dated. 28th March, 2022 (enclosed as **Annexure-I**). Further, the case was again considered by MoEF&CC for amendment in ToR which was issued vide letter no. - 10/6/2022-IA.III dated 5th dec 2022, is attached as **Annexure-I(a).**

An Index Map of the Project corridor is shown in Figure 1-1 Index map



Figure 1.1: Location map of Project Corridor



Figure 1.2: Location Google map of Project Corridor

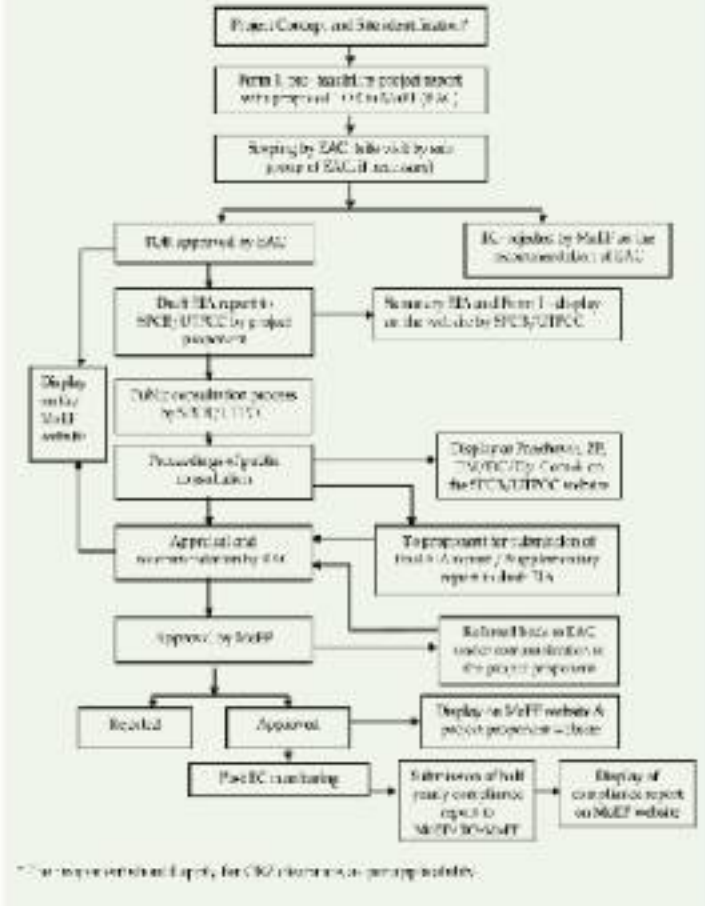


Figure 1.3: Prior Environmental Clearance Process for Category A Project

1.4 DESCRIPTION OF THE PROJECT:

The National Highways Authority of India is developing NH-248BB (Dwarka Expressway) with its approaches and interchange at NH-48, and intends to connect it with NH-148AE (Nelson Mandela Marg) in Delhi. NH-248BB ends at the proposed interchange near Shivmurti at NH-48. Proposed road

traverses from 28°31'56.38"N longitude 77°6'35.35"E and latitude 28°31'44.71"N longitude 77°6'52.08"E.

For more details on work done by agencies involved, refer table No.1.1:

Table 1.1: Agency Involved and Work Awarded

Sl. No.	Agency	Work awarded
1	MoRTH	Ministry of Road Transport and Highways
2	NHAI	Nodal Agency for the proposed Project
3	SMEC International Pty Ltd	DPR Consultant vide letter no. PIU/DWE/20/03/1924 dated 29th October 2020
4	Ambiental Global Private limited	1. ToR Approval vide letter no. File No. 10/6/2022-IA.111 dated. 25th March,2022 2. ToR Amendment Vide Letter No. F. No. 10/6/2022-IA.III dated 5th dec 2022 3. Draft EIA Report 4. Final EIA Report

1.5 BRIEF DESCRIPTION OF THE PROJECT AND ITS IMPORTANCE TO THE COUNTRY

The National Highways Authority of India is developing NH-248BB (Dwarka Expressway) with its approaches and interchange at NH-48, and intends to connect it with NH-148NE (Nelson Mandela Marg) in Delhi. NH-248BB ends at the proposed interchange near Shivmurti at NH-48.

As NH-48 carries very heavy traffic to Chattarpur/Vasant Kunj from Gurugram creates a heavy congestion at Mahipalpur due to very narrow city road. traffic to and from Delhi airport and Mahipalpur/Rangpuri market. Since, the road bears heavy traffic and have very heavy settlement enroute, heavy congestion along this route occurs during the peak hours of the day. Widening along this route is almost difficult due to heavy settlement, and therefore, it was proposed to connect NH-248BB with NH-148NE at Nelson Mandela Marg to avoid this congestion. The proposed alignment is a green field alignment and enroute posh area of Westend Green and across the Rangpuri Ridge.

1.5.1 The advantages of this project are as follows:

- Easy flow of traffic from Dwarka Expressway to Nelson Mandela Marg which remain heavily congested areas in Mahipalpur and Rangpuri. No major congestions on NH-48 in peak hours.
- Availability of 6 lane road at Nelson Mandela Marg meets the design configuration of tunnel that has also been proposed a 6-lane tunnel. Traffic flow would be easy without any major hassles.

- No private land is being acquired. However, Forest land of approx. 7.5145 ha of land will be diverted around the Southern Ridge and Deemed Forest. Permission for which has already been applied through FCA proposal no. **FP/DL/OTHER/8/463049/2024 dated 22.01.2024**.
- It will create a short distance route that will take less travel time, and hence, resolve traffic congestions problem at the aforesaid places. In addition, it will improve local ambient air quality and reduction in carbon footprints during entire life cycle of the project.
- The project also does not trigger displacement; however, some public utility will be impacted at the Nelson Mandela area which is the exit point of the proposed Tunnel.
- And being a Greenfield project, it will envisage negligible impact upon the environment.

1.6.2 Salient features of the project

The project starts from Near Shivmurti Interchange NH-8 proposed Ch. 0+000 and ends at Nelson Mandela Marg at Vasant Kunj with Chattarpur-Mahipalpur Road proposed Ch. 4+983.

The proposed underground Tunnel is passing through New Delhi & South Delhi district in the NCT of Delhi. The main objective of the project is that NH-48 carries very heavy traffic to Chattarpur/ Vasant Kunj from Gurugram creates a heavy congestion at Mahipalpur due to very narrow city road, traffic to and from Delhi airport and Mahipalpur Rangpuri market.

The salient features of the proposed project have been presented in **Table No. 1.2**

Table 1.2: Salient features of the proposed project

1.	Project Name	Construction of a road tunnel for NH-148E with its approach and connection to NH-248BB in NCT of Delhi.
2.	Location of the sub project road	The project NH-148AE starts from Shiv murti Interchange Ch. 0.000 Km (Dwarka Expressway Package-1/UER/NH248BB) at NH-48 and ends at Nelson Mandela Marg Ch. 4.983 Km in Vasant Kunj in New Delhi.
3.	Total design length of the project	4.983 Km
	3.1 Tunnel Length	4.306 Km
	3.2 Approach Ramp	0.594 Km
	3.3 At Grade	0.074 Km
	3.4 New Proposed Flyover	0.668 Km
4.	Geographical Location	Start 28°31'55.31"N, 77°06'27.34"E End 28°31'44.79"N, 77°8'53.25"E
5.	Start Point	NH-8 Near Shivmurti Interchange
6.	End Point	Nelson Mandela Marg Vasant Kunj
7.	Project Category (as under EIA	Category-A

	Notification, 2006)	
8.	Total Civil cost	3426.38 Cr
9.	Total Capital Project Cost (including Civil, Utility Shifting and Forest, Environment)	4089.09 Cr
10.	**Resource Requirement**	
	i. Reinforcement	17,213.42 Tons
	ii. Concrete	**Item** / **Estimated Qty (m3)** Dry lean Cement Concrete (DLCC) / 14896.05 Plain Cement Concrete (PCC) / 33360 M30 / 48459 M25 / 7714
	iii. Water	**Thematic area** / **Quantity (m3/day)** Road construction (tunnel) / 300 KLD Road making Local surface/ground water / 20 KLD Dust suppression / 50 KLD Others (including drinking and domestic purposes) / 50 KLD Total / 420 KLD 10% Contingency / 42 KLD Total / 462 D
	iv. Estimated Manpower requirement (Skilled and unskilled)	400 – 450 per day
11.	Transportation	
	i. Muck Disposal	122 trip per day
	ii. Concrete	88025 m^3
	iii. Segments (To be estimate TBM contractor)	10563 Nos
12.	Power of Consumption	
	i. DG Set during construction phase	3 Nos x 750 KVA
	ii. TBM Capacity	7371758 KWH
13.	Terrain	Plain & rolling
14.	Existing right of way (ERoW)	0-45 m.
15.	Proposed Right of Way	30-45 m
16.	Carriageway	10.5 m (3.5m + 3.5m + 3.5m)
17.	Design Speed	80 Km/hr
18.	Safety Measure	New Jersey Crash Barriers

19.	Flyover	1 Nos.
20.	Proposed Toll Plaza	1 Nos (Ch 4+900)
Feature of EIA importance		
21.	Type of Mode	EPC
22.	Location of Proposed Project Name	Construction of a road tunnel for NH-148E with its approach and connection to NH-248BB in NCT of Delhi.
23.	Jurisdiction	**Sl No.** / **State** / **District** / **Village** 1 / NCT of Delhi / New Delhi / Samalka 2 / / New Delhi / Rajouri 3 / / New Delhi / Rangpuri 4 / / New Delhi / Masoodpur 5 / / South Delhi / Mehrauli
24.	Seismic Zone	Zone IV
25.	Forest Land Diversion	Forest land involving 5.8207 ha falling under Southern Ridge Reserved Forest and 1.5888 ha falling under Deemed Forest will be diverted. The Project involves 417 trees cutting at the exit point and U-turn Modification. **Permission for the same has been granted by Hon'ble** Supreme Court via diary no.(s) 34870/2023 in W.P. (Civil) no. 467/1985 listed date on 18.10.2023 (Copy Attached as **Annexure II**).
26.	Water bodies Impacted	None
27.	Existing trees within ROW	417 at the exit point near Nelson Mandela Marg and modification of U-turn are given in **Annexure III**
28.	Compensatory Plantation	Approx. 4170 (ten times of total trees to be felled) shall be planted as compensatory plantation.
29.	Wildlife Sanctuaries	NIL
30.	Nos of Structure Affected	NIL
31.	Total Area of Land Acquisition	Land Acquisition would not be required due to the project is an underground Tunnel

a. SCOPE OF THE EIA/EMP STUDY (AS PER TOR)

The Ministry of Environment, Forest and Climate Change (MoEF&CC), Government of India, in its Notification S.O. 1533 dated September 14, 2006 has made it mandatory to obtain Environmental Clearance (EC) for any new national highways/expressway project before its implementation. As a

requirement for seeking Environmental Clearance (EC), the consultant is required to prepare the detailed Environmental Impact Assessment (EIA) report and the Environmental Management Plan (EMP) for getting environmental clearance from the Ministry of Environment, Forest and Climate Change (MoEF&CC). The ToR was obtained for the proposed project vide File No. 10/06/2022-IA.III dated 25th March 2022. Further, the case was again considered by MoEFCC for amendment in ToR which was issued vide letter no. 10/6/2022-IA.III dated 5th December 2022 is attached as **Annexure-I (a)**. EIA has been prepared as per approved ToR (Copy of the approved ToR is attached as **Annexure-I**).

The scope of the EIA/EMP study is: -

- To establish present environmental condition along the project corridor through available data/information supported by field studies.
- Screening, scoping and consultations with public, experts in various fields, non-government organization (NGOs), etc.
- Review of policies and legal framework.
- Identification of the potential impacts during pre-construction, construction and operation phases.
- Developing mitigation measures to sustain and maintain the environmental scenario.
- Designing the Environmental Management Plan.
- Suggesting the Environmental Enhancement and its monitoring Scheme.

1.6 OBJECTIVES OF THE CONSULTANCY SERVICES

M/s Ambiental Global Private Limited is responsible for the preparation of the EIA/ EMP report. The main objectives of the Consultancy service are: -

- To suggest appropriate measures for mitigating the effects of property and community severance and circulation of the local traffic.
- To ensure that the drainage pattern of the area is not disturbed, and natural environment, human habitation and heritage sites are fully protected.
- To integrate safety in design, construction and operation of the Tunnel. Infrastructure for user amenities, operation and maintenance, incident management and user information system will be an integral part of the study.
- To develop the Highway/tunnel in EPC Model.

1.7 POLICIES, LEGAL AND ADMINISTRATIVE FRAMEWORK

Statutory permissions and clearances required during construction and operation of the project are summarized in **Table No. 1.3.**

Table 1.6: Summary of Relevant Environmental Laws and Guidelines

Sl. No	Act/Rules	Year	Objective	Applicable Yes/No	Reason for applicability	Authority	Responsibility
1	Environmental (Protection) Act	1986 (And its Amendments)	To protect and improve overall environment	Yes	As all environmental notifications, rules and schedules are issued under this act	MoEF&CC (At Corporate & Ex-Depo), Govt Delhi, CPCB, SPCC	Client
2	Environmental impact assessment (EIA) Notification	2006 (And its Amendments)	To provide environmental clearance to new development activities following environmental impact assessment	Yes	The Project falls in the conditions of the Notification 2006 and further amendments	MoEF&CC	Client/ EMC
3	Forest (Conservation) Act	1980 (And its Amendments)	To check deforestation by restricting conversion of Forestlands into non-forestal activity.	Yes	Forest Ridge area is identified along the alignment	Forest Department of Delhi	Client/EMC
4	Water (Prevention and Control of Pollution) Act and Cess Act of 1977 as amended in 1988	1974 (And its Amendments)	To control water pollution from Water pollutants as per the prescribed	Yes	The act will be applicable during construction, the establishments of hot mix plant, stone crushers, construction camp, workers'	Delhi Pollution Control Committee	Contractor and its compliance shall be reported to PMC

			necessary.		camp, etc.		
5.	Air (Prevention and Control of Pollution) Act as amended in 1987	1981 (Amended in 1987)	To control air pollution by controlling emission and air pollutants according to prescribed standards.	Yes	This act will be applicable during construction for obtaining NOC for establishment of hot mix plant, workers camps, stone crusher, construction camp, etc.	Delhi Pollution Control Committee	Contractor and its compliance shall be reported to PIU
6.	Noise Pollution (Regulation and Control) rules	2000 (Amended in2010)	Noise pollution regulation and controls	Yes	This act will be applicable during the construction phase to estimate noise on project routes required to assess for future years and necessary additional measures need to be considered in design.	Delhi Pollution Control Committee	Contractor and its compliance shall be reported to PIU
7.	Ancient Monuments and Archaeological Sites and Remains (Amendment and Validation) Act, 2010	2010 (Amend in Amendments)	Conservation of Cultural and Historical Artefacts found in India.	No	The project route is not close to any Ancient Monument declared protected under the act. However, if any archaeological site is found during excavation the contractor will inform local and appropriate action will be taken.	Archaeological Dept. Gol, Dept. of Archaeology Govt. of Delhi	Contractor and its compliance shall be reported to PIU

8.	Notification for use of fly ash	2016 (Amend. thereof)	Promoting the utilization of fly ash in the manufacture of building materials and in construction activity within a specified radius of 300 kilometers from mid- or figure based thermal power plants	Yes	As per Notification and its amendments It is mandatory to use fly-ash in the construction of roads or flyover within a radius of 300km of a thermal power plant	SLSPCB,CC	Comments and its compliance shall be reported to MoEF
9.	The Explosives Act (& Rules)	1884 (And its Amendments)	An Act to regulate the manufacture, possession, use, sale, transport, import and export of Explosives	Yes	For transporting and storing diesel, kitchen etc	Delhi Pollution Control Committee	Comments and its compliance shall be reported to MoEF
10.	Public Liability Insurance Act	1991 (And its Amendments)	Insurance for the purpose of providing immediate relief to the persons affected by accident occurring while handling any	Yes	Employers is supposed to insure hazardous material like diesel, Bitumen, Explosives etc. safely	Delhi Pollution Control Committee	Comments and its compliance shall be reported to MoEF

			Hazardous substance and for matters connected therewith or incidental thereto				
11.	Coastal Regulation Zone	2011 (And its Amendments)	To regulate activities in the coastal zone to protect ecologically sensitive areas	Yes	The proposed project does not passes through CRZ area.	MoEF&CC	None
12.	Hazardous and Other Wastes (Management and Transboundary Movement) Rules	2016(And its Amendments)	Storage, handling, transportation and disposal of hazardous waste	Yes.	Storage and handling of hazardous waste during construction	Delhi Pollution Control Committee	Contractor and its compliance shall be recorded in ESMS
13.	Solid Waste Management Rules	2016 (And its Amendments)	Management and handling of solid waste	Yes	For disposal of solid waste generated during construction phase	Delhi Pollution Control Committee	Contractor and its compliance shall be recorded in ESMS
14.	Construction and Demolition Waste Management Rules	2016 (And its Amendments)	Management of construction and demolition waste	Yes.	For disposal of solid waste generated due to construction and demolition	Delhi Pollution Control Committee	Compliance with the said rule shall be recorded in ESMS
15.	Batteries (Management & Handling) Amendment Rules	2010 (And its Amendments)	Management and handling of used batteries	Yes	Safe disposal of used lead batteries.	Delhi Pollution Control Committee	Contractor and its compliance shall be recorded

							to NHAI
10.	E-Waste (Management) Rules	2016 (As per its Amendments)	Effective mechanism to regulate generation, collection, storage, transport, import, export, recycling, treatment and disposal of e-wastes.	Yes	Handling of e-waste	Delhi Pollution Control Committee	Contractor and its compliance shall be reported to NHAI
11.	Central Motor Vehicles Act	1988	To control vehicular air and noise pollution	Yes	The rule will be applicable to road users and construction machinery	Motor Vehicle Department	Contractor will take permission and compliance will be submitted to NHAI.
12.	Minor Minerals and concession Rules	1960	For Leasing new quarry	Yes	Requires use of minor minerals like stones, soil, river sand etc	District Collector	Contractor will take permission and compliance will be submitted to NHAI.
13.	The Mines Act	1952	The mining act has been notified for soils and sound mining activity.	Yes	The construction of proposed flyover will require aggregates. These will be procured through mining from quarries.	Directorate General of Mines Safety	Tenant will seek permission and implementation of the safety and its compliance

							assurance will be done by MMRC.
32.	The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act	2013	Set out rules for fair compensation and acquisition of land	No	This act is not applicable as the proposed tunnel is a underground tunnel.	Revenue Department State Government	None
33.	The National Highway Act	1956	For Land Acquisition	No	This act is not applicable as the proposed tunnel is a underground tunnel.	Revenue Department, Govt of Delhi	None

1.8 STRUCTURE OF THE REPORT

The report consists of ten Chapters and the content is briefly described in this section

Chapter 1: Introduction: This chapter contains the general information about the project, scope of the EIA/EMP study and the policies, legal and administrative framework and identification of the project proponent.

Chapter 2: Project Description: This chapter contains the description of the project, such as, the type of project, need for the project, project location, highway alignment, utilities, implementation schedule and the road side safety measures.

Chapter 3: Description of the Environment: The methodology for assessing various baseline environmental components in the study area prior to the commencement of the project has been identified in this chapter. The various parameters of present environmental status are identified under different aspects, which include location and regional setting of the area, topographical aspect which include land use, land cover and soil quality of the study area. Drainage aspect consists of surface and ground water quality. Meteorological aspect contains all the climatic factors and ambient air quality of the study area. Ecological environment describes the flora and fauna of the region. Human aspect includes the demography features, socio-economic environment and infrastructure facilities of the area.

Chapter 4: Anticipated Environmental Impact and Mitigation Measures: This chapter contains the anticipated impact on the environment and mitigation measures. The method of assessment of impact including studies carried out, modeling techniques adopted to assess the impact where pertinent shall be elaborated in this chapter. It gives the details of the impact on the baseline parameters, both during the construction and operational phases and mitigation measures to be implemented by the proponent.

Chapter 5: Analysis of Alternatives: This chapter contains the details of various alternatives in respect of both location of site and technologies to be deployed. Alternatives have been compared in terms of their potential environmental impacts, capital and recurrent costs, suitability under local conditions, and institutional training and monitoring requirements.

Chapter 6: Environmental Monitoring Program: This chapter covers the planned Environmental Monitoring Program. It includes the technical aspects of monitoring the effectiveness of mitigation measures and the cost for the Environmental Monitoring.

Chapter 7: Additional Studies: This chapter covers the details of the additional studies, required in addition to those specified in the approved ToR by MoEF&CC and which are necessary to cater to more specific issues applicable to the particular project.

Chapter 8: Project Benefits: This chapter covers the benefits accruing to the locality, neighborhood, region and nation as a whole. It brings out the details of benefits by way of improvement in the physical infrastructure, social infrastructure, employment potential and other tangible benefits..

Chapter 9: Environmental Management Plan: This chapter comprehensively presents the Environmental Management Plan (EMP), which includes the administrative and technical setup, summary matrix of EMP, green belt development plan, the cost involved to implement the EMP, both during the construction and operational phases.

Chapter 10: Summary of conclusion: This chapter briefs the EIA study outcome along with recommendation for the project.

Chapter 11: Disclosure of Consultants Engaged: This chapter should include the names of the consultants engaged and nature of consultancy rendered.

1.9 TOR APPROVED BY MoEF&CC AND ITS COMPLIANCE

The EIA/EMP report has been prepared in conformity with all issues brought out in the detailed ToR issued by MoEF&CC vide letter No. 10/6/2022-IA.111 dated. 25th March, 2022 and amendment in ToR which was issued vide letter no. F. No. 10/6/2022-IA.III dated 5th dec 2022. The copy of the approved ToR is attached as **Annexure-I(a)**. The brief issues involved and their compliance have been presented in **Table No. 1.4**.

Table 1.4: Compliance of ToR

Sr. No.	ToR Points	Reference of Compliance
A. Specific Conditions		
1	Fresh base line monitoring data should be collected for preparing EIA/EMP studies.	Monitoring has been done and its results being enumerated in Chapter 3rd.
2	A comprehensive hydrological and hydro geological investigation shall be conducted by a reputed institute for the site and should be incorporated in the EIA report.	For details, refer to Annexure **Annexure IV**
3	A comprehensive assessment of impact of seismicity on tunnel stability needs to be studied by a reputed institute and should be incorporated in the EIA report.	Seismic factors has been considered in the design, for details, refer to **Annexure V.**
4	Details regarding ventilation system envisaged for the tunnels need to be presented in the EIA report.	The details regarding Ventilation system are given in **Annexure VI.**
5	Detailed muck and dredge material disposal plan including specific earmarked locations be identified.	Detailed Muck disposal plan is attached in **Annexure-VII.**
6	Evacuation plans in case of fire, floods, earthquake etc. be carefully studied with models and explanations be presented as a part of the EIA report.	The VCPs at regular intervals of 750m has been considered for evacuation of vehicles downstream of fire. The VCPs are considered with fire doors and pressurized

		for safe evacuation
Green Belt/Tree cutting		
7	The alignment of road should be such that the cutting of trees is kept at bare Minimum and for this the proponent shall obtain permission from the competent authorities. Alignment also should be such that it will avoid cutting old and large and heritage trees if any. All such trees should be geo-tagged, photographed and details be submitted in the EIA / EMP report.	417 number of trees will be cut down for the proposed alignment, the prior permission will be taken from the competent authority. Girth Class, species, height on whether LHS OR RHS to be presented in **Annexure VIII.**
8	A comprehensive plan for plantation of three rows of native species, as per IRC guidelines, shall be provided in consultation with state forest department including the costs involved. Such plantation alongside of forest stretch will be over and above the compensatory afforestation. Tree species should be same as per the forest type.	4170 (ten times of total trees to be felled) shall be planted as compensatory plantation. A place of 4.17 ha land will be required for compensatory plantation of 4170 saplings. As informed by PIU Dwarka, the land is available for transplantation and compensatory afforestation at UER PKG-III of NH-344M in NCT of Delhi. The Proposed land 4.17 ha at UER PKG-III of NH-344M Plain shall be used for Transplantation / compensatory plantation regarding construction of NH 148AE. Cost provision should be made for regular maintenance of the trees planted. Details have been mentioned in Chapter 4 of the EIA report
Compliance of Circulars/Ors		
9	As per the Ministry's Office Memorandum F. No. 22-65/2017-IA.III dated 30th September, 2020, the project proponent, based on the commitments made during the public hearing, shall include all the activities required to be taken to fulfil these commitments in the Environment Management Plan along with cost estimates of these activities in addition to the activities proposed as per recommendations of EIA Studies and the same shall be submitted to the ministry as	The details EMP plan has been given in Chapter 9 for each intervention.

	part of the EIA Report. The EMP shall be implemented at the project cost or any other funding source available with the project proponent.	
10.	In pursuance of Ministry's OM is required to state in an additional annexure in the EIA report stating that all the commitments made by the PP to the public during public hearing and the same be submitted to the Ministry and the EAC.	Additional annexure in EIA will be complied and submitted as requested.
11.	The Action Plan on the compliance of the recommendations of the CAG as per Ministry's Circular No. J-11013/71/2018-IA. II(M), dated 25th October, 2017 needs to be submitted at the time of appraisal of the project and included in the EIA/EMP Report.	Action Plan is attached in **Annexure-IX**.
Rainwater Harvesting		
12.	Rain water harvesting structures to be constructed at the either side of the road with Special precaution of oil filters and de-silting chambers.	As the proposed project is an underground tunnel so there is no possibility of Rainwater Harvesting structures. However, Drainage Plan is proposed and attached in **Annexure X**.
B. GENERAL CONDITIONS		
Project Description and Design		
13.	A brief description of the project, project name, nature, size, its importance to the Region/state and the country shall be submitted.	The details have been shown in section 1.3 of Chapter 1.
14.	Details of any litigation(s) pending against the project and/or any directions or orders passed by any court of law/any statutory authority against the project to be detailed out.	There is no litigation(s) pending against the project and/or any directions or orders passed by any court of law/any statutory authority against the project.
15.	Bridge design in eco sensitive area mountains be examined keeping in view the rock classification hydrology etc.	As proposed project is an underground tunnel so there is no scope of Bridge as project alignment does not cross any water stream.
16.	Examine the road design standards, safety	All the details regarding Road safety are

	equipment specifications and Management System training to ensure that design details take account of safety. Concerns and submit the traffic management plan.	given in Chapter 2nd of the EIA report. The traffic Study has been attached as **Annexure XI**.
Forest/Green Belt		
17.	In case the project involves diversion of forests land, guidelines under OM dated 20.03.2013 shall be followed and necessary action be taken accordingly.	There is no diversion of Forest land involved in the project. Hence, it is not applicable. However, the project passes through the Ridge, the NOC from the Authority is attached in **Annexure-II**.
18.	The information shall be provided about the details of the trees to be cut including their species and whether it also involves any protected or endangered species. Measures taken to reduce the number of the trees to be removed should be explained in detail. The details of compensatory plantation shall be submitted. The possibilities of relocating the existing trees shall be explored.	Details of trees need to be cut for the project is mentioned in Chapter-4 of EIA/EMP report.
19.	Necessary green belt shall be provided on both sides of the highway with proper central verge and cost provision should be made for regular maintenance	Developing Green belt inside the tunnel is not possible. However, 4170 no. of trees will be planted against the no. of trees to be felled. 4.17 Ha land is available at UER PKG-III of NH-344M in NCT of Delhi. The Proposed land 4.17 ha at UER PKG-III of NH-344M Plain shall be used for Transplantation / compensatory plantation regarding construction of NH 148AE. Cost provision should be made for regular maintenance of the trees planted. Details have been mentioned in Chapter 4th of the EIA report
20.	Land use map of the study area to a scale of 1:25,000 based on recent satellite imagery delineating the crop lands (both single and double crop), agricultural plantations, fallow lands, waste lands,	The land use map of the study area of 1: 25,000 is shown in Figure 3.1 of Chapter-4.

	water bodies, built-up areas, forest area and other surface features such as railway tracks, ports, airports, roads, and major industries etc. along with detailed ground survey map on 1:2000 scale showing the existing features falling within the right of way namely trees, structures including archaeological & religious, monuments etc. if any, shall be submitted.	
21.	If the proposed route involves tunneling, the details of the tunnel and locations of tunneling with geological structural fraction should be provided. In case the road passes through a flood plain of a river, the details of micro-drainage, flood passages and information on flood periodicity at least of the last 50 years in the area shall be examined and submitted.	The proposed project is a tunnel project of 4.883 km length. The project does not pass through the flood plain area. The drainage design system report has been attached in **Annexure X**.
Project alignment passing through E SA/E SZ etc.		
22.	If the project is passing through/ located within the notified ecologically sensitive zone (ESZ) around a notified National Park/Wildlife Sanctuary or in the absence of notified ESZ, within 10 km from the boundary of notified National Park/Wildlife Sanctuary, the project proponent may simultaneously apply for the clearance for the standing committee of NBWL. The EC for such project would be subject to obtaining the clearance from the standing committee of NBWL.	The project does not pass through the National Wildlife Sanctuary/ESZ zone. The project although is passing through a notified ridge for which NOC has been obtained and attached as **Annexure II**.
Flora /Fauna		
23.	Study regarding the animal bypasses underpasses etc. across the habitation areas shall be carried out. Adequate cattle pass for the movement of agriculture material shall be provided at the stretches passing through habitation areas. Underpasses shall be provided for the	This point is not applicable as the proposed alignment is underground tunnel.

	movement of Wild animals.	
24.	Study regarding in line with the recent guidelines prepared by Wildlife Institute of India for linear infrastructure with strong emphasis on animal movement and identifying crossing areas and mitigation measures to avoid wildlife mortality.	Not Applicable. The project does not encounter any Animal Movement.
25.	If there is a possibility that the construction/widening of road may cause an impact such as destruction of forest, poaching or reduction in wetland areas, examine the impact and submit details.	Not applicable. It is an underground tunnel and does not trigger forest destruction or reduction in wetland areas.
Alignment		
26.	Detailed alignment plan, with details such as nature of terrain (plain, rolling, hilly), land use pattern, habitation, cropping pattern, forest area, environmentally sensitive areas, mangroves, notified industrial areas, sand dunes, sea, rivers, lakes, details of villages, tehsils, districts and states, latitude and longitude for important locations falling on the alignment by employing remote sensing techniques followed by "Ground truthing" and also through secondary data sources shall be submitted.	The alignment is passing through the plain area. However, land use pattern, habitation etc. everything has been given in chapter 3rd of the EIA report.
27.	Describe various alternatives considered, procedures and criteria adopted for selection of the final alternative with reasons.	Different alternatives are given chapter 3rd of the EIA report.
28.	If the proposed route is passing through a city or town, with houses and human habitation on either side of the road, the necessity for provision of bypasses/diversions/under passes shall be examined and submitted. The proposal should also indicate the location of wayside amenities, which should include petrol stations/service centers, rest areas	No private or public structures are affected by the proposed project.

	including public conveyance, etc.	
29.	Details about measures taken for the pedestrian safety and construction of underpasses and foot-over bridges along with flyovers and interchanges shall be submitted.	Not Applicable, as it is an underground tunnel.
30.	The possibility that the proposed project will adversely affect road traffic in the surrounding areas (e.g. by causing increases in traffic congestion and traffic accidents) shall be addressed.	The proposed project is completely green field project and has been proposed to reduce the traffic adversity. Approximately 200 trucks will be deployed for the transportation of construction material and muck disposal, which is being proposed in the night hours.
31.	If the proposed route is passing through any hilly area, the measures for ensuring stability of slopes and proposed measures to control soil erosion from embankment shall be examined and submitted.	Not Applicable. The proposed project is an underground tunnel.
32.	In case of river/cross crossing, details of the proposed bridges connecting on either banks, the design and traffic circulation at this junction with simulation studies.	No river is flowing within 10 km radius. However, river Yamuna is Approx 18km away in the East direction from the end point i.e. from Nelson Mandela Marg.
33.	If there will be any change in the drainage pattern after the proposed activity, details of changes shall be examined and submitted.	There will be no changes in the drainage pattern due to proposed activity as there is no river flowing within 10km radius of the project site. However, river Yamuna is Approx 18km away in East direction from the end point i.e. from Nelson Mandela Marg.
34.	In case of by passes, the details of access control from the nearby Habitation which may come up after the establishment of road.	No bypass is being proposed as the construction work will not take place during the peak hours.
35.	Details to ensure free flow of water in case the alignment passes through water bodies/rivers/streams etc.	The proposed alignment does not pass through any water body/River or stream.
Recycle/Reuse of Material		
36.	The details of use of fly ash in the road construction, if the project road is located	At the time of bidding, the NHAI shall integrate the provision of this notification

	within the 100 km from the Thermal Power Plant shall be examined and submitted.	and ensure its compliance.
37.	The possibilities of utilizing debris/waste materials available in and around the project area shall be explored.	Based on requirement of the construction materials, approx. 46% quantity of rock muck (3,94,752 cum) and 19% quantity of soil muck (1,91,407 cum) has been planned to be reused in the construction of this project. Remaining 54% quantity of rock muck (4,70,755 cum) and 81% of soil quantity (8,19,648 cum) would need to be shifted to another Project site of NHAI (Connector Corridor from Delhi Meerut Ex-way.
38.	The details on compliance with respect to Research Track Notification of Ministry of Road, Transport and Highways shall be submitted.	Compliance report will be submitted.
39.	The details of sand quarry and borrow area as per OM No.J-30/2012-IA-III dated 18.12.2012 on 'Rationalization of procedure for Environmental Clearance for Highway Projects involving borrow areas for soil and earth" as modified vide OM of even No. dated 15th March 2013, shall be examined and submitted.	The total quantity of muck that will be generated is estimated to be 18,66,047 cum. Based on requirement of construction materials, approx. 46% quantity of rock muck (3,94,752 cum) and 19% quantity of soil muck (1,91,407 cum) has been planned to be reused in the construction of this project. The remaining 54% quantity of rock muck (4,70,755 cum) and 81% of soil quantity (8,19,648 cum) would need to be shifted to another project site of NHAI (Connector Corridor from Delhi Meerut Expressway).
Data Collection		
40.	Climate and meteorology (max and min temperature, relative humidity, rainfall, frequency of tropical cyclones and snow fall); the nearest IMD meteorological station from which climatological data have been obtained to be indicated.	The detail has been given in Chapter 4 and wind rose diagram in Fig.3.2
41.	The water bodies including the seasonal ones within the corridor of impacts along	No seasonal or perennial river has been found flowing within the corridor of impact.

	with their status, volumetric capacity, quality and likely impacts on them due to the project along with the mitigation measures shall be examined and submitted.	
42.	The details of water quantity required and source of water including water requirement during the construction stage with supporting data and classification of ground water based on the CGWA classification, shall be Examined and submitted.	The total water requirement for proposed project is around 420 KLD. The break of water requirement is given below; 300 KLD TBM operations and other construction Road making :20KLD Dust Suppression: 50KLD Others (including drinking water and domestic Purposes): 50KLD Total 420 KLD +15% extra = 483KLD. Excluding drinking water, the water will be procured from nearby STP via water tankers and the drinking will be procured from ground water or Municipality with prior permission from the competent authority.
43.	Accident data and geographic distribution shall be reviewed and analyzed to predict and identify trends - in case of expansion of the existing highway and provide Post accident emergency assistance and medical care to accident victims.	Proposed project is a new greenfield tunnel. One no. of ambulance and toe vehicle at entry and exit will be deployed. The contractor will take care of the emergency assistance in construction phase and its compliance will be submitted by NHAI.
Pollution Control		
44.	The air quality monitoring shall be carried out as per the notification issued on 16th November, 2009. Input data used for Noise and Air quality modeling shall be Clearly delineated.	The monitoring has been done and the results are given in Chapter 4 of the EIA report.
45.	The project activities during construction and operation phases, which will affect the noise levels and the potential for increased noise resulting from this project, shall be identified. Discuss the effect of noise levels on nearby habitations during the construction and operational phases of the proposed highway. Identify noise reduction	Noise monitoring has been done and the results for the same are given in Chapter 3rd of the EIA. The mitigation measures are given Chapter 5.

	measures and traffic management strategies to be deployed for reducing the negative impact if any. Prediction of noise levels shall be done by using mathematical modeling at different representative locations.	
46.	The impact during construction activities due to generation of fugitive dust from crusher units, air emissions from hot mix plants and vehicles used for transportation of materials and prediction of impact on ambient air quality using appropriate mathematical model, description of model, input requirement and reference of derivation, distribution of major pollutants and presentation in tabular form for easy interpretation shall be examined and carried out.	The prediction of impact on ambient air quality has been done and the mitigation measures have been given in Chapter 5 of the EIA report.
47.	The details about the protection to existing habitations from dust, noise, odour etc. during construction stage shall be examined and submitted.	The details about the protection of flora and Fauna are also mentioned in chapter 5th of the EIA report.
48.	If the proposed route involves cutting of earth, the details of area to be cut, depth of cut, locations, soil type, volume and quantity of earth and other materials to be removed with location of disposal/ dump sites along with necessary permission	The Muck Disposal Plan is attached in **Annexure-VII**
49.	If the proposed route is passing through low lying areas, details of filling materials and initial and final levels after filling above MSL shall be examined and submitted.	The proposed project does not pass-through low-lying areas and hence this is not applicable.
Safety		
50.	The details of measures taken during construction of bridges across rivers/ canals/major or minor drains keeping in view the flooding of the rivers and the life span of the existing bridges shall be examined and submitted. Provision of	Not applicable as the proposed tunnel does not involve bridges across rivers/ canals/major or minor drains.

	speed breakers, safety signals, service lanes and foot paths shall be examined at appropriate locations throughout the proposed road to avoid accidents.	
51.	The details of road safety, signage, service roads, vehicular under passes, accident prone zones and the mitigation measures, shall be submitted.	The details are mentioned in Chapter 2 & Chapter-5.
52.	IRC guidelines shall be followed for widening & up-gradation of roads.	To be complied
53.	Details of blasting if any, methodology/technique adopted, applicable regulations/permissions, timing of blasting, mitigation measures proposed keeping in view mating season of wildlife.	The excavation of twin tunnels will be carried out through Tunnel Boring Machine (TBM) instead of Blasting.
Other Details		
54.	Rain water harvesting pit shall be at least 3 - 5 m above the highest ground water table. Provisions shall be made for oil and grease removal from surface runoff.	Rainwater harvesting is not being proposed.
55.	The details of social impact assessment due to the proposed construction of the road shall be submitted.	As no structures are getting impacted due the alignment, hence there is no such impact on the social environment although the details are given in Chapter 4 of the EIA.
56.	If the proposed project involves any land reclamation, details shall be provided of the activity for which land is to be reclaimed and the area of land to be reclaimed.	Since the project is an underground tunnel, no land reclamation is applicable. .
57.	Details of the properties, houses, business activities etc. likely to be affected by land acquisition and an estimation of their financial losses, shall be submitted	Not Applicable. The proposed project does not involve any private land acquisition.
58.	Detailed R&R plan with data on the existing socio-economic status of the population in the study area and broad plan for resettlement of the displaced population, site for the resettlement colony, alternative	R&R is not applicable as no structures or people are being displaced.

	livelihood concerns/ employment and rehabilitation of the displaced people, civil and housing amenities being offered, etc and the schedule of the implementation of the specific Project, shall be submitted.	
59.	The environment management and monitoring plan for construction and operation phases of the project shall be submitted. A copy of your corporate policy on environment management and sustainable development shall also be submitted.	Environment monitoring plan has been given in Chapter 9 of the EIA report.
60.	Estimated cost of the project including that of environment management plan (both capital and recurring) and source of funding. Also, the mode of execution of the project, viz. EPC, BOT, etc. shall be submitted.	Project Cost is given in Chapter-2 and EMP cost is given in Chapter-9 of EIA/EMP report.
61.	Details of litigation pending against the project, if any, with direction/order passed by any Court of Law against the Project should be given.	There is no litigation pending against the project.
62.	The cost of the Project (capital cost and recurring cost) as well as the cost towards implementation of EMP should be clearly spelt out.	Project Cost is given in Chapter-2 and EMP cost is given in Chapter-9 of EIA/EMP report.
63.	Any further clarification on carrying out the above studies including anticipated impacts due to the project and mitigative measure, project proponent can refer to the model ToR available on Ministry website "http://moef.nic.in/ManualHighways".	The ToR available on website will be used in case of any clarification required.

CHAPTER-2: PROJECT DESCRIPTION

2.1 INTRODUCTION

The Ministry of Road Transport and Highways (MoRTH), a Ministry of the Government of India, is the apex body for formulation and administration of the rules, regulations and laws relating to road transport and transport research, in order to increase the mobility and efficiency of the road transport system in India.

The Ministry of Road Transport and Highways (MoRTH) / National Highways Authority of India (NHAI) have decided to develop Economic Corridors, Inter Corridors, Feeder Routes and Coastal Road primarily to improve the efficiency of freight movement in India under. The main objective of the proposed project is to reduce the distance and travel time in Delhi state and more efficient traffic dispersal surrounding NCT Delhi region.

The National Highways Authority of India has been assigned the work of "Construction of a road tunnel for NH-148E with its approach and connection to NH-248BB in NCT of Delhi."

2.2 PROJECT LOCATION

The project road starts from Shiv murti Interchange (Dwarka Expressway Package-1) to Nelson Mandela Marg. A Bypass to Rangpuri will connect Dwarka Expressway with Vasant Kunj through Nelson Mandela Marg. It has been proposed to extend the existing Nelson Mandela Marg via a tunnel towards Gurgaon/ Dwarka with an interchange near Shiv Murti to connect NH-8 and Dwarka Expressway. The entire alignment is green field till Nelson Mandela Marg. An Index Map of the Project corridor is shown in Figure 2.1 Index map



Figure 2-1: Location Google map of Project Corridor

The initial stretch of the alignment is passing beneath the Rangpuri Farmhouse area after that the alignment passes through the Rangpuri Forest and Vasant Kunj farm houses till Nelson Mandela Marg. The Project falls under category 'A' as per the MoEF&CC Notification dated Sep. 14, 2006 and its subsequent amendments.

2.3 NEED OF THE PROJECT & BRIEF ABOUT THE PROJECT

2.3.1 Need of the Project

The purpose of the project is to provide connectivity directly from Delhi- Gurgaon Expressway (NH 248BB and NH-48) to Nelson Mandela Road by way of an underground road tunnel (NH 148NE). Traffic congestion/ traffic jam takes place at Delhi- Gurgaon Expressway near Mahipalpuri Rangpuri etc. and such type of situations cause significant delay to commuters and creates local pollution due to slow-moving traffic. Widening along this route is almost difficult due to heavy settlement, and therefore, implementation of the proposed project will create a shorter distance route reducing the travel time, and hence, resolve traffic congestions problem at the aforesaid places. In addition, it will improve local ambient air quality and reduction in carbon footprints during entire life cycle of the project. The junctions with existing road will be planned in the form of interchanges and flyover to ensure uninterrupted flow of traffic. Further the availability of 6 lane road at Nelson Mandela Marg meets the design configuration of tunnel that has also been proposed a 6 lane tunnel. Traffic flow would be easy without any major hassles.

The proposed road would act as the prime artery for the economic flow to this region. It will enhance economic development, provide employment opportunities to locals, ensure road safety, and provide better transportation facilities. Vehicle operating cost will also be reduced due to improved road quality and shorter distance. The compensatory plantation shall further improve the air quality of the region. The salient features of the proposed project have been presented in **Table No. 2.1**

Table 2.1: Salient features of the proposed project

1.	Project Name	Construction of a road tunnel for NH-148E with its approach and connection to NH-248BB in NCT of Delhi
2.	Total Length of the Proposed Project Road	**Total Project Length: - 4.992 Km.** 1. Tunnel Length: - 4.306 Km. 2. Approach Ramp: - 0.004 Km. 3. At Grade: - 0.074 Km. 4. New Proposed Flyover 0.668 Km.
3.	State	NCT of Delhi
4.	District	Two District involve in from NCT of Delhi i.e. New Delhi & South Delhi
5.	Village	Samalka, Rangpuri, Rajokari, Masoodpur from New Delhi District and Mehrauli from South Delhi District
6.	Terrain	Plain & Rolling

7.	Geographical Location	Start 28°31'55.31"N, 77° 06'27.34"E End 28°31'44.78"N, 77° 8'53.25"E
8.	Start Point	NH-8 Near Shivmurti Interchange
9.	End Point	Nelson Mandela Marg Vasant Kunj
10.	Seismic Zone	Zone IV
11.	Land Use	Southern Ridge / Built up
12.	Existing RoW (ERoW)	0-45m
13.	Proposed RoW (PRoW)	30-45m
14.	Status of Land Acquisition	Land Acquisition would not be required due to the project is an underground Tunnel
15.	Status of Forest	Reserved Forest = 7.5145 Ha. Southern Ridge area = 5.8257 Ha. Deemed Forest area = 1.6888 Ha.
16.	Carriageway	10.5 m (3.5m + 3.5m + 3.5m)
17.	Vehicle Cross passage (VCP)	8 Nos (Every 500 m in Tunnel)
18.	Lay Bye	2 Nos. (Ch. 1+400 and 2+900)
19.	Elevated Flyover	1 Nos.
20.	Toll Plaza	1 Nos. (Ch. 4+500 at Nelson Mandela Marg)
21.	Construction Period	60 months
22.	Employment Likely to be Generated	400-450
23.	Total Civil Cost	3426.38 Cr
24.	Total Capital Project Cost (including Civil, Utility Shifting and Forest, Environment)	4085.09 Cr.

2.3.2 Pavement Design

Pavement is the most significant component of a road and therefore its design strengths must be assured to support the projected traffic loading throughout the design period. In the Pavement study 3 options were studied;

- New flexible pavement on the widening part and for full reconstruction stretches
- Flexible overlay over the existing pavement
- Flexible Pavement for partial reconstruction stretches of existing pavement. Flexible pavement with rigid base.

The different pavement design methods for above pavement options shall be studied and applied, which are given in table below:

Table 2-2: Pavement design Method

Pavement option	Option type	Design Method
1	New Flexible Pavement	IRC: 37-2012
2	Flexible Overlay	IRC: 81-1997
3	New Rigid Pavement	IRC: 58-2015

Recommendation:

After the detailed study it was recommended that rigid pavements should be used only for tunnel and approach ramps stretches, and the flexible pavement shall be provided in at-grade stretches.

2.3.3 Right of Way (ROW)

The desirable Right of Way is kept as given in table below, as prescribed in IRC: 73 & IRC: 86 road are given in Table 2-3 below:

Table 2.3: Desirable Road Land Widths (meters)(ROW)

Cross slope of the country (%)	Plain and Rolling Terrain	
	Open Areas	
	Normal	Exceptional
National Highways	60	45

Proposed right of way has been ascertained by the client based on the portal locations and minimum formation width required.

2.3.4 Lane Width of Carriageway

The standard lane width of the Project Highway is 3.5 m as per IRC: SP: 87-2019 & IRC: 73-2018 (cl.2.4).

2.3.5 Shoulders

The shoulder width is as per IRC SP 73 2018 is given in table 2-4 below, subjected to availability of land.

Table 2.4: Width of Shoulder

Type of Section	Urban Area			
		Paved	Earthen	Total
Built up area and approaches to grade separated structures	Nelson Mandela Marg	-	-	-

2.3.6 Traffic Control, Road Marking, Traffic Signs and Safety Measures

Indian Road Congress (IRC) codes are followed in proposing and designing road safety features. Pavement markings are done for traffic lane line, edge lines and hatching. The marking shall be with hot applied thermoplastics materials. The pavement markings shall be reinforced with raised RR pavement markers and shall be provided for median and shoulder edge longitudinal lines and hatch markings. Highway lightings including high masts shall be provided at intersections in order to improve the nighttime visibility. All the urban locations as well grade separated structure locations shall be provided lighting arrangements.

2.3.7 Proposal for Wayside Amenities cum Rest Area

As the proposed project is of underground tunnel of 4.983 km will have no facility for Wayside Amenities and rest area except two bye lane in each tunnel at Ch 1+400 & Ch 2+900 both sides.

2.3.8 Toll Plazas

Toll Plaza is proposed at the End Point of the tunnel Ch. 4+900.

2.3.9 Standards and Specifications Adopted

Geometric design standards will be adopted keeping the above in view. The project road lies in mountainous and steep terrain. The geometric design will be mainly prepared based on IRC: SP:87-2019 besides adopting relevant standards from IRC SP:23 - Vertical Curves for Highways, IRC:73-Geometric Design Standard of Rural (Non-Urban) Highway.

Ministry of Shipping, Road Transport & Highways, Government of India prepared "**Manual of Specifications and Standards for Six Laning of National Highways through Public Private Partnership**" (IRC:SP:87-2019) shall be used as main guidelines along with other relevant IRC codes. For parameters where there are no IRC standards, recommendations have been made on the basis of MoRTH circulars and International Standards.

Apart from above, following shall be used:

- IRC:35-2015- Code of Practice for Road Markings (Second Revision)
- IRC:67-2012- Code of Practice for Road Signs (Third Revision)
- IRC:79-1981- Recommended Practice for Road delineators
- IRC:93-1985- Guidelines on Design and Installation of Road Traffic Signals
- IRC: SP:37-2018- Guidelines for Evaluation of Load Carrying Capacity of Bridges (First Revision)
- IRC:37-2012- Guidelines for the Design of Flexible Pavements
- IRC:102-1988- Traffic Studies for Planning Bypasses Around Towns

- IRC:81-1997- Guidelines for Strengthening of Flexible Road Pavements Using Benkelman Beam Deflection Technique (First Revision)
- IRC:56-2011- Recommended Practices for Treatment of Embankment and Roadside Slopes for Erosion Control (First Revision)
- IRC:106-1990- Guidelines for Capacity of Urban Roads in Plain Areas
- IRC:38: 1988- Guidelines for Design of Horizontal Curves for Highways and Design Tables (First Revision)
- IRC: SP:23-1983- Vertical Curves for Highways

2.2.10 Geometric Design Standards for 6-lane Expressway

a. General

The design of the road geometry for the assigned project shall cover the following main principles, which form the basis of desirable standard of highway design.

- Road safety and the smooth flow of traffic are of prime concern in the design. The selection of optimum design standards reduces the possibility of undesirability of the facility to be provided.
- Both horizontal and vertical geometry shall be accorded due importance as per selected standards. It shall not be compromised unless it becomes formidable to accept for the particular situation.
- Consistent Design shall be adopted and abrupt changes in the design speed to be avoided.
- The proposed design will minimise the total transportation cost, including initial construction costs, costs for the maintenance of the facility and the costs borne by the road users.

"Ruling" standards are **adopted and "Minimum" standards** are allowed only where serious restrictions are imposed by technical or economic considerations.

b. Warrant for 6 Lane Expressway

Capacity analysis for the project corridor is carried out to assess the Level of Service (LOS) offered by road sections under prevailing roadway and traffic conditions.

Capacity and design service volumes for various lane configurations specified in the Manual and Specifications for Four Laning of Highways through PPP (IRC: SP: 84-2019) by Indian Roads Congress, the warrants for widening as two-lane highways, and design service volumes for two lane and four lane highways with paved shoulders, have been compiled in **Table No. 2.6**.

Table 2.6: Capacity and Design Service Volume

	Flow Rate (pc/h/ln)				
	LOS A	LOS B	LOS C	LOS D	LOS E
Capacity/lane	550	875	1,275	1,740	2,250
Road Capacity (Hourly)	3,300	5,250	7,650	10,440	13,500
Road Capacity (Daily)	79,200	126,000	183,600	250,560	324,000

2.3.11 Conclusion

The lane requirement analysis finds the proposed 6-lane tunnel configuration with standards and highlights potential points of capacity stress. The Level of Service (LOS) capacity check, considering various categories and an 80 km/h design speed, thoroughly evaluated the tunnel's capacity. Additionally, assessing a 10% increase in peak-hour volume for each year provided valuable insights into the tunnel's resilience.

2.4 LAND REQUIREMENT FOR THE PROPOSED PROJECT

Total length of the proposed alignment is approx. 4983 m and proposed Right of Way (RoW) of the project varies from 30-45 m.

The land acquisition would not be required as the proposed project is underground tunnel.

2.5 WATER REQUIREMENT FOR THE PROPOSED PROJECT

The peak water requirement for the project will be 483 KLD during the construction stage. Water requirement for construction will be meet from nearest STP and for drinking purpose it will meet through tankers. These all are arrange by the contactor. The breakup of the water requirement has been presented in **Table No. 2.8**.

Table 2.8: Water requirement for the Project

Purpose	Peak (KLD)	Source
TBM Operation & Other Construction	300	In Contractor Scope
Road Making Local Surface/Ground Water	20	
Dust Suppression	50	
Others (including drinking and domestic purposes)	50	
Total	**420+16% Extra = 483 KLD**	

2.6 TRAFFIC SURVEY AND ANALYSIS

2.6.1 Introduction

To capture and assess the traffic characteristics and travel pattern, the consultants have conducted the following primary traffic surveys.

- Classified Traffic Volume Count Surveys
- Origin - Destination and Commodity Movement Surveys

These features facilitated a framework for carrying out the necessary count surveys in accordance with the guidelines specified in IRC codes of practice. The various survey locations have been selected with careful assessment of the traffic of competing road of project.

2.6.2 Objectives of Traffic Surveys

The primary objective of these traffic studies is:

a. To determine characteristics of traffic movement and to establish base year traffic demand.

b. To identify the zone of influence for the project stretch and extent of influence based on O-D survey.

c. To determine the travel pattern of goods and passenger vehicles

d. For capacity assessment

e. To determine the percentage of right turning traffic at road intersections as a guide to the intensity of vehicle – vehicle conflict

f. To determine vehicle damage factor

g. For toll revenue analysis.

2.6.3 Methodology of Traffic Surveys

The methodology employed for this analysis follows a systematic approach to ensure a thorough understanding of the traffic dynamics and capacity considerations for the proposed tunnel. Initial steps involve the identification of major traffic flows and the calculation of diverted traffic percentages based on the travel time ratio. Subsequently, a detailed forecast of tunnel traffic is conducted, considering vehicle type data from traffic count surveys. The analysis then shifts to the evaluation of required lane numbers and the verification of the proposed tunnel's compliance with Level of Service (LOS)B and C capacity standards. The following points provide a succinct breakdown of the key steps taken in this comprehensive methodology.



Figure 2-2: Traffic Survey Location map

The detailed traffic study to assess inflow of traffic from adjoining National Highways/ State Highways including detailed traffic planning studies have been attached as **Annexure-XI**

2.7 TRAFFIC MANAGEMENT PLAN

The overall traffic management plan is designed and intended to specify adequate safety measures in advance against identified hazards and stipulated implementation of the said safety measures to ensure safe movement of traffic during the construction operations of tunnel. The objective of safety standards is to provide safe travel to the drivers of vehicles plying on the tunnel at all times of the day, throughout the year and provide protection to the Project workers when they are at work. This overall

traffic management plan delineates the safety standards in terms of Construction zones, Signs and Safety measures in work zones and during normal operations.

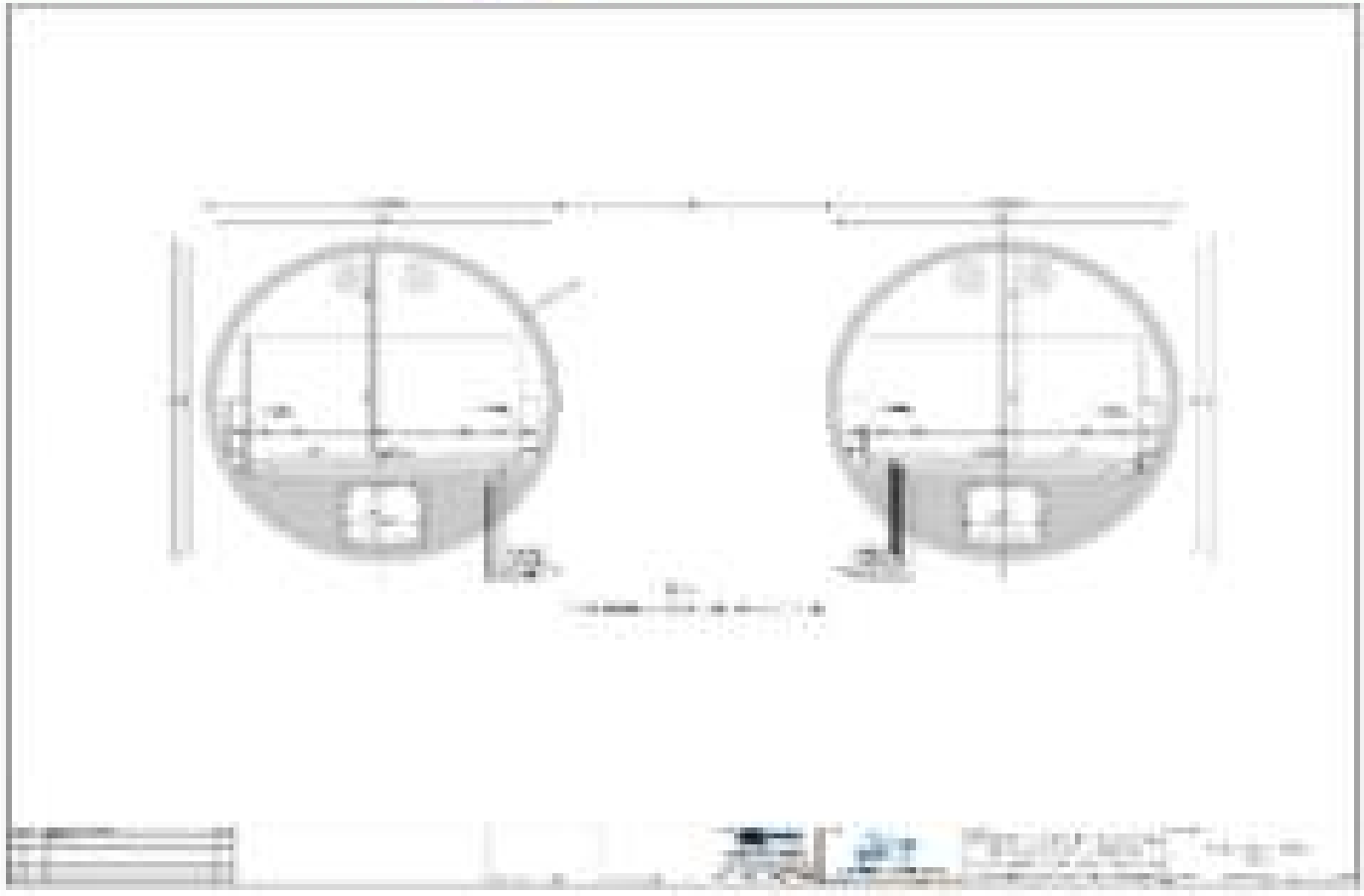
Traffic Control Devices, Road Safety Devices and Roadside Furniture shall comprise of road signs, road markings, object markers, hazard markers, studs, delineators, attenuators, safety barriers, boundary fences, boundary stones, kilometer stones, etc. Guidelines given in (IRC 25, IRC:8, IRC :26, IRC:35, IRC:67, IRC:79, IRC:103, IRC:119 IRC SP 87 and Section 800 of MORTH Specifications shall be used for providing these items unless otherwise specified in this Section.

2.8 DETAILS OF THE STRUCTURES PROPOSED ALONG THE PROPOSED ALIGNMENT

As the proposed project is of tunnel no structure such as VUP, SVUP, LVUP, Bridges except a flyover which is proposed after End of tunnel.

2.8.1 TYPICAL CROSS SECTION

Cross-section requirements for tunnel vary according to the capacity and level of service to be provided. Universal standards in the design of roadways are not practical. Each roadway section must be individually analyzed, and its cross section determined based on the volume and type of projected traffic, capacity, desired level of service, and available right-of-way. These cross sections are typical for facilities in a new location and where right-of-way constraints are not critical. A sample of typical Cross section (TCS) of six lane tunnel is given in **Figure 2-3 & Figure 2-4** and further details are attached as **Annexure XII**.



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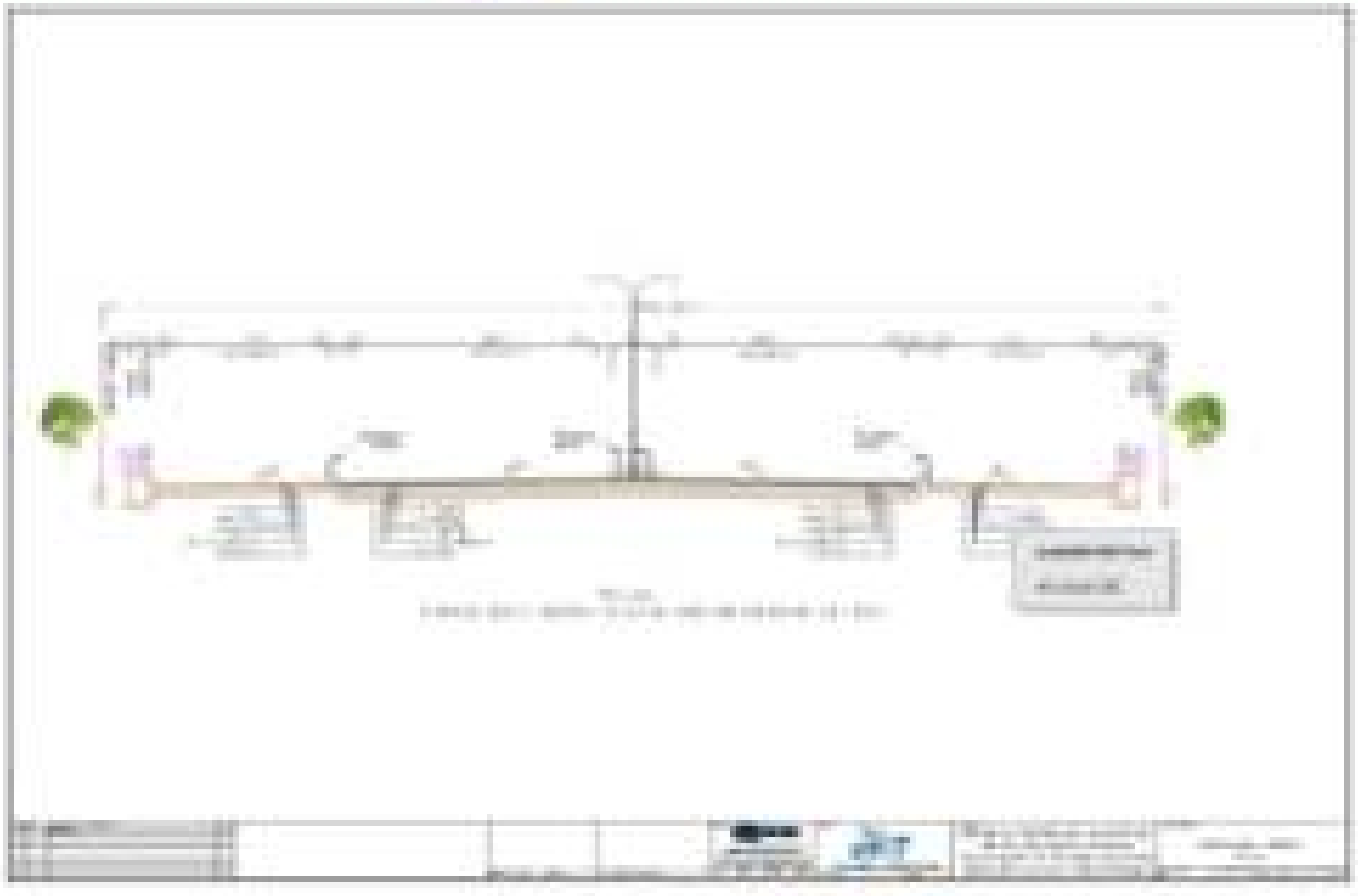


Figure 3.4: Typical Cross Section for Loop with Service Road

2.9 TUNNELING BOARING MACHINES (TBMS)

The proposed tunnel construction will be performed by Tunnel Boring Machines (TBMs), which are nowadays are full-face, rotational (with cutter heads) excavation machines that can be generally classified into two general categories: Gripper and Segment (refer figure below). There are three general types of TBMs suitable for rock tunnelling including Open Gripper/Main Beam, Closed Gripper/Shield, and Closed Segment Shield, as shown within the dashed box on the Figure.

The closed shield type of TBMs for most rock tunnelling applications are suitable for friable to unstable rocks which cannot provide consistent support to the gripper pressure. The closed shield type of TBMs can either be advanced by pushing against segment, or gripper. Note that although these machines are classified as a closed type of machine, they are not pressurized at the face of the machine thus cannot handle high external groundwater pressure or water inflows. Shielded TBMs for rock tunnelling include Single Shield, Double Shield and Gripper Shield.

Pressurized-face Closed Shield TBMs are predominantly utilized in tunnelling in soft ground and unstable ground or in urban environment where stability of face and ground settlements control are must. A detailed study about the TBM is attached as **Annexure XIII.**

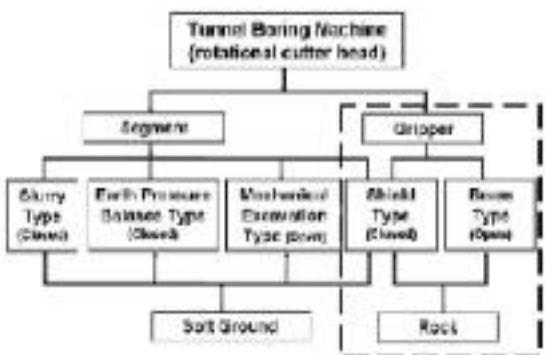


Figure 2-5: Classification of tunnel boring machines (TBMs) (Source: FHWA)

2.9.1 Selection of Tunnel Methodology

Though tunnel through TBM is quite expensive as compared to the traditional Drill and Blast method, tunnelling through TBM brings vast range of merits over the latter. Tunnelling through TBM (See Figure 2-5) significantly reduces the potential environmental impacts in terms of noise, ground vibration, and dust generation including less impact on local traffic movement and generation of C & D wastes.

In addition to above the impact of vibrations over the ground caused due to tunnelling with TBM is quite negligible with respect to blasting technique and bears no impact to the ecology over the ground.

An assessment on the vibration induced by tunnel boring machine in urban areas with an in situ measurements and the respective analysis of the measurements was published in Journal of Rock Mechanics and Geotechnical Engineering. It was evident in the research paper that the amplitude of the velocities measured in the TBMs is of the order of 0.1 mm/s in clay soils, 1 mm/s in sand and gravel, and 10 mm/s in rocky soils. On the ground surface, the particle velocities between 10 m and 30 m in front of the cutting face are about 10 times lower than those inside the TBM (Refer Figure 5 2). The high contrast between velocities measured inside the TBM and on the surface reveals that only a part of the energy measured inside the TBM is transmitted to the ground. 80% of the energy of the vibration signals in the TBMs is in the range 0–40 Hz.

The selection of TBM shall be done after the Pre-Construction activities or before start of construction and will be done by the contractor by considering topographic and geotechnical study of the project area under the supervision of Tunnel specialist and Authorities.

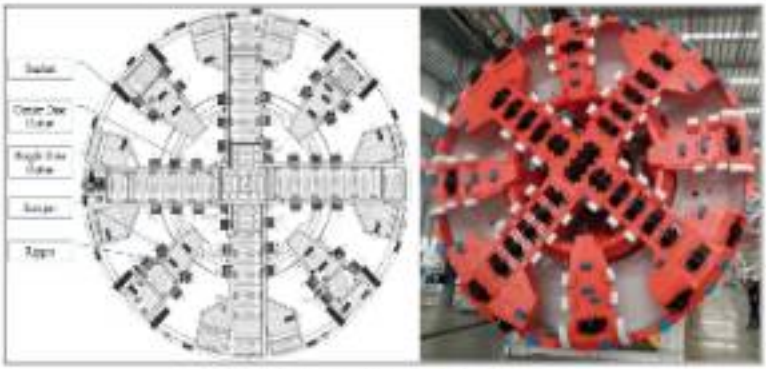


Figure 2-6: Tunnel Boring Machine Cutter heads

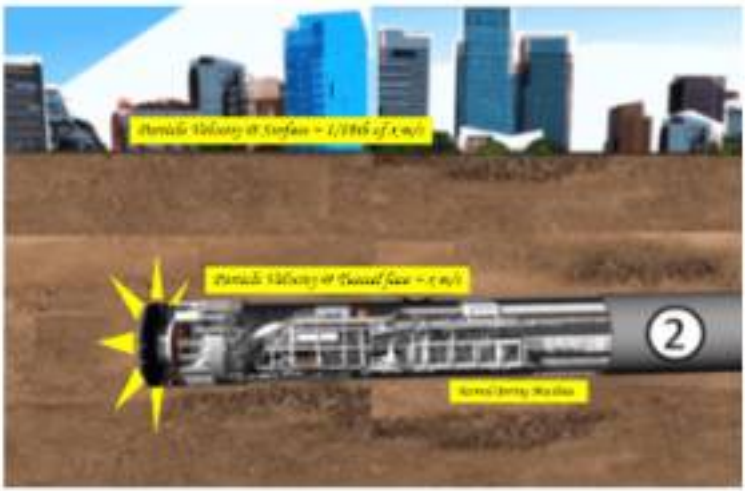


Figure 2-7: Vibrations impact of TBM at Surface and at Face

2.9.2 Steps involved in TBM Tunneling

Following are the steps involved in the TBM tunnelling process:

- Lower main body, cutting head, segment erector, screw conveyor, tail shield, thrust frame
- Assemble TBM
- Erection of reaction frame
- Connection of hose and cables
- Installation of temporary segments
- Initial drive
- Completion of initial drive
- Modification of TBM including removal of reaction frame, cradle and temp rings, laying rail
- Main drive
- Break through soft eye (reach receiving shaft)
- Dismantle TBM

2.10 COMPARISION BETWEEN TBM TUNNEL DRILL AND BLAST METHOD

I. Efficiency and Speed

When it comes to speed and efficiency, TBMs have a clear advantage over the Drill and Blast method. TBMs can excavate at a constant rate, while the Drill and Blast method's progress depends on the effectiveness of the drilling and blasting process, which can be subject to variations in rock conditions.

ii. Safety and Environmental Impact:

TBMs offer a safer working environment for tunnelling crews since most of the excavation takes place within the TBM itself. In contrast, the Drill and Blast method involves more hazardous activities related to drilling and explosives handling. Additionally, the Drill and Blast method may cause more surface disturbances and vibrations, potentially affecting nearby structures and the environment.

iii. Geotechnical Conditions:

The choice between TBM tunnelling and the Drill and Blast method often depends on the geotechnical conditions of the project site. TBMs work best in stable rock formations, while the Drill and Blast method can be more adaptable to varying geological conditions.

iv. Project Size and Budget:

The size of the tunnelling project and budget considerations play a crucial role in the selection of the tunnelling method. TBMs are better suited for long tunnels with a consistent cross-section, as the initial investment in a TBM may be significant. For shorter tunnels or projects with budget constraints, the Drill and Blast method can be a cost-effective solution.

2.11 PROJECT IMPLEMENTATION SCHEDULE

The construction of the project shall be completed in 5 years from the date of start of construction including pre-construction activity and civil work.

2.12 COST ESTIMATES

The total Capital cost of project is approx. **Rs 4089.09 Crore**. The breakup of project cost is given **Table 2.7**

Table 2.7: Summary of Cost

Sl. No.	DESCRIPTION	Amount
1.	Site Clearance and Dismantling	1,22,863
2.	Earth Work	6,58,56,675
3.	SUB-BASE, BASE-COURSES for Tunnel	4,62,25,466
4.	Pavement Courses	22,77,92,484
5.	Tunnel Cost (including Vcp+Mep)	28,05,90,66,600
6.	TUNNEL APPROACH (RAMP)	98,15,08,262
7.	DRAINAGE	12,89,27,175
8.	ROAD FURNISHINGS	4,93,12,992
9.	TWO LANE FLYOVER WITH RAMP	19,00,56,942
10.	SERVICE ROAD BOTH SIDE & MISCELLANEOUS	6,53,13,423
11.	**BASE CONSTRUCTION COST (A)**	29,81,52,60,883
	Utility Amount (B)	75,00,00,000

12.	**Total Civil Construction Cost with Utility Amount (C)**	30,56,62,60,883
13.	Add GST of over Civil Construction Cost (A) @12%	3,67,79,51,306
	Add GST over Utility Cost (B) @ 12%	9,00,00,000
	Add Labour Cess 1% over Utility Cost + Supervision Charges 2.5% and 18% GST over Supervision charges	2,96,25,000
14.	**Total Civil Construction Cost as on Bid due date (D)**	34,26,38,37,188
	COST PER KM (Rs in Crores)	687.61
15.	Contingencies @ 1% of (A)	29,81,62,609
16.	Construction Supervision charges @ 3% of (A)	89,44,87,826
17.	Escalation @ 5% of (D) per annum for 2nd to 5th years' (Construction Period 5 Year)	3,56,81,69,016
a	Escalation @ 0% of (D) per annum for 15% of Civil Construction Cost	-
b	Escalation @ 5% of (D) per annum for 20% of Civil Construction Cost	25,10,68,267
c	Escalation @ 10% of (D) per annum for 25% of Civil Construction Cost	68,16,53,367
d	Escalation @ 15% of (D) per annum for 20% of Civil Construction Cost	1,28,48,03,800
e	Escalation @ 20% of (D) per annum for 20% of Civil Construction Cost	1,37,05,53,488
18.	Maintenance charges @ 0.25% Yearly for 5 Year and 0.5% Yearly for next 5 Year of (C)	1,14,62,54,783
19.	**Total Estimated Project Cost**	40,19,08,91,423
20.	**Pre-Construction Activities** (A) Environmental Measures etc.	70,00,00,000
21.	**Total Pre-Construction Activities**	**70,00,00,000**
22.	Total Capital Cost (Estimated Project Cost + Cost of Pre-Construction Activities)	40,89,08,91,423
	COST PER KM (Rs in Crores)	**820.61**
	TOTAL LENGTH (Kms)	**4.983 KM**

2.13 GEOTECHNICAL INVESTIGATIONS

Geotechnical investigations have been carried at proposed tunnel locations to explore sub surface conditions by drilling boreholes to different depths to identify the thickness and sequences of various strata and to ascertain the subsurface profile of soil sand bed rock to determine the most suitable foundation level of structures.

The technical details as interpreted have been given in **Annexure V.**

2.14 HYDRAULIC AND HYDROLOGICAL INVESTIGATIONS

As per the drill hole data, there is no groundwater encountered up to the tunnel invert. Therefore, there is no impact of ground water on the tunnel.

Further, the drilling was carried out between Feb 2021 to Apr 2021 and no groundwater was encountered. Non-occurrence of groundwater up to a depth of 40m (drilling depth) may be due to the seasonal effect (Pre-monsoon). However, as per report of Central Groundwater Board (2017-2018), the depth of water table was recorded at 40m during January 2018 in the project and surrounding area, as shown in the fig 2-8 and the annual fluctuation varies between 0-2m depth as shown in fig. 2-9.

Hence, groundwater is not anticipated at the tunnel depth (30-35m), however, any occurrence of groundwater shall be confirmed during the upcoming investigation through drilling in the ridge area.

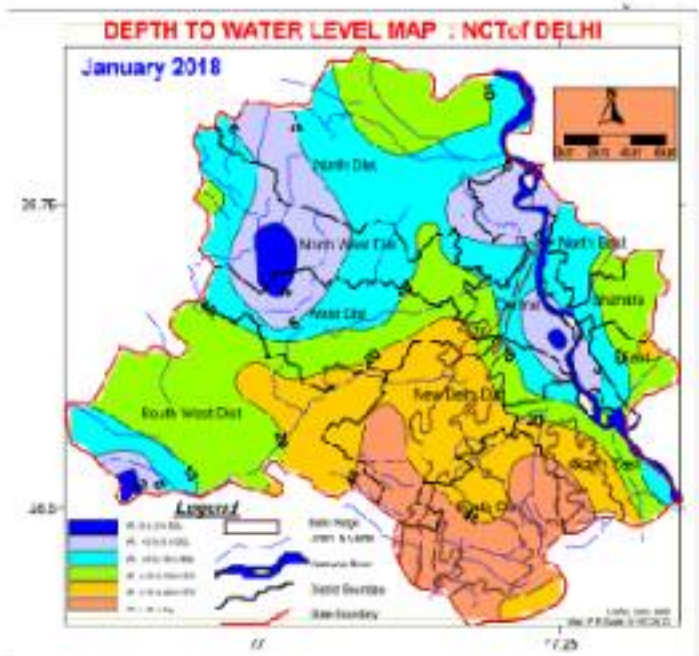


Figure 2-8: Depth to water level Map: NCT of Delhi

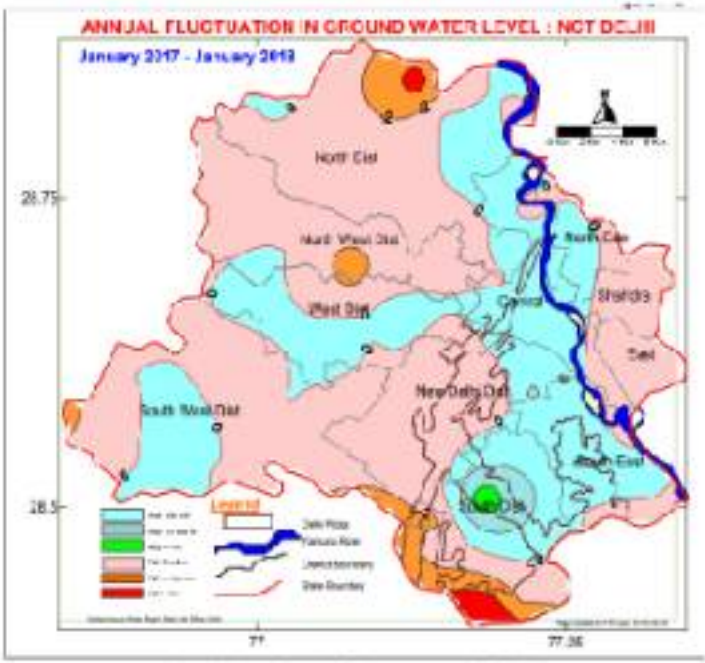


Figure 2-9: Annual fluctuation in Ground water Level: NCT of Delhi

CHAPTER-3: DESCRIPTION OF ENVIRONMENT

In order to understand the baseline environmental status and impacts due to the proposed construction of Expressway, observations were made by field visits. The relevant secondary data was also collected. Consultation with the concerned authority is also conducted. The Baseline Period of the Project is March 2022 to May 2022. The methodologies adopted can be classified in the following way:

1. The preparation of questionnaire for environmental surveys.
2. Field observations and public consultation.
3. Screening, testing, and monitoring of environmental factors like Air, Water, Soil and Noise level.
4. Collection of secondary data from various departments.
5. Compilation, analysis, and presentation of the report.

3.1 PREPARATION OF QUESTIONNAIRES FOR ENVIRONMENTAL PARAMETERS

Questionnaires were prepared after thoroughly studying the environmental guidelines and conditions of the Ministry of Environmental, Forest and Climate Change (MoEF&CC). Questionnaires for Environmental appraisal for Road / Highway projects by MoEF&CC were also considered. A total of four sets of questionnaires were prepared for field survey/data collection. The details of these are as follows.

1. Environmental screening information like national parks, wildlife sanctuary, forests, archeological, cultural, religious structures etc. within 10 Kms on both sides of the alignment.
2. Environmental screening survey, effects on environment; views of the community.
3. The survey of features within Right of Way (ROW) on both sides of the proposed Tunnel.
4. Wildlife/National Park survey questionnaires for villagers, road users etc.

3.1.1 Field Observation on Questionnaire

A team under the leadership of Environmental Expert was constituted to undertake the field survey of the questionnaire. The young workers were apprised of the comprehension of the work emphasis on public consultation.

3.1.2 Screening, Testing & Monitoring of Physical Environmental Factors

The entire stretch of proposed alignment was surveyed and screened. The collection of water samples, soil samples and other data pertaining to air quality and noise were done along the proposed alignment. The samples were analysed by Enviro Tech Services, which is a NABL accredited laboratory.

3.1.2.1 Ambient Air Quality

Ambient air quality is the most significant parameter that is required to quantify the impact on the natural and biophysical environment.

Ambient Air Quality (AAQ) was monitored along the proposed alignment at selected sites. The locations selected were those of the city / town area, the marketplace, and the rural areas. The details of locations and monitoring results are discussed in Chapter – 3. The air quality parameters considered for the study include Particulate Matter 10 (PM_{10}), Particulate Matter 2.5 ($PM_{2.5}$), Nitrogen Oxides (NO_2) Sulphur Di-oxide (SO_2), and Carbon monoxide (CO).

a) Particulate Matters (PM10 & PM2.5)

PM_{10} and $PM_{2.5}$ were monitored using a Respirable Dust sampler (RDS) and PM2.5 Sampler. A pre-conditioned and weighted glass fiber filter paper is used for PM10 and PTFE filter paper is used for RDS/PM2.5 samplers. A known quantity of the air was sucked through the filter paper in a prescribed sampling time. The flow was noted from the manometer. The multiplication of time with rate gave the total quantity of air passed through the filter paper. After sampling, the filter paper was removed, conditioned, and weighed finally for getting the concentrations in ambient air.

b) Sulphur Di-Oxides (SO_2)

A known quantity of the air was bubbled through impingers containing tetrachloromercurate. SO_2 formed a disulfitomercurate complex, which gave a pinkish blue colour with p-rosaniline and formaldehyde solution. The intensity of colour produced was proportional to concentration of sulphur dioxide. The measurement was made by using a spectrophotometer at the wave length of 560 nm.

c) Nitrogen Di-Oxides (NO_2)

A known quantity of air was passed through impingers containing sodium hydroxide-sodium arsenite solution. The estimation of NO_2 was done colorimetrically using hydrogen peroxide, sulfanilamide, NEDA, etc. The intensity of the colour was measured at 540 nm using a spectrophotometer.

d) Carbon Monoxide (CO)

Sample taken in Tedlar Bag and been tested by Non- dispersive Infrared (NDIR) Spectroscopy method.

3.1.2.1.1 Instrument Used for Sampling

Respirable Dust Samplers APM-250 of Lata Envirotech Services make were installed for monitoring Suspended Particulate Matter (SPM), Respirable fraction (<10 microns) and gaseous pollutants like SO_2 and NO_2 whereas the concentration Particulate matter 2.5 was monitored by installing Envirotech made APM 50MFC particulate matter sampler.

3.1.2.1.2 Techniques for Ambient Air Quality Monitoring

The techniques used for Ambient Air Quality monitoring have been presented in **Table No. 3-1.**

Table No. 3.1: Techniques used for Ambient Air Quality Monitoring

Parameter	Technique	Technical Protocol	NAAQM Standards (24 hrs basis)
Particulate Matter (Size less than 10µm) or PM_{10} µg/m³	Respirable Dust Sampler (Gravimetric method)	IS-5182 (Part-IV)	100
Particulate Matter (Size less than 2.5µm) or $PM_{2.5}$ µg/m³	PM 2.5 APM 550 Fine Particle Sampler (Gravimetric method)	-	60
Sulphur Dioxide (SO_2), µg/m³	Improved West and Gaeke Method	IS-5182 (Part-II)	80
Nitrogen Dioxide (NOx), µg/m³	Jacob and Hochheiser	IS-5182 (Part-IV)	80
Carbon Monoxide (CO), mg/m³	Non – dispersive Infrared (NDIR) Spectroscopy	IS-5182 (Part-IV)	4

3.1.2.2 Water Quality

Samples of ground water were collected from existing Borewells/Tubewells whereas samples of surface water were collected from rivers and available local surface water body like ponds, lakes etc. The physico-chemical quality of water samples were characterized by adopting the relevant parts of IS:3025 "Standard Methods for Water Analysis", APHA methods and other standard methods for select parameters prescribed in IS 10500 and those which are relevant from the point of view of environmental impact of the proposed project.

3.1.2.3 Soil Quality

For studying soil quality, sampling location was selected to assess the existing soil conditions in and around the project area representing various land use conditions. The sample was collected by ramming a core-cutter into the soil up to 30-cm depth. Soil samples were collected and analysed for relevant physical and chemical characteristics to assess the impact of the proposed project on soil.

3.1.2.3.1 Sampling Frequency and Analysis Methodology

The physical and chemical characteristics of the soil of the study area have been assessed by analyzing various parameters as per the methods described in "Soil Chemical Analysis" (M.L Jackson) and Department of Agriculture and Cooperation. Standard classification of Soil as per Indian Council of Agriculture Research, New Delhi has been presented in **Table No. 3.2.**

Table No. 3-2: Standard Classification of Soil

Sl. No.	Soil Test	Classification
1.	pH	<4.5 Extremely acidic 4.51- 5.50 Very strongly acidic 5.51-6.0 moderately acidic 6.01-6.50 slightly acidic 6.51-7.30 Neutral 7.31-7.80 slightly alkaline 7.81-8.50 moderately alkaline 8.51-9.0 strongly alkaline 9.01 very strongly alkaline
2.	Salinity Electrical Conductivity (mmhos/cm) (1 ppm = 640 mmhos/cm)	Upto 1.00 Average 1.01-2.00 harmful to germination 2.01-3.00 harmful to crops (sensitive to salts)
3.	Organic Carbon	Upto 0.2: very less 0.21-0.4: less 0.41-0.5 medium, 0.51-0.8: on an average sufficient 0.81-1.00: sufficient >1.0 more than sufficient
4.	Nitrogen (Kg/ha)	Upto 50 very less 51-100 less 101-150 good 151-300 Better >300 sufficient
5.	Phosphorus (Kg/ha)	Upto 15 very less 16-30 less 31-50 medium, 51-65 on an average sufficient 66-80 sufficient >80 more than sufficient
6.	Potash (Kg/ha)	0-120 very less 120-180 less 181-240 medium 241-300 average 301-360 better >360 more than sufficient

3.1.2.4 Noise Level

Sound Pressure Level (SPL) was measured by a sophisticated sound level meter (Integrating Sound Level Meter Cygnet, Model 2031A).The noise level (Leq) was measured using noise meter at various sites along the entire stretch of tunnel during day (6.00 am to 10 pm) and night (10 pm to 6.00 am).

The noise levels are expressed as an equivalent noise level (Leq), which is the measurement duration of sound pressure level as the averaging time. It is calculated as follows:

$$Leq = 10 \, Log10 \left[\frac{\Sigma^{n} \quad 1 \quad}{n 10^{Li/10}} \right]$$

Where, Li = Instantaneous sound intensity level dB (A)

n = No. of observations

3.1.2.4.1 Noise Standards

The Ambient Noise Quality Standards with respect to noise have been stipulated by Govt. of India vide Gazette Notification dt. 14.02.2000. **Table No. 3.3** describes the Ambient Noise Standards.

Table No. 3.3: Ambient Noise Standards

Area Code	Category of Area	Limits in dB (A), Leq	
		Day time	Nighttime
A	Industrial Area	75	70
B	Commercial Area	65	55
C	Residential Area	55	45
D	Silence Zone*	50	40

*- Silence zone is defined as an area up to 100 meters around such premises as hospitals, educational institutions, and courts. The silence zones are to be declared by the competent authority.

3.1.3 Secondary Available Data

The secondary data were collected from following sources has been presented in **Table No. 3.4**.

Table No. 3.4: Source of secondary data Collection

1.	General information	District Collector/Gazetteer Office, Southwest Delhi District
2.	Meteorological data	Indian Meteorological Department
3.	Statistical data	District Statistical Office
4.	Irrigation and hydrogeology data	Central Ground Water Board
5.	General Land use and Cropping Pattern	Agriculture Department
6.	Relief and slope	Survey of India
7.	Rocks and minerals	Geological Survey of India
8.	Industries	District Industries Center
9.	Maps and Topo sheets	Survey of India

10.	Forest Types, Wildlife and Biodiversity	State Forest Department, Government of Delhi
11.	Archaeological Data	Archaeological Survey of India

3.2 ANALYSES, COMPILATION AND PREPARATION OF REPORT

The data collected by survey teams were compiled. Along with the field monitoring studies and secondary data, these were used to identify the environmental problem spots or 'Hot Spots'.

The following analyses were carried out based on compiled information:

1. The levels of environmental parameters were compared with the prescribed limits suggested by Central Pollution Control Board (CPCB). This gave a clear idea that special attention is paid to areas where the level of pollution is higher than desirable. Those stretches, where the pollution level does not exceed the desired limits despite construction of the Expressway will be dropped from further study.
2. The sites where the impact is minimum or nearly absent have been identified. This may help in the selection of major storage sites during construction work.
3. The mitigation measures have been suggested to reduce the adverse impacts due to the proposed widening and detailed environmental management plan have been prepared covering both the phases i.e., construction and operation of Expressway.

3.3 BASELINE ENVIRONMENTAL CONDITIONS

3.3.1 Physical/Natural Environment

Baseline environmental data plays a key role in identification of environmental parameters likely to be affected due to the proposed project. This also facilitates the decision maker to assess a particular environmental parameter which needs to be incorporated during the detailed Environmental Assessment study and for further detailed investigation. The scope of this chapter is limited to only those issues which are of concern in the environmental assessment. With rapid strides in economic development, the need to rationalize the development is imperative. During the process of development, there has been intensive use of natural resources, very often leading to ecological imbalances. In a road project like this involving wide ranging construction activities, conservation of flora, fauna and the ecosystem form an important aspect of overall sustainable development process. The data/ features documented hereunder have been collected through field investigation, interaction with local population and desk research and published data sources.

The environmental baseline data comprise the features present within a strip of 10 km or affected area whichever is more on either side of the proposed alignment. This area is referred to as study area/ project area in the report. It includes environmental features such as forest areas, conservation areas, water bodies (rivers, lakes ponds and reservoirs), industries, wildlife/National parks and, places of historical importance, tourism etc.

3.3.2 Geographical Location of the project Expressway

The proposed tunnel is entirely green field project and proposed for 6 lane which starts from near Shiv murti Interchange (Dwarka Expressway Package-1) to Nelson Mandela Marg in New Delhi.. The proposed tunnel traverses from 28°31'55.17"N, 77° 5'22.62"E to 28°31'44.18"N, 77° 8'53.05"E.

3.3.3 LAND USE AND TERRAIN

Studies on land use aspects of eco-system play important roles for identifying sensitive issues if any and taking appropriate actions for maintaining the ecological balance in the development of the region.

3.3.3.1 Objective

The objectives of the study of land use are:

- To determine the present land use pattern.
- To analyse the impacts on land use due to proposed project in the study area.
- To give recommendations for optimizing the future land use pattern vis-à-vis growth of plant activities in the study area and its associated impacts.

3.3.3.2 Methodology

A hybrid technique has been used i.e. visual interpretation and digital processing has been used for the preparation of land use/ land cover map of present study. Survey of India reference map on

1:50,000 scale have been used for the preparation of base map and geometric correction of satellite data. Ground truthing has been carried out to validate the interpretation accuracy and reliability of remotely sensed data, by enabling verification of the interpreted details and by supplementing with the information, which cannot be obtained directly on satellite imagery.

ERDAS 9.2 and Arc GIS 9.3 software was used for digital processing of the spatial data. Digital image processing techniques were applied for the mapping of the land use land cover classes of the provided area from the satellite data.

3.3.3.3 Land Use/Land cover of the study area

The existing land use around the proposed Expressway/tunnel primarily comprises of agricultural land, forest area & settlements. The proposed alignment passes mostly through inhabited area.

The land use map for a buffer length of 500 m and along the alignment and of 10km radius has been prepared to a scale of 1:25000 based on recent satellite imagery. It shows features such as crop lands, agricultural plantations, fallow lands, waste lands, water bodies, built-up areas, forest areas and other surface features such as railway tracks, roads.

Table No. 3.6 and 3.8 describes the land use of the study area along the alignment and in 10 km buffer area. The land use map based on satellite imagery within buffer length of 500 m along the alignment and of 10 km buffer area for the proposed project has been km shown in **Fig. No. 3.1 and Fig.No.3.2**

Table No. 3.6: Land use of the Study Area Along the alignment

Sl. No.	Land Use	Area in Ha
1	Settlement	68.56
2	Forest Land	125.85
3	Water Bodies	1.22
4	Park/ Green Area	21.60
5	Farmhouse/ Vegetation	152.96
6	Open Land	15.84
7	Open Scrub	54.80
8	Agricultural land	145.74
Total Area		**686.37**

Table No. 3.8: Land use of the Study Area within 10Km Buffer area

Sl. No.	Land Use	Area in Ha
1	Settlement	8897.59
2	Forest Land	1286.78
3	Water Bodies	27.03
4	Park/ Green Area	6296.19

5	Farmhouse/ Vegetation	6840.98
6	Open Land	4076.93
7	Open Scrub	8792.47
8	Agricultural land	1329.79
Total Area		**40647.76**

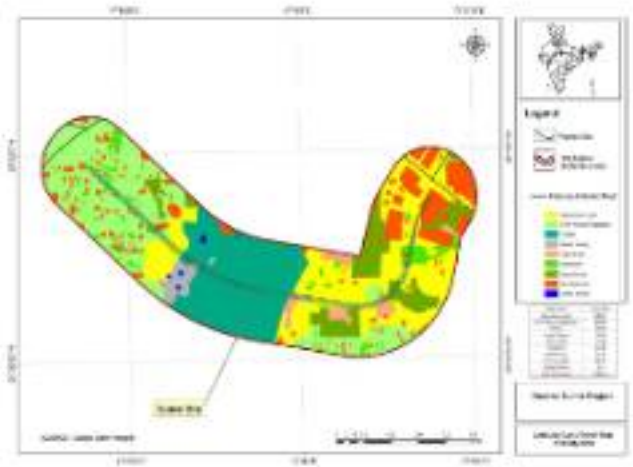


Fig. No. 3.1: Land use of the proposed Tunnel along the alignment

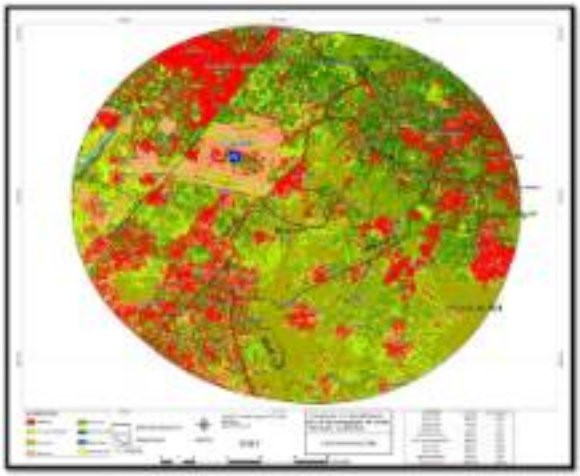


Fig. No. 3.2: Land use of the proposed Tunnel (10 km buffer)

3.3.4 Climate and Micro-Meteorological Parameters

3.3.4.1 Climate and Rainfall

The climate of district is mainly influenced by its inland position and prevalence of air of the continental type during major part of the year. Extreme dryness with intensely hot summer and cold winter are characteristics of the climate. The cold season starts towards the latter half of November when both day and night temperatures drop rapidly with the advance of the season. January is the coldest month with the mean daily maximum temperature at 21.3°C and the mean daily minimum temperature at 7.3°C. May and June are the hottest months. In May and June, maximum temperature may sometimes reach 40 or 47°C.

Rainfall

The average annual rainfall of the district is 794 mm at Palam. About 81% of the annual rainfall is received during the monsoon months of July, August and September. The rest of the rainfall is received as thunderstorm rain and as winter rain in the pre and post monsoon months. The variation of rainfall from year to year is large. On an average, rainfall of 2.5 mm or more falls on 27 days in a year including 19 days during the monsoon months. Two to three days in June are rainy. In other months, except in November and in first half of December, when it is practically rainless, rain falls on a day or two only in each month.

3.3.4.2 Cloud Cover

The sky is heavily overcast during the monsoon season. During the rest of the year the sky is clear and lightly clouded.

3.3.4.3 Humidity

The air over Delhi is dry during the greater part of the year. Humidity is high in the monsoon months. April and May are the driest months with relative humidity of about 30% in the morning and less than 20% in the afternoons. The average annual relative humidity is 54%.

3.3.4.4 Wind Speed/Direction

The wind speeds are generally moderate to low in the month of March 2022 to May 2022. The wind rose diagram for Delhi IMD station (project district) was developed during the months from March 2022 to May 2022 (study period) and shown in **Fig. No. 3.3**. The data reveals that pre-dominant wind direction of Delhi with the average wind speed of 6.73 m/s is South-West.

The meteorological Data Parameters at Delhi IMD has been presented in **Table No. 3.7**.

Table No. 3.7 :- Meteorological Data Parameters at Gr.II (MS) station

Date	Temperature, deg C			Humidity, %			Pressure, hPa			Wind Speed, m/s	Predominant Wind Direction blowing from	Rainfall mm
	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Avg		
March	8.0	28.6	20.7	31	66	52	13.8	14.8	12.7	3.76	SW	0
April	11.4	43.4	27.1	23	43	34	13.6	15.3	14.5	3.82	SW	9.1
May	24	4.8	28.8	24	44	34	14.3	14	14.8	0.89	SW	15.2

Source: Observed IMD Data

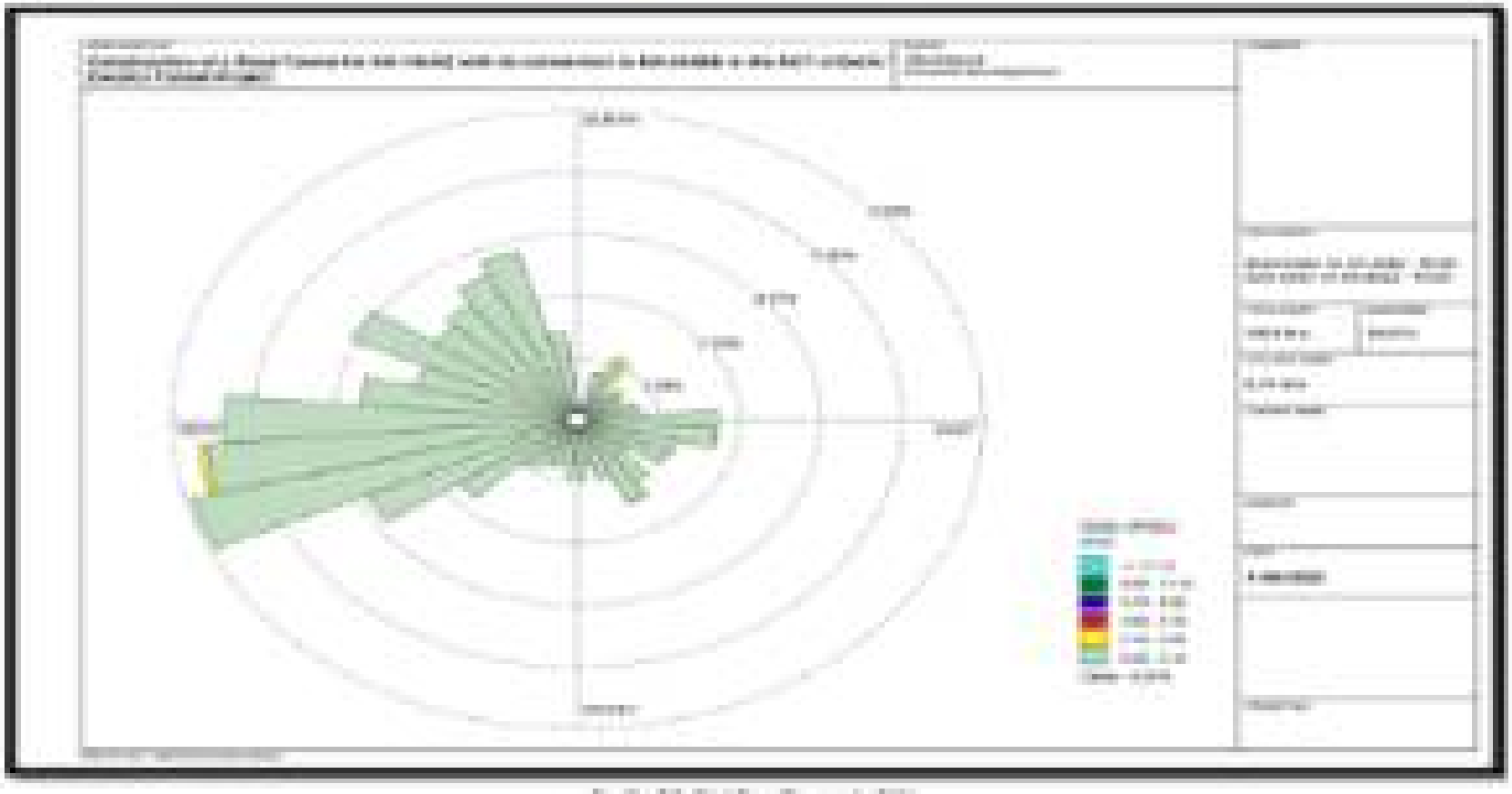


Fig. No: 3.3 : Wind Rose Diagram for Delhi

3.3.6 Natural Hazards and Vulnerability of the sub project area

3.3.6.1 Seismic Profile of the area

The project State falls in one seismic zone – Zone IV and which has high seismicity where the general occurrence of earthquakes is of 5-6 magnitude, a few of magnitude 6-7 and occasionally of 7-8 magnitude. Delhi thus lies among the high-risk. Therefore, the Expressway/tunnel also falls in zone IV.

The seismicity map shows zone factors as per IS 1893 as shown in **Fig. No. 3.5** shows that the proposed Tunnel falls in high zone (Zone IV). The map showing seismic zone of India is shown in **Fig. No. 3.4.**

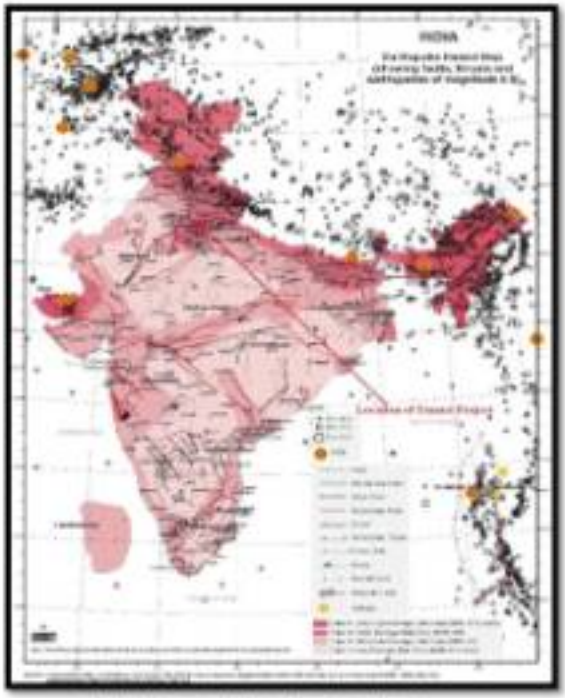


Fig. No. 3.4: Seismicity Map of India Showing Project Location

3.4 GEOLOGY OF THE STUDY AREA

- **Geomorphology & Soil types**

The ground water availability in NCT, Delhi is controlled by the hydrogeological situation characterized by occurrence of different landforms developed on different geological formations. Geomorphology map of Delhi is presented in Fig. 3.5. Entire area of NCT, Delhi can be grouped into three broad geomorphic units:

- Rocky surface
- Older Alluvial Plain
- Flood Plain of Yamuna River

Rocky Surface: The rocky surface represents structurally controlled relict linear ridges and isolated hillocks comprising of rocks of Delhi Supergroup and isolated hills mostly occurring in the south- and south-central parts and extends from Mehpalpur to Wazirabad in the north. Towards south of Mehpalpur the ridge gets bifurcated, one arm extends towards Mandi and further south while the other arm takes a turn towards southeast and extends up to Tughlakabad Greater Kailash-Nehru Place and Okhla. It attains a maximum elevation of 362 m above m.s.l. which gradually diminishes towards north where rocks are exposed on the western bank of Yamuna near Wazirabad.

Older Alluvial Plain: The gently undulatory terrain on either side of the rocky surface is described as Older Alluvial Plain. This surface is separated from the Yamuna Flood Plain by a bluff. Depending upon the morphological expressions / features, this unit is further divided into different subunits: (i) Najafgarh Older Alluvial Plain (ii) Delhi Older Alluvial Plain and (iii) Maidan Garhi Plain. Najafgarh Older Alluvial Plain occupying western and southwestern part of the region is partly covered by sand dunes and sandy sheets. The gently sloping surface including the covered pediment along the eastern flank of the ridge represents the Delhi Older Alluvial Plain. Maidan Garhi Plain is a relatively higher plain surface and forms part of *Chhatarpur* Basin. A narrow zone of badland has formed mostly along the western margins of structural ridges due to intense development of gullies and rills.

Flood Plain of river Yamuna: The low-lying flat surface representing the Flood Plain of river Yamuna occupying northern, northeastern, and eastern parts of the NCT is an important geomorphic unit. North of Narela, the width of flood plain varies from 15 to 17 km. The wider Older Yamuna flood plain indicates lateral migration of river Yamuna over large areas. This belt has good potential for ground water development. It forms the erosional terrace. The Yamuna Active Flood Plain represents the wide belt bounded on both the sides by Eastern and Western bunds and is naturally prone to annual/periodic floods being in the flood way and flood fringe zone of river Yamuna. It forms depositional terrace and is characterized by abandoned channels, cut-off meanders, meander scrolls, point bars and channel bars. The presence of number of cut- off meanders in the Yamuna Flood Plain suggests oscillatory shifting of river. The lakes near Bhalswa, Kondli and Khichdipur are remnants of large meanders. Major soil types of the district are sand, clay & kankar.

Source: CGWA Report 2016

➢ **Physiography & Geology**

Physio graphically the area represents a mature topography with vast gently undulatory plains, low linear ridges and isolated hillocks. Physiography of Delhi is dominated by the river Yamuna, the Aravalli range, and the plains in between, formed by alluvium deposits of Recent age. The SSW - NNE trending Aravalli Ranges, designated as Delhi Ridge, occupy the south-central part of Delhi and extend up to western bank of Yamuna River near Okhla in the south and Wazirabad in the north-east. Ecologically, the Ridge acts as a barrier between the Thar desert and the plains and slows down the movement of dust and wind from the desert. The ridges are covered with forests and are the city's lungs and help maintain its environment. This green belt, a natural forest, has a moderating influence on temperature, besides bestowing other known benefits on the people. The area towards east of ridge has a gentle slope of 3.5 m/km towards Yamuna.

The area towards west of ridge representing Older Alluvial Plain is mostly covered by sand dunes and has a westerly slope. Yamuna River flows across Delhi in a south-southeasterly direction with vast flood plain, marked by a bluff of 3 to 4 m on either bank. Digital Elevation Model Map of Delhi is presented in Fig. 3.5. Surface elevation varies from 332 m above mean sea level at the ridge to 62 m above mean sea level at river Yamuna. The low-lying Yamuna flood plains, with an elevation as low as 198 m above mean sea level, provide fertile alluvial soil suitable for agriculture but are prone to recurrent floods.

Source: http://cgwb.gov.in/cgwbonmisbi/cluploads/documents/1557174643124090609126e.pdf

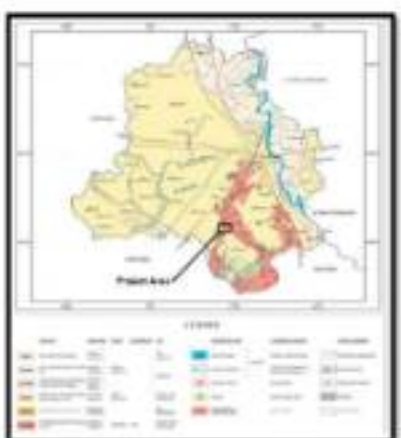


Fig No. 3.6 Geological map of Delhi Region showing Project Location

3.4.1 Field Study and Soil Sampling Locations

For studying soil quality, sampling location was selected to assess the existing soil conditions in and around the project area representing various land use conditions. The sample was collected by ramming a core-cutter into the soil up to 30-cm depth. The sample collection, preservation, storage, transportation, and analysis were carried out as per the standard methods. The soil samples after collection were immediately subjected to the analysis of various parameters in the Enviro Tech Services a NABL Accredited laboratory. The locations map and details of the soil sampling locations have been presented in **Figure 3.6** & **Table No. 3.8** respectively.

Table No. 3.8: Soil Sampling Locations

Sl. No.	Locations	Monitoring Location
1	S1	Monitoring Location
2	S2	Project Site (Starting Point)
3	S3	Field near to Ashok Avenue
4	S4	Field Near to Durga mandir
5	S5	Garden near to Lotus residency
6	S6	Field near to Sanathan Dharm Mandir Rangpuri
7	S7	Field near Road Junction
8	S8	Graden field near Yamuna Apartment, Vasantkunj

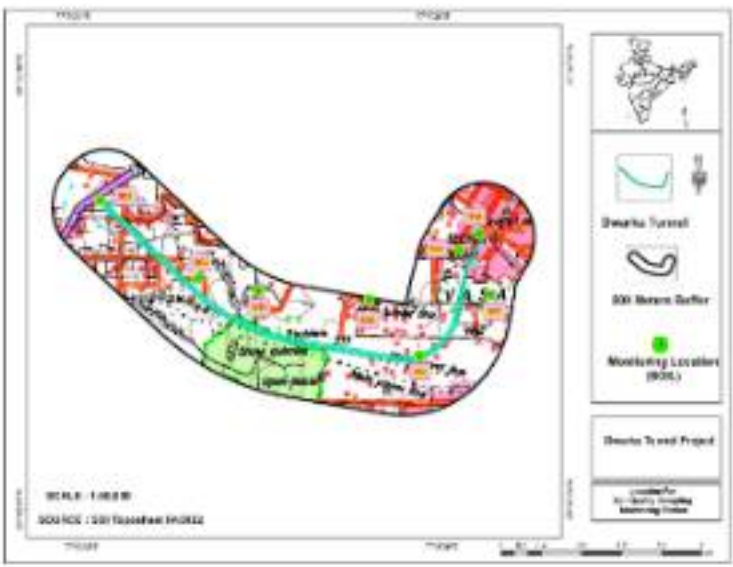


Figure 3.6: Soil Sampling Map

Some photographs showing the collection of soil samples along the project area has been presented below





3.4.2 Soil Quality along the study area

Soil samples were collected from agriculture land along the proposed Expressway and were analyzed for the physical, chemical properties and heavy metal concentrations. They were assessed for agricultural and afforestation potential. The characteristics of the soil along the Expressway have been presented in **Table No. 3.9**

Table No. 3.8: Soil Analysis along the proposed project

S.No.	Test Parameters	Unit	SS1	SS2	SS3	SS4	SS5	SS6	SS7	SS8
1	Texture	---	Sandy Clay Loam	Sandy Clay Loam	Sandy Clay Loam	Sandy Clay Loam	Sandy Clay Loam	Sandy Clay Loam	Sandy Clay Loam	Sandy Clay Loam
2	Sand	%	52.2	48.6	44.4	51.2	54.8	53.2	52.2	53.4
3	Silt	%	31.6	36.4	31.6	36.1	30.53	33.1	32.1	31.1
4	Clay	%	33.2	33.0	33.0	32.7	31.36	33.7	33.6	33.4
5	Electrical Conductivity (EC)	µs/cm	19.6	21.1	36.5	20.3	23.06	21.1	34.0	22.3
6	pH	---	7.21	7.36	7.16	7.24	7.4	7.25	7.36	7.36
7	Bulk Density	g/cm3	1.1238	1.11	1.08	1.26	1.02	1.18	1.08	1.17
8	Water Holding Capacity (WHC)	%	17.2	14.7	18.8	14.3	13.77	21.2	18.1	17.2
9	Sodium (Na)	mg/kg	76.6745	77.1	76.3	81.4	82.44	86.3	83.6	86.3
10	Potassium (K)	mg/kg	180.3	187.6	178.3	168.0	188.84	180.7	182.3	183.2
11	Total Nitrogen (N)	mg/kg	3.33	5.24	3.66	< 5.0	3.6	5.36	5.45	4.56
12	Chloride (Cl)	mg/kg	432.6	389.7	402.9	21.9.6	434.8	384.8	434.5	215.7
13	Magnesium (Mg)	mg/kg	146.16	76.4	72.1	74.4	86.4	84.3	84.4	86.6
14	Organic Matter (OM)	%	3.55	5.85	3.56	5.51	5.53	5.27	5.71	5.76
15	Aluminium (Al)	mg/kg	0.54	0.45	0.77	0.56	0.56	0.43	0.53	0.57
16	Cadmium (Cd)	mg/kg	0.41	0.44	0.41	0.46	0.44	0.45	0.44	0.46
17	Chromium (Cr)	mg/kg	0.38	0.33	0.31	0.52	0.388	0.74	0.32	0.53
18	Copper (Cu)	mg/kg	1.11	1.55	1.31	1.07	1.43	1.53	1.74	1.53
19	Iron (Fe)	mg/kg	130.179	141.6	138.1	126.7	119.33	146.6	141.7	133.6
20	Lead (Pb)	mg/kg	0.38	0.51	0.36	0.53	0.34	0.57	0.57	0.55
21	Manganese (Mn)	mg/kg	1.51	2.11	1.36	1.53	1.306	1.53	1.53	1.53
22	Zinc (Zn)	mg/kg	1.58	1.88	1.37	1.31	1.07	1.73	1.86	2.02
23	Nickel (Ni)	mg/kg	317.7	331.6	318.8	371.3	336.46	319.7	344.6	389.1

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
31	Calcium (Ca)	mg/kg	83.17	40.12	500.4	3910.3	5.01.00	43.7.3	323.3	393.1
32	Phosphorous (P2O5)	mg/kg	37.482	21.7	38.7	45.3	13.11	21.7	16.7	28.1

3.4.2.1 Analysis and Interpretation

- The pH of the soil samples ranged from 7.19 to 7.30 during the study period, indicating that soils are neutral to slightly alkaline in nature.
- The soil Electrical Conductivity (EC) also varies from 19.6 µs/cm to 24 µs/cm. These parameters indicate that soils are neutral in reaction and having average EC.
- Nitrogen content ranges from 2.88 kg/ha to 5.81 kg/ha which is more than sufficient.
- Zinc content ranged from 1.66 mg/kg to 2.02 mg/kg.
- Bulk density ranges from 1.02 to 1.20 gm/cm^3 during the study period.

Based on soil analysis data it is concluded that soils are poor in nutrients. The availability of Nutrients for the plant growth in the study area is not good.

3.5 AIR ENVIRONMENT

Air pollution can cause significant effects on the environment and subsequently on humans, animals, vegetation and materials. In most cases, air pollution aggravates pre-existing diseases or degrades health status, making people easily susceptible to other infections and development of chronic respiratory and cardiovascular diseases. Further, environmental impacts from air pollution can include acidic deposition and reduction in visibility. Ambient air quality is the most significant parameter that is required to quantify the impact on the natural and biophysical environment.

All air pollutants emitted by point and non-point sources are transported, dispersed or concentrated by meteorological and topographical conditions. To assess the impact on existing air environment due to the proposed projects, it is necessary to have baseline air status of various pollutants. The prime objective of baseline air quality survey was to assess the existing air quality of the area. This will also be useful for assessing the conformity to standards of ambient air quality.

3.5.1 Ambient Air Monitoring Locations

The Ambient air quality has been carried out at 8 different locations. Major environmental receptors such as settlements etc. were also considered for selection of monitoring locations in the study area. The locations & details of the Ambient Air monitoring locations have been presented in **Figure 3.7& Table No. 3.10.**

Table No. 3.10: Air Monitoring Locations

Sl. No.	Locations	Monitoring Location
1.	AAQ1	Project Site (Starting Point)
2.	AAQ2	Road Junction
3.	AAQ3	Near Durga mandir
4.	AAQ4	Road Junction near to Lotus residency
5.	AAQ5	Kendriya Vidalaya Rangpuri
6.	AAQ6	Road Junction
7.	AAQ7	Road near Yamuna block Vasant kunj

8.	AAQ8	Project Site near Vasant Kunj (End Point)

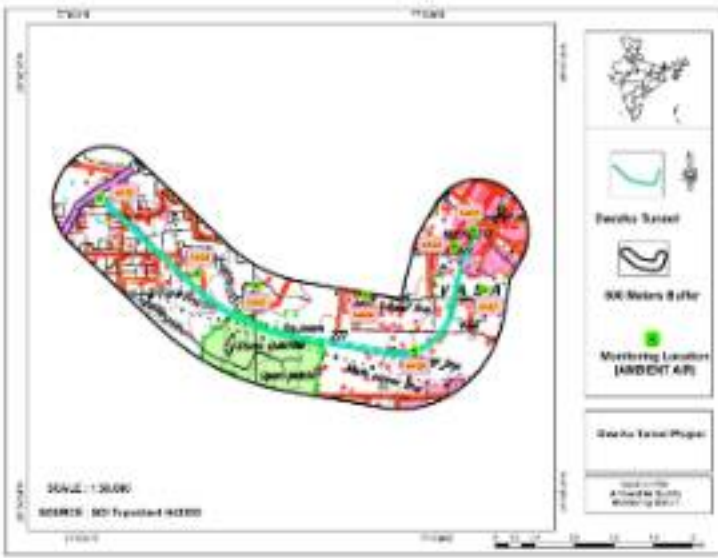


Figure 3.7: Air Monitoring Map

Some photographs showing the Air Monitoring Conducted along the project area has been presented below.



3.6.2 Ambient Air Quality along the study area

The Ambient Air Quality was measured during the period from March 2022 to May 2022 at 8 locations and results have been presented in **Table No. 3.11.** The chart showing the concentrations of the pollutants at various locations has been shown from **Fig. No. 3.3 (a)** to **3.3 (e)**. The Results show that all the parameters are well below the National ambient air quality standards, 2009.

Table No. 3.11: Value of the AAQ along the proposed project boundary

S. No.	Locations	PM10 (µg/m³)				PM2.5 (µg/m³)				SO2 (µg/m³)				NO2 (µg/m³)				CO (mg/m³)			
		Max	Min	Avg	98P	Max	Min	Avg	98P	Max	Min	Avg	98P	Max	Min	Avg	98P	Max	Min	Avg	98P
1	AAQ-1	318.0	118.0	163.0	306.0	126.0	60.7	85.4	121.0	16.0	10.5	14.7	15.8	34.0	16.7	30.1	33.4	1.68	0.70	1.41	1.58
2	AAQ-2	305.0	308.0	146.0	162.0	116.7	121.0	80.7	126.0	17.0	16.0	12.0	16.0	33.0	23.1	23.9	28.3	1.58	1.68	1.33	1.78
3	AAQ-3	302.0	120.0	153.7	178.0	108.0	58.7	82.0	102.0	16.0	11.0	13.7	15.0	29.0	16.0	22.1	28.7	1.64	0.76	1.28	1.60
4	AAQ-4	306.0	125.7	150.0	181.0	110.1	70.4	86.2	106.3	17.1	11.3	13.4	16.4	30.4	20.7	23.6	28.7	1.77	0.87	1.32	1.77
5	AAQ-5	170.0	114.0	135.0	162.0	108.0	60.0	77.9	96.9	15.0	10.3	12.2	14.8	27.0	16.2	21.0	26.3	1.53	0.72	1.14	1.53
6	AAQ-6	160.0	105.0	127.0	150.0	110.7	70.1	86.0	106.0	17.0	12.2	14.1	16.0	30.0	20.7	24.0	28.3	1.64	0.88	1.36	1.60
7	AAQ-7	202.7	111.0	134.1	168.7	87.6	53.4	76.8	92.0	15.0	10.0	12.0	14.0	27.0	17.0	21.3	26.7	1.51	0.80	1.16	1.50
8	AAQ-8	175.0	117.0	141.7	168.0	102.0	64.0	81.0	98.0	15.0	10.0	12.0	13.0	28.0	16.0	22.0	27.0	1.71	1.00	1.24	1.70

Source: — Ambient Air Quality Monitoring conducted by Vatavaran Group of Companies

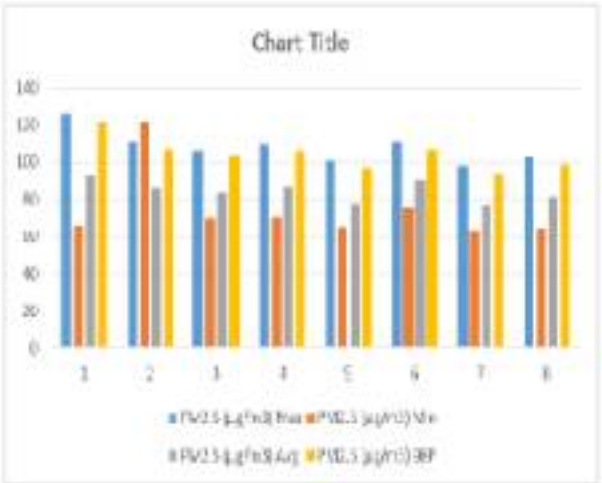


Fig. No. 3.6 (a): Chart Showing Concentration of PM2.5 at various locations



Fig. No. 3.6 (b): Chart Showing Concentration of PM10 at various locations

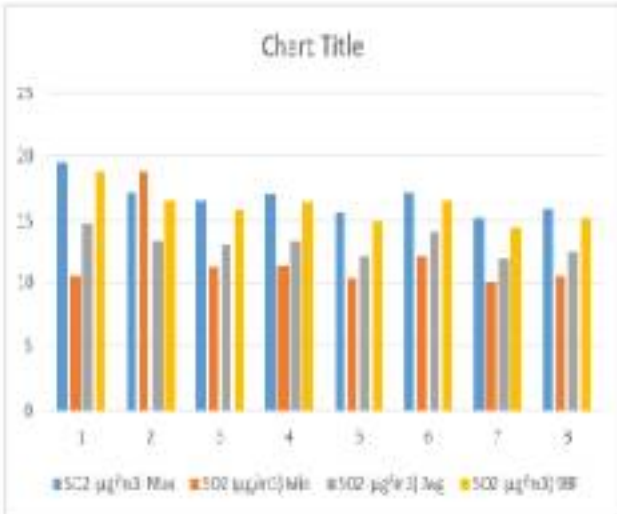


Fig. No. 3.8 (c): Chart Showing Concentration of SO2 at various locations



Fig. No. 3.8 (d): Chart Showing Concentration of NO2 at various locations

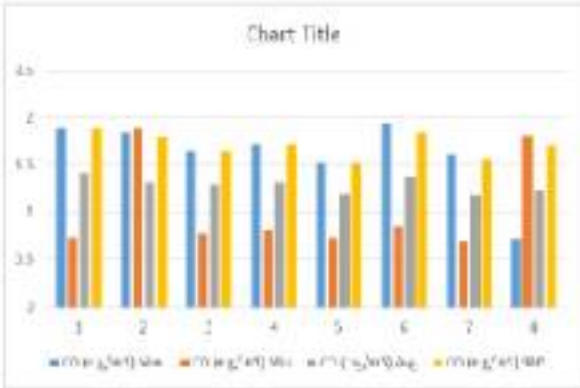


Fig. No. 3.8 (a): Chart Showing Concentration of CO at various locations

3.6.2.1 Analysis and Interpretation

Specific station-wise Ambient Air Quality (AAQ) data for PM_{10}, $PM_{2.5}$, SO_2, NO_2 and CO as recorded during the months from March 2022 to May 2022. The minimum and maximum values of, $PM_{2.5}$, PM_{10}, SO_2, NO_2 and CO analysed along the proposed project tunnel are 111.5 ($\mu g/m^3$) to 208.5 ($\mu g/m^3$), 62.4 ($\mu g/m^3$) to 121.9 ($\mu g/m^3$), 19.5 ($\mu g/m^3$) to 18 ($\mu g/m^3$), 17.8 ($\mu g/m^3$) to 34.6 ($\mu g/m^3$) and 0.69 (mg/m3) to 1.52 (mg/m3) respectively. All the parameters have been analysed and show that all the parameters are well below the National Ambient Air quality standards, 2009.

3.6 NOISE ENVIRONMENT

Noise can be defined as any sound that is undesirable because it interferes with speech and hearing and is intense enough to damage hearing or is otherwise annoying. Noise impacts can be of concern during construction and operational phases of the project. Factors those are important in determining noise levels include distance from the noise source, natural or manmade barriers between the source and the receptors, weather conditions, etc.

3.6.1 Noise monitoring locations

An assessment of baseline noise quality was undertaken to (a) establish the status of exposure of the major sensitive receptors, and (b) to identify the noise pollution levels in and around the site. The noise monitoring was done following CPCB protocol of Noise Monitoring. The details of the Noise level monitoring locations have been presented in **Table No. 3.12**.

Table No. 3.12: Noise level Monitoring Locations

Sl. No.	Locations	Monitoring Location	Zone
1.	N1	Project Site (Starting Point)	Commercial Area
2.	N2	Ashok Avenue	Commercial Area
3.	N3	Near Durga mandir	Commercial Area
4.	N4	Road Junction near to Lotus residency	Residential Area
5.	N5	Kendriya Vidalaya Rangpuri	Residential Area
6.	N6	Road Junction	Residential Area
7.	N7	Road near Yamuna block Vasant Kunj	Residential Area
8.	N8	Project Site near Vasant Kunj (End Point)	Commercial Area

Some photographs showing noise monitoring along the project area has been presented below





3.6.2 Noise Monitoring along the study area

An analysis of the different Leq data obtained during the study period (March 2022 to May 2022) has been made. Variation was noted during the daytime as well as night-time, noise monitoring was conducted at 8 locations along the proposed project. The details of the ambient noise quality along the proposed project locations have been presented in **Table No. 3.13**. The chart showing the noise level along the proposed project locations has been shown in **Fig. No. 3.9.**

Table No. 3.11: Ambient Noise Quality along the proposed project

Location	Results		Noise standards, 2000 Leq dB(A)		
	Leq Day dB(A)	Leq Night dB(A)	Location	Day*	Night*
N1	59.7	51.0	Project Site (Starting Point)	65dB(A)	55 dB(A)
N2	57.5	48.8	Ashok Avenue	65 dB(A)	55 dB(A)
N3	58.5	49.5	Near Durga mandir	65dB(A)	55 dB(A)
N4	53.4	44.8	Road Junction near to Lotus residency	55dB(A)	45 dB(A)
N5	52.4	43.7	KendriyaVidalayaRangpuri	55dB(A)	45 dB(A)
N6	53.4	44.7	Road Junction	55dB(A)	45 dB(A)
N7	52.6	43.9	Road near Yamuna block Vasantkunj	55dB(A)	45 dB(A)
N8	58.0	49.3	Project Site near Vasant Kunj (End Point)	65dB(A)	55 dB(A)

Source :-Enviro Tech Services Testing Laboratory

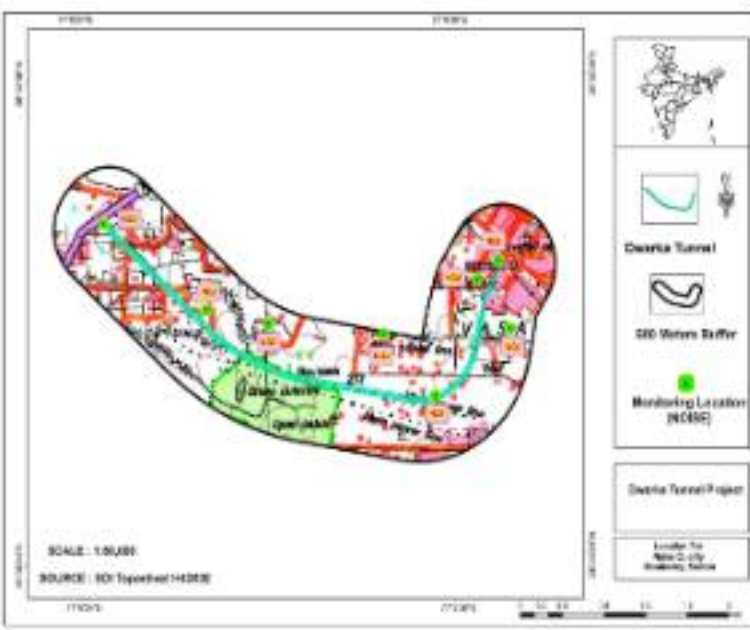


Figure 3.3: Noise Monitoring Location Map

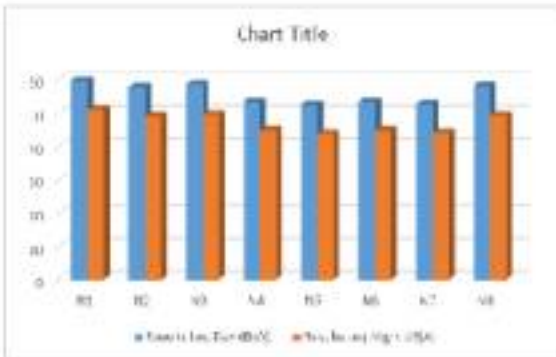


Fig. No. 3.10: Noise level along the proposed project location

3.6.2.1 Analysis and Discussion

The hourly recorded noise level at various locations in the study area shows fluctuations because of change in traffic movement, construction activities and other man-made sources. The noise levels vary from 52.4 to 59.7 dB (A) during daytime and whereas during night time the noise level varies from 43.7 dB to 51.0 dB (A), which are within the prescribed norms as defined in Noise standards, 2000.

3.7 WATER ENVIRONMENT

3.7.1 Water Bodies within proposed RoW

There are no water bodies falling along the project road.

3.7.2 Hydrogeology for the study area

3.7.2.1 Hydrogeology

The Delhi Quartzite ridge acts as the recharge zone. The Quaternary deposits in the form of aeolian and alluvial deposits constitute the major repository of ground water in the area. In the East of the ridge, the thickness of unconsolidated sediments gradually increases away from the ridge, with the maximum reported thickness being 170m. In the Southwestern, Western and Northern parts of the area, the thickness of sediments is more than 300 m except at Dhansa where the bedrock has been encountered at 257 m below land surface. In Chhattarpur basin, the maximum thickness of sediments is 116 m. The aeolian deposits are mainly comprised of loam, silty loam, and sandy loam. The bedrock is overlain by these deposits. Older alluvial deposits consist mostly of interbedded, lenticular and inter fingering deposits of clay, silt, and sand along with kankar. These deposits overlay the aeolian deposits and are in turn overlain by the newer alluvium, which occurs mostly in the flood plains of river Yamuna. Figure 4.5 shows the Hydrological features of Delhi.

Depth of Water Level

Pre-Monsoon: The Depth to water level recorded in NCT Delhi during May 2015 ranges from 1.20 to 62.22 metres below ground level (mbgl). Ground water level data of a total of 114 observation wells have been analyzed district wise. It is observed that 50% wells of South district have shown water level more than 40 mbgl and around 19% wells had water level in the range of 20 to 40 mbgl. In New Delhi and Southwest districts, about 57% and 35% of the wells have registered water levels ranging from 10 to 20 mbgl respectively (Fig. 4.7). In 45% and 46% of the wells in East and Northwest districts respectively, water level varied from 5 to10 mbgl. In the entire Yamuna flood plain, the water levels varied between 2 and 5 m.

Post-Monsoon: The Depth to water level recorded in NCT Delhi during May, 2015 ranges from 1.20 to 62.22 metres below ground level (mbgl). Ground water level data of a total of 114 observation wells have been analyzed district wise. It is observed that 50% wells of South district have shown water level more than 40 mbgl and around 19% wells had water level in the range of 20 to 40 mbgl. In New Delhi and Southwest districts, about 57% and 35% of the wells have registered water levels ranging from 10 to 20 mbgl respectively (Fig. 4.7). In 45% and 46% of the wells in East and Northwest districts respectively, water level varied from 5 to10 mbgl. In the entire Yamuna flood plain, the water levels varied between 2 and 5 m.

Seasonal water level fluctuation: The fluctuation of water levels between Pre-monsoon (May, 2015) and Post Monsoon (November, 2015) shows 0.01 to 10.15 m fall in 33% of the wells. Most parts of the State have registered a rise in water levels, which varies from 0.01 to 8.82 m. A few localized pockets in Southwest, South, West, New Delhi, East and major part of Northeast and Northwest districts have registered decline.

Decadal Fluctuation On comparing data of May 2015 with decadal mean water level of May (2005 – 2014), it is observed that 63% of the wells analysed in the State have registered fall in the range of 0.24 to more than 10.10 m. About 32% of wells located in parts of East, North, Northwest, West, South, Southwest and New Delhi have been observed to show rising condition in the range of 0 to 2 m. The maximum fall has taken place in districts of South and Southwest (i.e. 6.19 to 8.99 m).The rise in water levels is mainly limited to Yamuna flood plain areas and areas in the Northwest and Southwest districts and part of South and New Delhi districts. In Northwest and Southwest districts, rise in ground water levels could be attributed to less withdrawal of ground water due to its inferior quality. In parts of South and New Delhi districts towards eastern side of the ridge, rise in ground water levels has been observed as withdrawal of ground water in these areas is limited due to adequate supply of Water from Delhi Jal Board (CGWB report, 2015).

Source: Central Ground Water Board, Ministry of Water Resources, Government of India



Fig No.3.11 Hydrogeological map of South West Delhi District locating the Tunnel Project

3.7.3 Water quality along the project

Selected water quality parameters of ground water resources within 10 km radius of the study area have been studied for assessing the water environment and evaluate anticipated impact of the project activity. Understanding the water quality is essential in preparation of Environmental Impact Assessment and to identify critical issues with a view to suggest appropriate mitigation measures for implementation. The purpose of this study is to:

- Assess the water quality characteristics for critical parameters; and
- Predict the impact of water quality due to project activities.

3.7.3.1 Water Sampling Locations

The information required has been collected through primary surveys and secondary sources. Water quality is a concern for the numerous surface groundwater sources. 10 ground water samples and 4 surface water samples have been collected from sources present along the proposed project to ascertain the baseline conditions of water quality. The locations of the Water sampling have been presented in **Table No. 3.14 & Figure 3.12**

Table No. 3.14: Details of water sampling locations

Sl. No.	Location Code	Location
1.	GW 1	Project Site (Starting Point)
2.	GW 2	Ashok Avenue
3.	GW 3	Near Durga mandir
4.	GW 4	Road Junction near to Lotus residency
5.	GW 5	Kendriya Vidalaya Rangpuri
6.	GW 6	Road Junction
7.	GW 7	Road near Yamuna Block Vasantkun)
8.	GW 8	Project Site near Vasant Kunj (End Point)

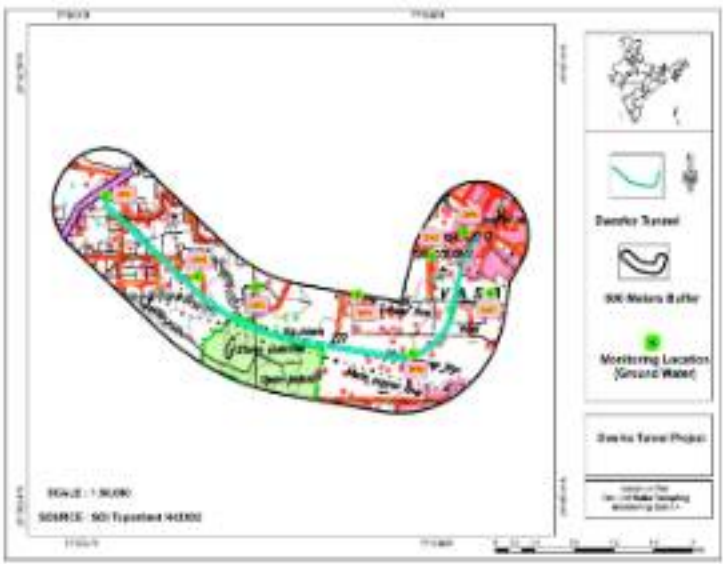


Figure 3.12: Ground Water Sampling Locations

Some photographs showing the collection of water samples along the project area has been presented below:





3.7.0.3 Ground Water Quality along the Study Area

There were many ground water sources such as tube wells/ bore well that exists along the project area. 8 sampling locations were identified along the proposed alignment to assess the ground water quality. All physical and general parameters were compared with the desirable limit and permissible limits as per IS10500:2012. The ground water quality along the proposed project locations were analyzed and have been presented in **Table No. 3.15**.

Table No. 4.12: Ground Water Quality data at the proposed project location

S. No.	Test Parameter	Unit	Sample (GW1	Sample (GW2	Sample (GW3	Sample (GW4	Sample (GW5	Sample (GW6	Sample (GW7	Sample (GW8	Specification/Limit (As per IS 10500: 2012) Desirable	Permissible	Test Method
1	Temperature	o C	26.4	26.2	25.8	27.2	25.8	27.9	27.2	26.1	Not Specified	Not Specified	APHA 2550-B
2	Colour	Hazen	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	5	15	APHA 2120-B
3	Odour	Qualitative	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	APHA 2150-B
4	Taste	Qualitative	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	APHA 2160-C
5	pH	—	7.3	7.2	7.3	7.3	7.2	7.3	7.2	7.2	6.5 - 8.5	No relaxation	APHA 4500-H+
6	Turbidity	NTU	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1	5	APHA 2130-B
7	Total Dissolved Solids (TDS)	mg/L	327.0	338.0	334.0	328.0	327.0	314.0	328.0	327.0	500	2000	APHA 2540-C
8	Fluoride (F)	mg/L	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	1	1.5	APHA 4500-F- D
9	Total Alkalinity (CaCO3)	mg/L	183.0	192.0	188.0	190.0	187.0	175.0	183.0	174.0	200	600	APHA 2320-B
10	Total Hardness (CaCO3)	mg/L	119.0	121.0	127.0	128.0	122.0	121.0	122.0	119.0	200	600	APHA 2340-C
11	Calcium (Ca)	mg/L	30.0	31.0	32.0	33.0	32.0	33.0	33.0	31.0	75	200	APHA 3500-Ca-B
12	Chloride (Cl)	mg/L	74.0	73.0	74.0	74.0	69.0	74.0	69.0	79.0	250	1000	APHA 4500-Cl- B
13	Magnesium	mg/L	3.6	4.8	7.6	7.7	10.8	14.2	7.2	8.4	30	100	APHA

S. No.	Test Parameter	Unit	Result GW1	Result GW2	Result GW3	Result GW4	Result GW5	Result GW6	Result GW7	Result GW8	Specification Limits (as per IS 10500: 2012) Desirable	Permissible	Test Method
	Odour												Agreeable
14	Nitrate (NO3)	mg/l	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	45	No relaxation	APHA 4500-NO3- B
15	Total Hardness (CaCo3)	mg/l	312	324	340	332	320	322	332	324	200	600	APHA 2340 C
16	Boron (B)	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.5	1	APHA 3500-B C
17	Aluminium (Al)	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.03	0.2	APHA 3120B
18	Arsenic (as)	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01	0.05	APHA 3120B
19	Cadmium (Cd)	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.003	No relaxation	APHA 3120B
20	Chromium (Cr)	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.05	No relaxation	APHA 3120B
21	Copper (Cu)	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.05	1.5	APHA 3120B
22	Iron (Fe)	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.3	No relaxation	APHA 3120B
23	Lead (Pb)	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01	No relaxation	APHA 3120B
24	Manganese (Mn)	ug/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.1	0.3	APHA 3120B
25	Mercury (Hg)	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001	No relaxation	APHA 3112B
26	Selenium (Se)	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01	No relaxation	APHA 3120B
27	Zinc (Zn)	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	5	15	APHA 3120B
28	Arsenic	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.3	1	APHA 3500-C

S. No.	Test Parameter	Unit	Result QW1	Result QW2	Result QW3	Result QW4	Result QW5	Result QW6	Result QW7	Result QW8	Specification Limit (as per C.+ICCo 2012) Desirable	Permissible	Test Method
	Detergent (MBAS)												
26	Mineral Oil	mg/L	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	0.3	No relaxation	ST 5030 (Part 54)
27	Phenolic Compounds (C6H5OH)	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001	0.002	APHA 5530-C
28	Coliform No.	per 100 ml	514.3	535.8	515.8	530.1	511.5	530.7	511.3	530.7	Not Specified	Not Specified	APHA 9215-B
29	Total Coliform Count	MPN/ 100 ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Shall not be detectable		ST 5111
30	Escherichia coli	MPN/ 100 ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Shall not be detectable		ST 5111

Remarks: Below Detection Limit

3.7.3.2.1 Analysis and Discussion

- The pH varies from 7.3 to 7.4.
- Total dissolved solids vary from 325.0– 344.0 mg/l.
- Total Hardness as $CaCO_3$ varies from 116.5 – 161.0 mg/l.

All physical and general parameters were compared with the desirable and permissible limits as per IS:10500:2012 for ground water and it is interpreted that all results are within Permissible limits and water can be used for drinking purpose.

3.7.3.3 Surface Water Quality along the study area

There is no stream of surface water flowing around the project within the vicinity of 10km.

3.8 BIOLOGICAL ENVIRONMENT

The proposed project is entirely a green field project of construction of tunnel and proposed for 6-Lane configuration. The project road starts from Shiv murti Interchange (Dwarka Expressway Package-I) to Nelson Mandela Marg. A Bypass to Rangpuri will connect Dwarka Expressway with Vasant Kunj through Nelson Mandela Marg. It has been proposed to extent the existing Nelson Mandela Marg via a tunnel towards Gurgaon/ Dwarka with an interchange near Shiv Murti to connect NH-8 and Dwarka Expressway.

3.8.1 FOREST COVER

The National Capital Territory of Delhi, situated between 28° 22' to 28°54' north and 76°48' to 77°23'east, is one of the greenest capital cities in the world and the greenest city in the country. Despite several infrastructural projects and large-scale construction taking place in Delhi, i.e., Metro, National Highway Project, High-Capacity Bus Service (HCBS), flyovers, underpasses, subways, and general road widening, the forest and tree cover of Delhi has been increasing on a sustained basis from 151 sq. km. (10.2%) in 2001 to 342 sq. km. (23.06%) in 2021.The State of Forest Report published in 2021 by the Forest Survey of India, Dehradun, has recorded the extent of Forest and Tree Cover in NCT of Delhi as 195 sq. km (13.15 %) and 147 sq. km (9.91 %), respectively which covers 23.06% of its total geographic area which is 1483 sq. km.

The forest type (or vegetation type) of an area refers to its physiognomy, structure and floristic features which are determined by geography, topography and anthropogenic factors. In A Revised Survey of Forest Types of India (1968), Champion and Seth classified Indian forest ecosystems into 16 type groups. These groups are further divided into sub-groups based on compositional patterns and region-specific formations. As per this classification the forest types of Delhi fall broadly into two groups:

(i) Tropical Dry Deciduous Forests (Group 5)

(ii) Tropical Thorn Forests (Group 6)

Further, they can be classified into three sub-groups:

(i) Northern Dry Mixed Deciduous Forest (Sub-group 5B/C2)

(ii) Ravine Thorn Forest (Sub-group 6B/C2)

(iii) Plantation/ Trees outside forests (TOF)

Present Status of Forests and Green Cover in NCT of Delhi

Of the total 342 sq km of green cover in NCT of Delhi (ISFR 2021), nearly 254 sq km (74.26%) has been added during the period 1997 to 2021. The change in Forest, Tree and Green Cover of Delhi as per the ISFR Report 2021 are given in Table below:

Table 3.19: Change in Forest and Tree Cover in Delhi between 2019 and 2021

(Area in sq km)

Class	2019 Assessment	2021 Assessment	Change
Geographical Area	1483		
Change in Forest Cover in NCT of Delhi			
Very Dense Forest	5.72	5.72	0
Moderate Dense Forest	90.16	79.60	-10.56
Open Forest	12.53	13.68	+1.62
Total Forest	**195.44**	**899**	**0.44**
Per cent of the Geographical Area	13.18	13.15	0.03
Change in Tree Cover in NCT of Delhi			
Total Tree cover	**129**	**847**	**+18**
Per cent of the Geographical Area	8.69	9.01	+1.32
Change in Green Cover in NCT of Delhi			
Green Cover (Forest & Tree)	**324.44**	**342**	**17.56**
Per cent of the Geographical Area	21.87	23.06	1.19

(Source: India State Forest Report, 2021)

Table 5.17: District-wise Forest Cover of NCT of Delhi

(Area in sq km)

S. No.	Districts	Geographical Area	Forest Cover Area	Change w.r.t report to 2019 Assessment	% of Geographical Area
1.	Central Delhi	21	1.41	+0.01	21.81
2.	East Delhi	03	3.81	+0.09	6.18
3.	New Delhi	35	15.47	00	47.85
4.	North Delhi	61	4.71	+0.37	7.72
5.	North East Delhi	02	4.14	+0.11	5.66
6.	North West Delhi	443	17.53	-0.51	3.96
7.	South Delhi	247	84.04	+0.01	34.27
8.	South West Delhi	421	51.61	-0.38	12.31
9.	West Delhi	132	5.31	00	4.27
	Total	1483	195	0.44	13.15

(Source: Delhi State Forest Report, 2021)

Source: India's Forest at Glance department of forest and Wildlife

5.5.2 Details of Forest Area and Tree felling Along the Project Corridor:

The tunnel has to be constructed through two different grounds i.e., soil and hard rock. alignment is passing below the built up/residential area in the initial reaches and below the southern ridge area.

The length of the Southern Ridge involved in this project is about 1.98 km. In this entire length of the Southern Ridge, an underground tunnel is proposed to be constructed and there is no surface intervention. The depth of the tunnel crown from the ground surface is approx. 25m. The start and end point of tunnel are proposed away from the Southern Ridge boundary.

Ridge Management Board: Clearance has been applied. It is under consideration by the Board and has been attached as **Annexure II**.

5.5.3 BIODIVERSITY

Maheswari (1963) describes the vegetation as semi-arid thorny scrub while Champion and Seth (1968) designate it as northern tropical thorn forest. Open canopied thorny appendages, wax coated, succulent and tomentose leaves. In spite of the tremendous anthropogenic pressures the sanctuary displays sufficient samples of the native floral and faunal communities necessitating reinforcement of its conservation. *Acacia nilotica, A. leucophloea, A. catechu and A. modesta* are some of the native vegetation in addition to *Butea monosperma, Cassia fistula and Salvadora persica*. A few scattered trees like *Anogeissus pendula* are seen besides shrubs like *Capparis separia, C. decidua, Tribulus terrestris, Zizyphus nemoplia, Croton sparsiflorus, Tephrosia purpurea. Prosopis juliflora* - an exotic species (of Mexico) planted sometimes back has established on barren de-vegetated area and areas near human settlements. These form the chief vegetal cover in the sanctuary. The common herbaceous flora is *Calothopis procera, Withaniasomnifera, Achyranthes asp era, Aerva scandens, Tristaxorocunibens, Alycicarpus vaginalis, Euphorbia hirta, Fucalleaceaceae and*

Peristrophebicalyculata. The soil commonly supports good variety of grasses in the protected areas and species like*Cenchrus ciliaris,Aristida spp., Bhagrostispoaeoides, Saccharum spontaneum* and *Vitiveriazizanioides* are a common sight. After the declaration of the area as sanctuary and stopping of mining - both legal and illegal, the habitat once extensively damaged and eroded started showing signs of recovery of some natural and exotic vegetation.

Table 3.15: List of Plants

Sl. no.	Species (Flora)	Family	Common Name
1	*Acacia nilotica*	Fabaceae	Gum Arabic Tree
2	*A. leucophloea*	Fabaceae	Safed Kikar
3	*A. catechu*	Fabaceae	Areca palm
4	*A. modesta*	Fabaceae	Phulai,
5	*Butea monosperma*	Fabaceae	Flame of Forest
6	*Cassia fistula*	Fabaceae	Amaltas
7	*Salvadora persica*	Salvadoraceae	Arak,
8	*Anogeissus pendula*	Combretaceae	Kardhai
9	*Capparis sepiaria*	Capparaceae	Wild Caper Bush
10	*C. decidues*	Capparaceae	kanra
11	*Tribulus terrestris*	Zygophyllaceae	Gokshur
12	*Zizyphusoenoplia*	Rhamnaceae	jackal jujube
13	*Croton sparaiflorus*	Euphorbiaceae	Ban Tulasi,
14	*Tephrocia purnila*	Fabaceae	Indigo Sauvage
15	*Prosopis juliflora*	Fabaceae	Mesquite
16	*Calothopis procera*	Calothopis procera	apple of sodom,
17	*Withaniasomnifera*	Solanaceae	Ashwagandha or winter cherry
18	*Achyranthus aspera*	Amaranthaceae	chaff-flower
19	*Aerva sanguinolenta*	Amaranthaceae	Kanaka
20	*Tridax procumbens*	Asteraceae	coatbuttons
21	*Alycicarpusvaginalis*	Fabaceae	Alyce Clover
22	*Euphorbia hirta*	Euphorbiaceae	Asthma Weed
23	*Pupalialappacea*	Amaranthaceae	Forest Burr,
24	*Peristrophebicalyculata*	Acanthaceae	Kali Angheli,
25	*Cenchrus ciliaris*	Poaceae	foxtail buffalo grass
26	*Aristida* sp.	Poaceae	Common needle grass
27	*Bigostispoaeoides*	Poaceae	canegrass,
28	*Saccharum spontaneum*	Poaceae	Wild Sugarcane
29	*Vetiveriazizanioides*	Poaceae	Vetivergrass

3.8.4 Animals along the Project Corridor

The main faunal element includes Nilgai, Jungle Cat, Small Indian Civet, Ruddy Mongoose and Small Indian Mongoose, Rufous Tailed hare, Por lizard and about 200 species of resident and migratory birds. Hyaena, Leopard, Wolf and Chinkara, reported in the Gazetteer of Delhi, have not been sighted after 1940. While various agencies are engaged in revitalizing the biological potentials and ecological functions of Asola-Bhatti Wildlife Sanctuary, it becomes obligatory to decipher the existing biodiversity of the area, its past potential and possible re-introduction or rehabilitation of the species lost earlier due to dismal degradation, erosion, mining and other human interference over the time. Kumar and Khanna (1997) published a faunal profile of ABWLS based on the work of Kalpavriksha (1991), Sawarkar and Hussain (1997) and Zoological Survey of India.

(1997). The comprehensive and updated faunal profile provided incorporated inventory of 248 species of fauna spreading over 3 species of Mollusca, one species of Thysaneura, one of Odonata, nine of Orthoptera, four of Isoptera, 4 of Coleoptera, one Diptera, 4 Lepidoptera, 5 Hymenoptera, 3 Chilopoda amongst invertebrates, and 2 species of Amphibia, 3 species of Reptilia, 156 species of Aves and ten species of Mammalia amongst vertebrates, as listed below:

Table 3.19: List of Fauna

S. no.	Common Name	Scientific Name	Status
		Aves	
1	Little Grebe	*Podiceps ruficollis*	Least concern
2	Common Coot	*Fulicaatra*	Least concern
3	Painted Sandgrouse	*Pterocles indicus indicus*	Least concern
4	Dusky Crag Martin	*Hirundo concolor*	Least concern
5	Common Redshank	*Tringa tetanus*	Least concern
6	Little Cormorant	*P halecrocoraxniger*	Least concern
7	Grey Heron	*Ardea cinerla*	Least concern
8	Indian Pond Heron or Paddybird	*Ardeolagrayii*	Least concern
9	Cattle Egret	*Bubulcus ibis*	Least concern
10	Little Egret	*Egrettagarzetta*	Least concern
11	The Painted Stork	*Mycteria leucocephala*	Near Threatened
12	Indian Spot-Billed Duck	*Anas poecilorhyncha*	Least concern
13	Black Kite	*Milvusmigransgovinda*	Least concern
14	Black-Shouldered Kite	*Elanuscaeruleus*	Least concern
15	Oriental Honey-Buzzard	*Pern is ptilorhynchus*	Least concern
16	Long-Legged Buzzard	*Buteo rufinus*	Least concern
17	Tawny Eagle.	*A. rapaxvindhiana*	Least concern
19	Western Marsh Harrier	*C. aeruginosus*	Least concern
20	Crested Serpent Eagle	*Spilornacheela*	Least concern

		Amphibians	
21	Indian Bullfrog,	*Rana tigrina*	Least concern
22	Indian Skipper Frog or Skittering Frog,	*Rana cyanophlyctes*	Least concern
		Mammals	
23	Rhesus Monkey	*Macaca mulatta*	Least concern
	Macaca mulatta	*Canis aureus*	Least concern
24	Golden Jackal	*Herpestesauropunctatus*	Least concern
25	Small Indian Mongoose	*Boselaphustragocamelus*	Least concern
26	Bluebuck (Nilgai)	*Lepus nigricolis*	Least concern
27	Black-Naped Hare	*Felis chaus*	Least concern
28	Reed Cat,	*Macaca mulatta*	Least concern
		Reptiles	
29	Pondichéry Fan-Throated Lizard	*Sitanaponticeriana*	Least concern
30	Brooke's House Gecko	*Hemidactylus brooki*	Least concern
31	Spiny-Tailed Lizard,	*Uromastixhardwickii*	Least concern

Source: Some selected Fauna of Asola Bhati Wildlife Sanctuary by Zoological Survey of India

3.8.6 Tree Cutting

The proposed alignment of tunnel is passing through builtup and forest ridge.. There are approximately 417 trees which need to be cut. In compensation for these loss 4170 trees shall be planted. The common trees/species along the alignment were ***Azadirachta indica*** (neem), ***Acacia nilotica*** (Desi Babul), ***Prosopis juliflora*** (Kikar), ***Eucalyptus globulus*** (Safeda), ***Mangifera indica*** (Mango), ***Phyllanthus emblica*** (Amla), ***Syzygiumcumini*** (Jamun), ***Cassia fistula*** (Amaltas) etc.The removal of the trees and vegetation cover will disrupt the local ecological balance and force small birds, mammals, and other species to migrate to other areas. However, the short-term impact of construction is expected to be reversed over the long term with the addition of trees and shrubs through transplantation efforts. It has been determined that no endangered species will be affected by the project. The girth wise trees that need to be cut have been shown in **Annexure VIII.**

Table 3.20: List of trees to be felled.

Name of Species	Scientific Name	Total Number of Trees
Amaltas	*Cassia fistula*	14
Bakain	*Melia azedarach*	2
Bargad	*Ficus benghalensis*	1
Ber	*Ziziphus mauritiana*	10
Chichhi	*Achyranthes aspera*	5
Ficus	*Ficus benjamina*	15
Gulmohar	*Delonix regia*	6

Gular	*Ficus racemosa*	3
Jamun	*Syzygium cumini*	19
Kachnar	*Bauhinia variegata*	6
Kanail	*Cascabela thevetia*	5
Kikar	*Vachellia nilotica*	60
Mahua	*Madhuca longifolia*	1
Neem	*Azadirachta indica*	66
Pakad	*Ficus virens*	7
Papri	*Holoptelea integrifolia*	10
Pipal	*Ficus religiosa*	9
Saptaparni	*Alstonia scholaris*	147
Semal	*Bombax ceiba*	2
Shahtoot	*Morus alba*	3
Shisham	*Dalbergia sissoo*	1
Sirs	*Albizia lebbeck*	1
Subabul	*Leucaena leucocephala*	17
Total		**417**










Trees which are going to be felled

3.8.6 Wildlife Protected Areas

In Project region there is no any presence of Eco-sensitive Zone or core zone of any Wildlife Sanctuary and National Parks.

3.9 SOCIO-ECONOMIC PROFILE OF THE STUDY AREA

3.9.1. Introduction

The project road starts from Shiv murti Interchange (Dwarka Expressway Package-1) to Nelson Mandela Marg. A Bypass to Rangpuri will connect Dwarka Expressway with Vasant Kunj through Nelson Mandela Marg. It has been proposed to extend the existing Nelson Mandela Marg via a tunnel towards Gurgaon/ Dwarka with an interchange near Shiv Murti to connect NH-8 and Dwarka Expressway. The entire alignment is green field till Nelson Mandela Marg.

The initial stretch of the alignment is passing beneath the Rangpuri Farmhouse area after that the alignment passes through the Rangpuri Forest and Vasant Kunj farm houses till Nelson Mandela Marg. The Entire project passes through the New Delhi.

Total length of the proposed alignment is approx. 4983 m and proposed Right of Way (RoW) of the project varies from 30-45 m. No land acquisition is proposed for the highway alignment.

The study aimed to make a comprehensive socio-economic assessment for the development of the 6-Lane Tunnel project.

3.9.2 Project Influence District:

The project alignment passes through New Delhi and South Delhi district in the state of Delhi. Therefore, in order to understand the socio-economic profile of the influence area of the project corridor, a micro-level analysis is essential.

3.9.3 Population

The proposed tunnel in Delhi passes through the developed part, where the socio-economic conditions of the people are good. Details of Population of Project District and state are given below **Table 3.21**

Table 3.21: Details of Project affected District i.e New Delhi & South Delhi

	District New Delhi			District South Delhi		
	Total population	**Total population Male**	**Total population Female**	**Total population**	**Total population Male**	**Total population Female**
Rural	-	-	-	12,193	6,819	5,374
Urban	1,42,004	77,942	64,062	27,19,736	14,60,609	12,59,127
Total	**1,42,004**	**77,942**	**64,062**	**27,31,929**	**14,67,428**	**12,64,501**

Source: Census 2011

3.9.4 Demographic Profile

The project is passing through The NCT of Delhi

The demographic profile of the project affected area shows that New Delhi and South Delhi would be mostly preferbous under the highway project in terms of area and population. The demographic profile of above project district is given below **Table 3.22**

Table 3.22: Details of Demographic Profile

Particular	Delhi	New Delhi	South Delhi
No. of Villages	112	0	3
Total Population	16,787,941	1,42,004	27,31,929
No. of Household	3,407,586	32,051	5,58,863
Decadal Population (%)	21.21	-20.81	20.51
Area in sq km	1483	35	247

Density of Population (Persons per sq Km.)	11320	4,057	11,050
Sex Ratio	868	822	862
Literates	12,737,767	1,14,179	20,78,402
Literacy	86.21	88.34	86.57
Schedule Caste	2,812,309	33,245	4,22,926
Schedule Tribes	0	0	0
Main Workers	5,307,329	56,471	8,65,089
Marginal Workers	279,720	3,070	55,307
Non-Workers	11,200,892	82,463	18,07,536

Source: Census 2011

3.9.5 Agriculture

The important crops grown in NCT of Delhi are Wheat, Gram, Bajra and Jowar. Production of wheat was 82142 metric ton, jowar was 30328 metric ton, paddy was 30297, bajra 2689, maize 834 metric ton among cereals in 2011-2012. The production of potatoes was 14628 metric ton and Sugarcane 226 metric ton in 2011-2012.The alignment is mostly passing through built up and Ridge area, there is no major agriculture activity found along the project except at few place where vegetables were sown at farmhouses.

3.9.6 Population Growth and Urbanization

According to 2011 Census, the population of NCT of Delhi is 1,67,87,941 which comprises of 89,87,326 males and 78,00,615 females. During the decade 2001-2011, the total population has grown by about 29,37,434 lakhs, recording a growth of 21.2 percent. District wise growth between 2001 and 2011 has been recorded as; North-West(27.8), North(13.8) ,North-East (25.8), East (16.8), New Delhi (-20.7), Central (-8.8), West (19.5), South West (30.6), South (20.3).

The proposed project will not cause any displacement or loss of livelihood along the project as tunnel is underground will not affect any structure.

3.9.7 State's Economy

The GSDP of Delhi at Current Prices is expected to increase from 8343756 Crore in 2011-12 to 8786342 Crore in 2020-21 and 8923967 Crore in 2021-22 signifying an annual average growth rate of 10.49% (2011-12 to 2021-22). The growth in nominal GSDP of Delhi during 2021-22 is estimated at 17.65% as compared to the contraction of 1.06% during 2020-21. The annual increase in nominal GDP at National level during 2021-22 is estimated at 19.4% as compared to the contraction of 1.4% during 2020-21.

In real terms, GSDP at constant (2011-12) prices is expected to increase from 8343756 Crore in 2011-12 to 9564669 Crore in 2020-21 and 9622450 Crore in 2021-22 with annual average growth rate of 6.19% (2011-12 to 2021-22). The growth in real GSDP of Delhi during 2021-22 is estimated at

10.23% as compared to the contraction of 3.86% in 2020-21. The annual increase in real GDP at national level during 2021-22 is estimated at 8.9% as compared to the contraction of 6.6% during 2020-21.

Source: Delhi State Statistical Abstract, 2022

3.9.8 The Per Capita Income

1st Revised and Advance Estimates of Per Capita Income for the year 2020-21 and 2021-22 at current prices are estimated at ₹344136 and ₹401982, respectively with the contraction of 3.27% and a growth of 16.81% over the previous years. At the National level, Per Capita Income for the year 2020-21 and 2021-22 were ₹126855 and ₹145848 respectively with the contraction of 4.0% and a growth of 15.1% over previous years.

Per Capita Income at constant prices for the years 2020-21 and 2021-22 is expected to touch a level of ₹242110 and ₹263477 as compared to 185001 during the base year 2011-12 indicating the contraction of 6.69% and a growth of 8.38% respectively over the previous years. At National level, Per Capita Income for the year 2020-21 and 2021-22 is estimated at ₹85110 and ₹91723 respectively showing contraction of 9.7% and a growth of 7.8% over the previous years. Per Capita Income of Delhi is around three times higher than the National level Per Capita Income.

Source: Delhi State Statistical Abstract, 2022

3.9.9 Education

The total number of schools (Pre-primary, Primary, Middle, Secondary, Sr. Secondary) estimated to be working during the year 2020-21 comes to 5666. The total nos. of students enrolled at different levels comes to 44.80 lakhs, the enrolled students up to Senior Secondary School, there were 23.60 lakhs boys and 21.20 lakhs were girls during the year 2020-21. The total number of teachers working at different levels and schools were 1.52 lakhs during the year 2020-21.

However, no school or any other education facility was found along the alignment of the proposed project.

Source: Delhi State Statistical Abstract, 2022

3.9.10 Industry

The total number of working companies as on 31st March-2021 registered under Companies Act-2013, in Delhi is 2,20,386, out of which 16,109 were registered during FY 2020-21. However, 37 companies have ceased to work during the same Financial Year. During 6th Economic Census-2013, there were 8,75,308 establishments in Delhi including 7008 Establishments engaged in Agriculture activities, 1,84,187 Non-Agricultural Establishments (Other than services) and 6,84,113 establishments engaged in Non-Agricultural activities (service sector). The Index of Industrial Production for the year 2020-21 is 140.91 (Base year 2011- 12=100), whereas index for Manufacturing Sector is 142.32 and for electricity sector is 138.90.

Source: Delhi State Statistical Abstract, 2022

However, no industry was found along the alignment of the proposed project.

CHAPTER-4: ANTICIPATED ENVIRONMENTAL IMPACTS & MITIGATION MEASURES

4.1 INTRODUCTION

This chapter identifies potential environmental impacts and its mitigation measures due to Construction of Tunnel. Impact Assessment involves evaluation of any adverse or beneficial impacts arising from project activities on physical and biological components of the environment. Mitigation measures are proposed in order to minimize and control adverse environmental impact to acceptable levels and to achieve the expected outcomes of the project being implemented with minimal loss to the environment.

Prediction of impacts is the most important component in environmental impact assessment studies. Both, qualitative and quantitative techniques and methodologies are used to identify/analyse the potential impacts likely to arise as a result of the proposed development activities on physical, ecological and socio-economic constituents of the environment within the study area.

The proposed project activity is expected to result in various impacts on the environment during two distinct phases of its execution, as indicated below.

- Construction Phase
- Operation Phase

The Environmental Impact Assessment focuses on following basic environmental components, viz.

- Environment Health & Safety
- Labour Welfare & Safety
- Land Environment (Soil)
- Water Environment
- Biological Environment
- Air Environment
- Noise Environment
- Socio-economic Environment
- Cultural Heritage

4.2 ENVIRONMENT HEALTH AND SAFETY

- Failure in safety measure shall lead to incident/accidents.
- Hazards due to improper ventilation system of tunnel.
- Fire & other mechanical accidents during the construction.
- Occupational hazards can arise during work.
- Transmission and spread of diseases.

Mitigation measure

- Tunnel ventilation will provided based on exhaust calculation by considering no of manpower, vehicle exhaust, construction dust etc.

- Entry and exist of workers are recorded in a register and tunnel entrance shall be guarded by security guard (24 hours x 7 days).
- Fire extinguishers and fire-buckets appropriate to the hazard should be conveniently located and identified.
- System of work permit shall be followed.
- Suitable warning and **'NO SMOKING' signs shall be posted in all such places**.
- Parallel water line shall be provided for fire and dust suppression
- Explore possibility of fogging machine for dust suppression
- Periodical medical check-up of the workers at least once in three months to be done and recorded
- All operations inside the tunnel shall be carried out under the supervision of a competent engineer.
- Contractor shall estimate the volume of air required in tunnel, and shall be estimated based on following: a) Length of heading b) Size of tunnel, c) Temperature and humidity
- Contractor should be committed for Environment, health, safety and workers wellbeing. Record keeping & should be well maintained
- EHS awareness through signage board. Provision of extinguishers at electrical installation, DG Set etc. along with Sand Buckets.
- Work rotation should be practiced to reduce worker's exposure to high noise levels
- Welder's protective eye-shields and gloves to workers engaged in welding works
- Protective goggles and clothing to workers engaged in stone breaking activities and workers shall be seated at sufficiently safe intervals
- Earplugs to workers exposed to loud noise (above75 dB(A)) and workers working in crushing compaction or concrete mixing operation.
- Adequate safety measures for workers during the handling of materials at the site are taken up.
- The Contractor shall not employ any person below the age of 18 years for any work.

4.3 LABOUR/EMPLOYEE WELFARE & SAFETY

Proposed construction works will generate employment for the local people which may raise risk of social conflicts due to religious, cultural or ethnic differences or Gender-based violence.

Mitigation measures

- Contractor should ensure that workers' working hours should not exceed more than nine hours a day or forty-eight hours a week and wage register must be maintained.
- Provide a day of rest every week.
- Proportional engagement of women to total human resource engagement. Engage women labour from different caste/class; provide equal remuneration; provide separate toilet facilities for women workers

- In cases where the workmen employed the Contractor perform the same or similar kind of work as the workman directly employed by the Principal Employer of establishment, the wages rates, holidays, hours of work and other conditions of service of the workman of the contractor shall be the same as applicable.
- In every establishment where 50 or more woman or ordinarily employed as contract labour there shall be provided two rooms of reasonable dimensions for the use of their children under the age of 6 years.
- One of such rooms would be used as a play room for the children and the other as bedroom for the children. For this purpose, the contractor shall supply adequate number of toys and games in the play room and sufficient number of cots and beddings in the sleeping room. The standard of construction and maintenance of the crèches may be such as may be specified BOWC Act.
- Every migrant workman shall be entitled to allowance, benefits, etc., as prescribed in the Act.
- No female workman shall be employed by any contractor before 6 a.m. or after 7 p.m. Also have provision under employment contract to reflect POSH rules 2013.
- All workers working in construction and allied activities shall have insurance
- A canteen facility shall be provided for the use of workers in case of more than 250 workers employed.

Note: To ensure safety, health and hygiene of workers, the contractor shall develop and implement site specific Health and safety plan and prepare a detail Standard operating procedures (SOPs) for each activity, which has potential to trigger injury and accident.

4.4 POTENTIAL IMPACTS ON SOIL

Soil is one of the most important components of the natural environment. For road development the soil is primarily needed for altered road embankment. The potential impacts due to project activities are listed below.

➢ **During Construction Phase**

4.4.1 Loss of Productive Soil

- Loss of productive soil due to site clearance and related activities.
- Operation of heavy machinery and related equipment for earthmoving and construction
- This region will be used for construction so the productivity does not arise.

Compaction of Soil

➢ Soil compaction due to movement of heavy equipment, movement of heavy vehicles at the site.

4.4.2 Erosion

The soil along the project is sandy clay loam in nature. The two important eroding agents are, (i) the run-off water due to construction, and (ii) the wind. The run-off dynamics are affected by the degree of

slope, extent of deforestation and the amount of water stored for irrigation. Grasses and other herbaceous plant limit the surface erosion effectively.

The potential impact includes:

- The ROW of the proposed alignment is mainly passing through Ridge and built-up area. The degree of soil erosion is noted to be less.
- Cutting of trees and clearance of vegetation at some points may cause the soil erosion but only for short duration. Some mitigation measures like:
  - (i) Cutting of trees in phases.
  - (ii) Taking advantage of the period of monsoon.

4.4.3 Contamination of Soil

In the present project, contractor will use diesel, Concrete, Bitumen, Emulsions etc during construction of tunnel. However, at material storage site, interceptor / HDPE sheets will be provided to avoid any soil contamination. Hence, the contamination of the soil is negligible. **Table No. 4-1** describes the impacts of soil and mitigation measures suggested.

Table No. 4-1: Impacts on Soil and mitigation measures suggested

Location	Type of impact		Mitigation measures suggested
	Loss of productive soil	Erosion / Contamination	
Along the project	Loss	Very less	➢ Top soil should be removed & stored separately during excavation. ➢ All hazardous wastes and hazardous materials, lubricating oil, solvents and fuels, will be stored within a bounded area. ➢ Adequate measures like provision of adequate drainage facilities, and slope stabilization will be carried out along the proposed access road. ➢ Minimize major earthworks during the rainy season, to the extent feasible

➢ **During Operation Phase**

No significant impacts are predicted other than those resulting from neglected protection works in erosion prone areas and failure to maintain re-vegetated areas along the alignment at approach road, and debris disposal sites.

Mitigation measures

To prevent soil erosion along the embankment during operation phase, regular monitoring inspections should be undertaken to ensure that drainage, approaches and re-vegetated areas are maintained and strengthened to prevent reoccurrence of soil erosion.

4.4.4 Muck Disposal

Waste will be generated due to construction of tunnel. Waste generated by excavation and by the tunnelling activity can be used for construction purpose. The unused muck which is left behind is proposed to be dumped at pre-identified locations nearer Connector corridor from Delhi Meerut Expressway. The Muck Disposal Plan along with muck generation quantity is attached as **Annexure-VII**.

4.5 IMPACTS ON WATER RESOURCES

Road development can lead to three types of modifications to the natural hydrological environment. These are:

4.5.1 Modification of the Surface Water Flow

The proposed project will no way alter the existing course of the surface water flow. However, the existing drainage problem will be mitigated in the proposed project.

The tunnel is design in such a way that the alignment of tunnel is not passing through any surface water body. So, no alteration and modification of surface water is required.

4.5.2 Modification of the Groundwater Flow

The ground water table in the project area is at about more than 40mbgl. However the chance of water contamination is less. The source of drinking water is the ground water/piped supply.

4.5.3 Rainwater Harvesting

As the proposed project is a tunnel does not have any scope of rainwater harvesting. However, a proper drainage system will be implemented during construction to avoid the problem of rainwater stagnant.

4.5.4 Use of Local Water Supply

There will not be any impact on local water supply since no local water supply will be used for construction purposes. Water will be arrange by contractor. Underground water will be taken after permission of concerned authority at construction sites if required.

4.5.5 Water Quality Degradation

Some important parameters like pH, Chlorides, alkalinity etc. were compared with the acceptable standard for drinking water. No direct impact on water quality is predicted.

4.5.6 Drainage

There are several impacts listed out for the drainage issues:

- Change in drainage pattern of surface due to construction of underground tunnel.

Mitigation Measures

- Adequate longitudinal drainage facility shall be provided along the proposed Tunnel Project.

- Adequate cross drainage channels will be provided for the smooth passage of the surface run-off.
- The existing drainage channels will be kept open without filling them.
- Provision of suitable drainage channels at the construction site to avoid any water stagnation, soil erosion and mosquito breeding.

4.6 IMPACT ON AMBIENT AIR QUALITY

The ambient air quality in the project corridor is not good and fails in national ambient air quality standards, 2009 at some locations. Some important observations in the Ambient Air quality are:

- The emissions of individual vehicles, their monitoring and regular checks are important. The maintenance of engines, and engine temperature must be properly regulated for improved scenario. Vehicle with valid PUC and fitness certificate will allowed at site.
- As there is no structure of archaeological importance going to be affected due to proposed alignment, the impact does not need an assessment from this point of view.
- By and large the pollution level with regard to Particulate Matter 2.5 ($PM_{2.5}$) and Particle Matter 10 (PM_{10}) at all study sites were within the limits. The other parameters of air quality measurements, namely, NO_x, SOx and Carbon Monoxide at all selected sites were also recorded to be within the prescribed limits.
- The mitigative measures suggested include enforcement programs covering vehicle standards and maintenance requirement, fuel quality and technology, management of traffic efficiency and removing the high-pollution vehicles besides plantation of tall, leafy, and dense vegetation to filter and adsorb some pollutants.
- Sensitive areas will be taken care of especially in this regard.

4.6.1 Impacts During Construction Phase

The project site impact on ambient air quality within the project site and nearby areas may be significant during the construction phases. The particulate matter will be the main pollutant due to the excavations, handling and transport of earth and construction material etc. at site. The other pollutants will be NO_x & SOx due to the construction activities like operation of construction equipment and traffic movement.

Since the construction activities is a temporary activity and hence the increase in particulate matter and NO_x will be for short duration and its impact will be felt close to the construction site only. Outside the boundary of project activities, the impacts would be marginal or insignificant.

Generation of exhaust gases is likely due to movement of heavy machinery for clearance of the proposed ROW for construction. Toxic gases are released through the heating process during bitumen production. Although the impact will be much localized, it can spread downwind direction depending upon the wind speeds. The health effects of inhaling particulate matter have been widely studied in humans and animals and include asthma, lung cancer, cardiovascular issues, and premature death.

4.6.1.1 Use of fly Ash

As per the direction of MoEF&CC.

4.6.1.2 Borrow Area Soil

Not required for tunnel.

4.6.1.3 Aggregates and Fine Aggregate (Sand) Materials

The Coarse Aggregate and Fine Aggregate will be used for the construction of the proposed project. The Aggregate will be brought from the approved Mine quarry and approved supplier of project districts and nearby places.

4.6.1.4 Bitumen

The Bitumen will be used for the construction of the proposed project. The total demand of Bitumen will meet from the nearest Refinery.

4.6.1.5 Cement

The Cement will be used for the construction of the proposed project. The total amount of cement will be brought through the nearby approved suppliers of Delhi NCR and nearby places.

4.6.1.6 Steel

The tentative 17,213.42 tonn of Steel will be used for the construction of the proposed project and will meet through the nearby approved suppliers of Delhi, NCR and nearby places.

4.6.2 Impacts During Operation Phase

In operation phase of tunnel due to traffic load leads to increase in the quantity of PM 10, PM2.5, NOx etc in environment especially at Entry and Exit of tunnel. .

4.6.2.1 Prediction of Impact on Ambient Air Quality

To assess the impact on air quality of the project area during operation phase, air pollution dispersion modeling was carried out using future traffic projections. The modeling was carried out using CALINE-4, line source model developed by the California Transport Department. Carbon monoxide (CO) is the main component of the vehicular pollution. So, prediction of CO concentration is representative of the impacts of air pollution due to traffic movement.

CALINE - 4 Model

The air dispersion model used is ***CL4 (A Graphical User Interface for CALINE4)*** developed by the California Department of Transportation (Caltrans) for predicting air pollutant concentrations near roadways. CALINE4 is a simple line source Gaussian plume dispersion model.

CALINE4 is a model based on the Gaussian diffusion equation and employs a mixing zone concept to characterize pollutant dispersion over the roadway. The purpose of the model is to assess air quality impacts near transportation facilities. Given source strength, meteorology and site geometry, the model can predict pollutant concentrations for receptors located within 500 meters of the roadway. It

also has special options for modeling air quality near intersections, street canyons and parking facilities.

CALINE4 divides individual highway sections into a series of elements from which incremental concentrations are computed and then summed to form a total concentration estimate for a particular receptor location. Downwind concentrations from the element are modeled using the crosswind FLS (Finite Line Source) Gaussian formulation, but dy and dz are modified to consider the mechanical turbulence created by moving vehicles and the thermal turbulence created by hot vehicle exhaust in the region directly over the highway, region considered as a zone of uniform emissions and turbulence.

Input Data Requirement:

- **Emissions**

  The emissions are provided by traffic volume (vehicles/h) and emission factor (grm/s/vehicle) for each section

- **Meteorology**

  Wind speed Wind direction Wind direction standard deviation Atmospheric stability Class Mixing Height Ambient Temperature.

The details of input parameters considered for the modeling exercises are presented in the following paragraphs.

- **Traffic Data**

The traffic surveys have been carried out along the corridor to establish base year traffic with reference to traffic movements. Average hourly traffic data has been considered for the present modeling exercises.

- **Meteorological Data**

"Worst case wind angle" run type was considered to predict the worst-case scenario. The met inputs entered were:

- Wind speed: 1.0m/s
- Stability Class: F
- Mixing Height: 50m
- Standard Deviation: 5°
- Ambient Air Temperature: 18°C

4.6.2.3 Change in Ambient air and GLC

The air pollution impact of excavation in ordinary earth and boulders & rock is directly dependant upon construction methodology, annual rate of excavation, mode of transport within the construction site, mode of screening and method of crushing. The air pollution sources at the proposed project site can be broadly classified into three categories, viz. area source, line source and instantaneous point source.

Excavation by various activities in project area is construed as an area source which includes excavation pit(s) and activities happening in the excavation area like digging, dozing, hauling and

loading/unloading. The dust emission from these areas will be fugitive in nature. The excavator operations, loading/unloading operations will also cause dust emission though it will be confined to the area of operation of the machinery. The gaseous emission from their operation shall be minimal and limited within the project.

Transportation of excavated material from the project site to dumping sites area located at Connector corridor from Delhi Meerut Expressway categorized as line source. As per calculation 184 trips per days will be done for transportation of muck from project site to dumping site. All dumper will be covered by tarpaulin to avoid the fall of material due to wind.

Dust Dispersion Modeling for Excavation Operation

1. Change in Ambient air and GLC

The air pollution impact of excavation in ordinary earth and boulders and rock is directly dependent upon construction methodology, mode of transport within the construction site.The air pollution sources along the project can be broadly classified into three categories, viz. area source, line source and instantaneous point source.

Dust Dispersion Modeling for Excavation

In the present study, United States Environmental Protection Agency (USEPA-42 series) approved mathematical equations have been used to predict concentrations for different operations in project including the material transportation. To predict the particulate emissions, Envirans AERMODCloud (Air Dispersion Modeling Software) an interface based on ISCST3 + was used to predict changes in **air quality i.e., maximum ground level concentration (GLC's) of Particulate Matter. Short term model** options were opted for uniform emissions rates. The air modeling was restricted to determination of PM10, PM2.5, SO2 and NOx in the present case for the start and end point of tunnel road.

<u>During Construction Period:</u>

The isopleth developed for PM10, PM2.5, SO2 and NOx along the project alignment at start and end point of tunnel and are shown in **Figure 4.1 to Figure 4. 4** for start point and in **Figure 4.5 to Figure 4.8** for end point for PM10, PM2.5, SO2 and NOx respectively.

The maximum ground level concentration (GLC) due to excavation, loading & unloading activities at start and end point of tunnel for PM_{10}, $PM_{2.5}$ SO_2 and NO_x has been shown in Table 1 and Table 2 respectively.

<u>Table 4.2: Maximum Concentration at receptors (At start point)</u>

Location	Pollutants	N-Cord.	E-Cord.	GLC ($\mu g/m^3$)
(AAQ1)	PM 10	28°3'55.17"N	77° 5'22.62"E	11.1
(AAQ1)	PM 2.5	28°3'55.17"N	77° 5'22.62"E	6.9
(AAQ1)	SO_2	28°3'55.17"N	77° 5'22.62"E	3.1
(AAQ1)	NO_x	28°3'55.17"N	77° 5'22.62"E	3.4

Table 4.3: Maximum Concentration at receptors (At end point)

Location	Pollutants	N-Cord.	E-Cord.	GLC (µg/m³)
(AAQ2)	PM 10	28°3'44.99"N	77° 8'53.91"E	10.8
(AAQ2)	PM 2.5	28°3'44.99"N	77° 8'53.91"E	6.6
(AAQ2)	SO_2	28°3'44.99"N	77° 8'53.91"E	2.8
(AAQ2)	NO_x	28°3'44.99"N	77° 8'53.91"E	3.1

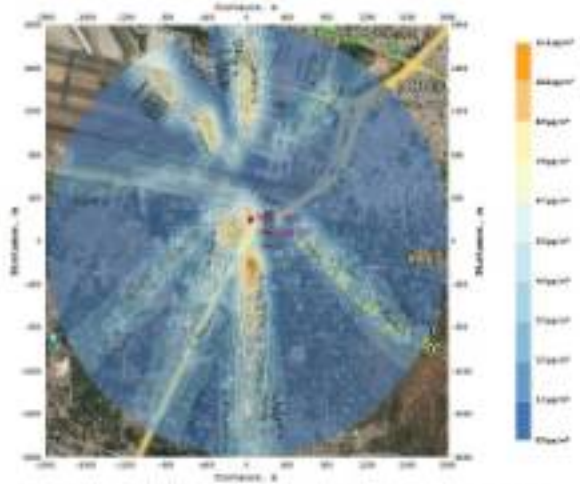


Figure 4.1: Isopath of Maximum Predicted 24 hourly Ground – Level Concentrations for PM_{10}

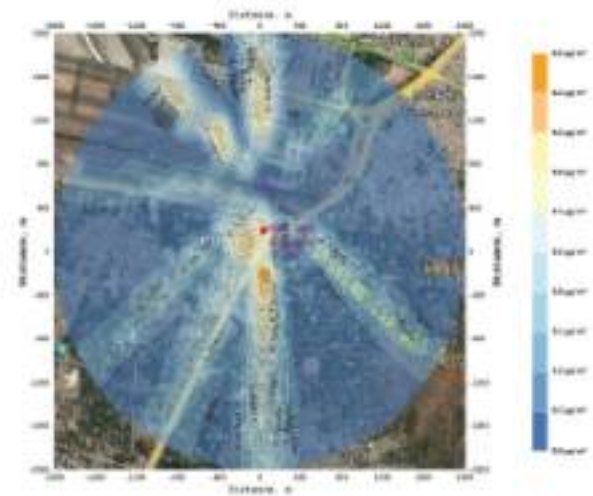


Figure 4.2: Isopleth of Maximum Predicted 24 hourly Ground – Level Concentrations for $PM_{2.5}$

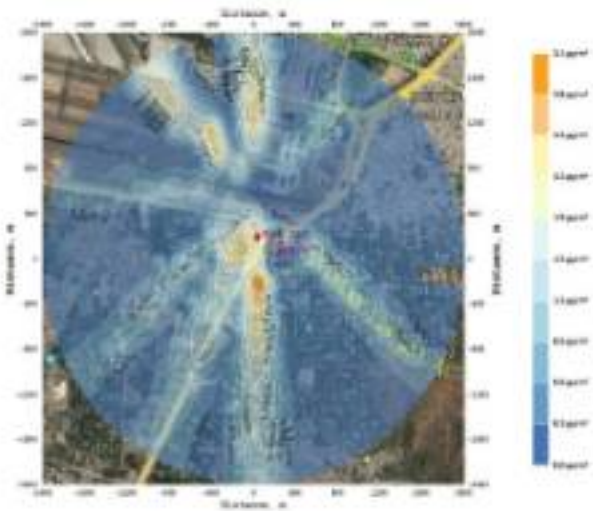


Figure 4.3: Isopleth of Maximum Predicted 24 hourly Ground – Level Concentrations for SO_2

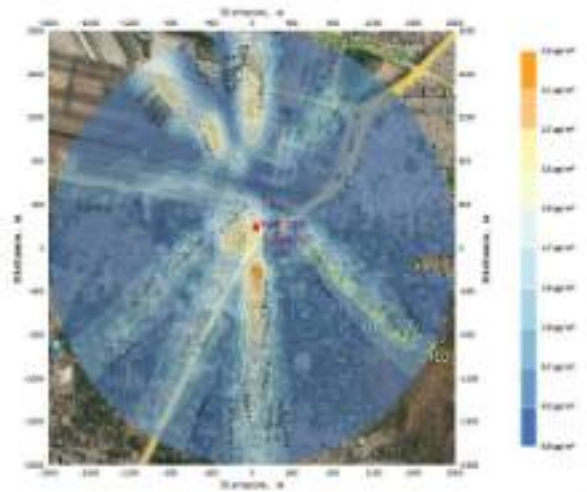


Figure 4.4: Isopleth of Maximum Predicted 24-hourly Ground – Level Concentrations for NO_x

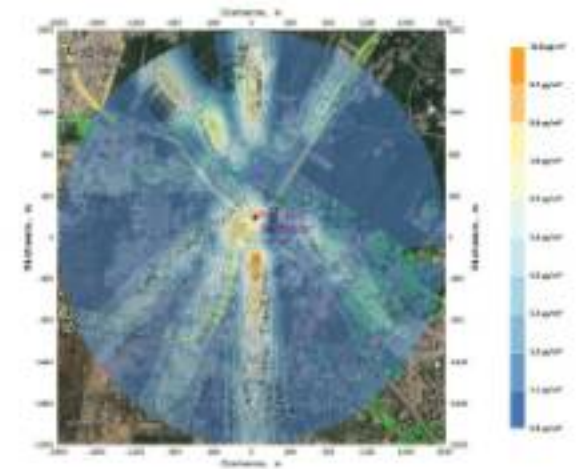


Figure 4.5: Isopleth of Maximum Predicted 24-hourly Ground – Level Concentrations for PM_{10}

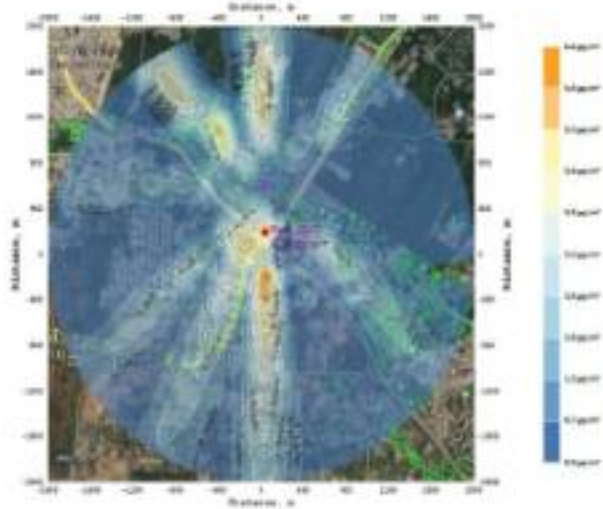


Figure 4.6: Isopleth of Maximum Predicted 24 hourly Ground – Level Concentrations for PM

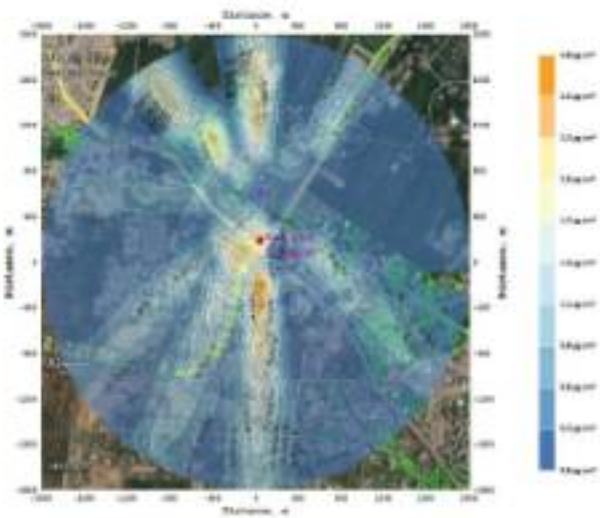


Figure 4.7: Isopleth of Maximum Predicted 24 hourly Ground – Level Concentrations for SO

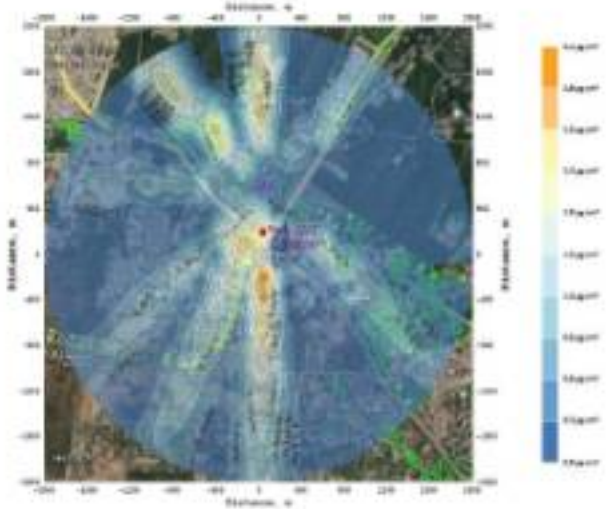


Figure 4.8: Isopleth of Maximum Predicted 24 hourly Ground – Level Concentrations for NO_x

Resultant Impact

The resultant impact due to construction activities on the ambient air quality for PM_{10}, $PM_{2.5}$, SO_2 and NO_x at start and end point of tunnel are presented in **Table 4.4 and Table 4.5.**

Table 4.4: Resultant levels due to excavation and construction activities (At start point)

Sampling Station	Pollutants	Max. Conc. ($\mu g/m^3$)	Predicted GLC ($\mu g/m^3$)	Resultant concentration ($\mu g/m^3$)	NAAQS ($\mu g/m^3$)
(AAQ1)	PM_{10}	216.5	11.1	227.6	100
(AAQ1)	$PM_{2.5}$	125.6	6.9	132.5	60
(AAQ1)	SO_2	19.5	3.1	22.6	80
(AAQ1)	NO_x	34.6	3.4	38	80

Table 4.5: Resultant levels due to excavation and construction activities (At end point)

Sampling Station	Pollutants	Max. Conc. ($\mu g/m^3$)	Predicted GLC ($\mu g/m^3$)	Resultant concentration ($\mu g/m^3$)	NAAQS ($\mu g/m^3$)
(AAQ8)	PM_{10}	176.4	10.8	187.2	100
(AAQ8)	$PM_{2.5}$	102.3	6.6	108.9	60
(AAQ8)	SO_2	15.9	2.8	18.7	80
(AAQ8)	NO_x	28.2	3.1	31.3	80

Mitigation Measures for Air Quality

Construction Phase

Impacts to the air environment during construction will largely result from the generation of dust. Dust will be generated as a result of site clearing and grading, heavy machinery travelling over exposed soils, traffic and off-site quarries. After removal of the vegetation, suspension of particulate matter is also supposed to high in the air by wind and vehicular/machinery movements. Increase in vehicular emissions is also anticipated as large construction vehicles would be employed during construction. Continuous gaseous emission from the running of DG sets at the construction camps.

Mitigation Measures:

Dust Control:

- Proper and prior planning and appropriate sequencing and scheduling of all major construction activities will be done, and timely availability of infrastructural supports needed for construction will be ensured to shorten the construction period vis a vis reduce pollution.
- Construction materials will be stored in covered go-downs or enclosed spaces to prevent the windblown fugitive emissions.
- Truck carrying soil, sand and stone will be duly covered to avoid spilling.
- Adequate dust suppression measures such as regular water sprinkling on unpaved haul roads & vulnerable areas of the construction sites from trucks or other suitable means will be undertaken to control fugitive dust during material handling & hauling activities particularly near habitation especially in the dry seasons.

Emission Control:

- During construction period, all activities are to adhere to the contractual obligations and all clearances and approvals such as 'Consent to Establish' and 'Consent to Operate' shall be obtained from the State Pollution Control Board under Air Act. All vehicles operating for the Contractor and the consultants shall obtain Pollution under Control (PUC) certificate.
- All required clearances are to be obtained from the State Pollution Control Board, SEIAA / MoEF&CC and the Mining Department for establishing quarries, borrow areas and crushers. Contractor should submit copy of such clearances to Supervision Consultant and monitored by PMC before start of activities.
- Sufficient Stack height as per CPCB norms will be provided to control emission within the permissible limits.
- Pollution control devices such as bag filter/cyclone separators/scrubbers shall be installed to control emissions from hot mix plants, crushing units and concrete batching plants. Height of the stacks shall be as per the statutory requirements.
- It will be ensured that all the construction equipment & vehicles are in good working condition, properly tuned and maintained to keep emissions within the permissible limits and engines turned off when not in use to reduce pollution.

During Operation Period:

The isopleth developed for PM_{10}, $PM_{2.5}$ SO_2 and NO_2 along the project alignment during operation phase (Year 2051) and is shown in Figure 9 to Figure 12 for start point and in Figure 13 to Figure 16 for PM_{10}, $PM_{2.5}$ SO_2 and NO_2 respectively.

The maximum ground level concentration (GLC) due to vehicular movement for PM_{10}, $PM_{2.5}$ SO_2 and NO_2 at start and end point has been shown in **Table 4.6 and Table 4.7** respectively.

Table 4.6: Maximum Concentration at receptors (At Start point)

Location	Pollutants	N-Cord.	E-Cord.	GLC (µg/m³)
(AAQ1)	PM 10	28°31'55.17"N	77° 0'22.62"E	6.1
(AAQ1)	PM 2.5	28°31'55.17"N	77° 0'22.62"E	2.8
(AAQ1)	SO_2	28°31'55.17"N	77° 0'22.62"E	2.3
(AAQ1)	NO_2	28°31'55.17"N	77° 0'22.62"E	3.0

Table 4.7: Maximum Concentration at receptors (At end point)

Location	Pollutants	N-Cord.	E-Cord.	GLC (µg/m³)
(AAQ8)	PM 10	28°31'44.99"N	77° 8'53.91"E	5.5
(AAQ8)	PM 2.5	28°31'44.99"N	77° 8'53.91"E	2.6
(AAQ8)	SO_2	28°31'44.99"N	77° 8'53.91"E	2.0
(AAQ8)	NO_2	28°31'44.99"N	77° 8'53.91"E	2.7

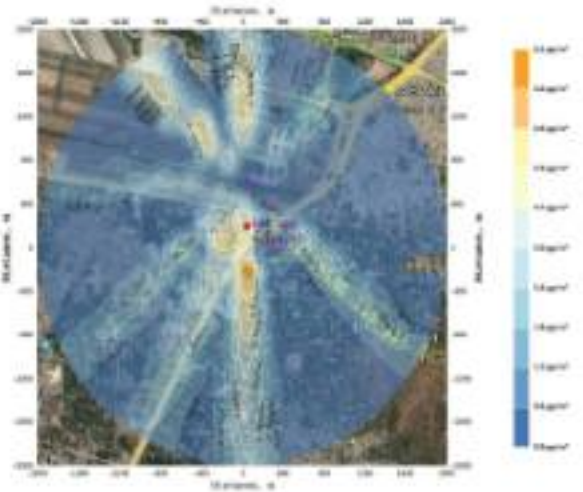


Figure 4.5: Isopleth of Maximum Predicted 24 hourly Ground – Level Concentrations for PM10

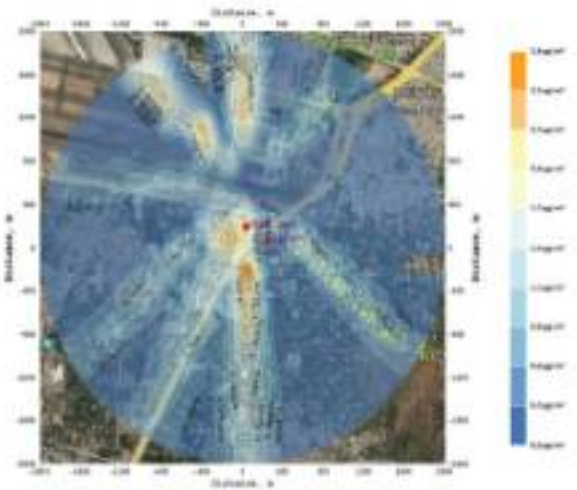


Figure 4.10: Isopleth of Maximum Predicted 24 hourly Ground – Level Concentrations for PM2.5

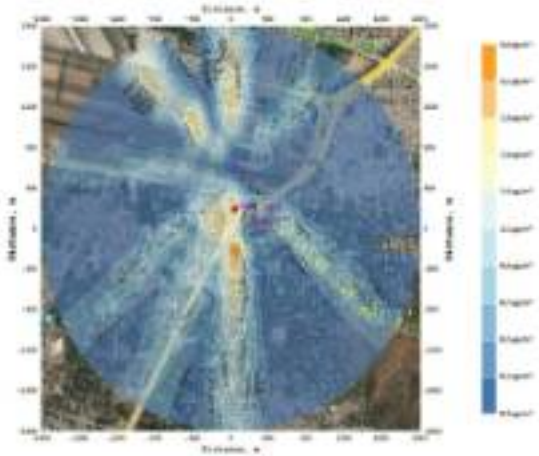


Figure 4.11: Isopleth of Maximum Predicted 24 hourly Ground – Level Concentrations for SO_2

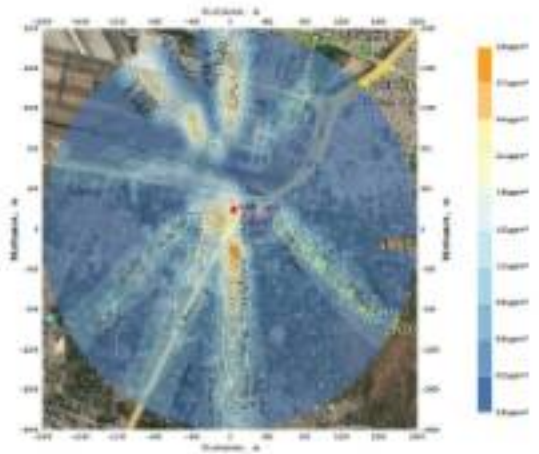


Figure 4.12: Isopleth of Maximum Predicted 24 hourly Ground – Level Concentrations for NO_2

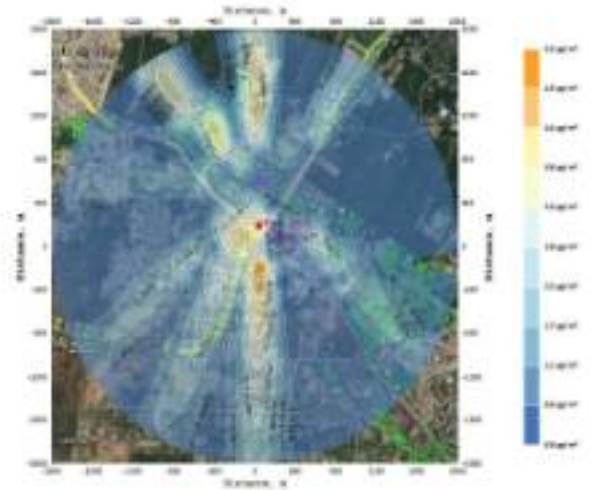


Figure 4.13: Isopleth of Maximum Predicted 24 hourly Ground – Level Concentrations for PM_{10}

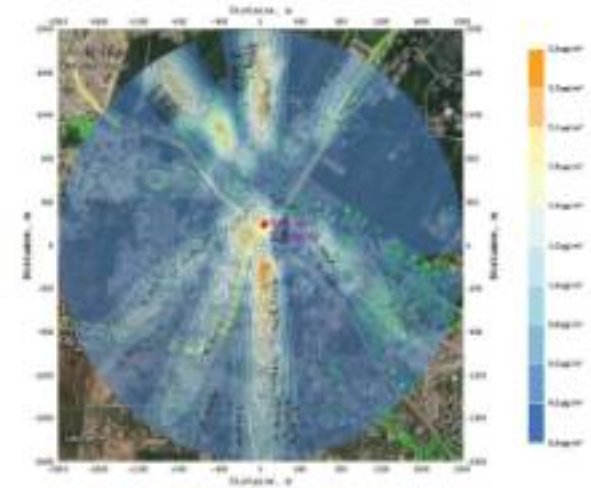


Figure 4.14: Isopleth of Maximum Predicted 24 hourly Ground – Level Concentrations for $PM_{2.5}$

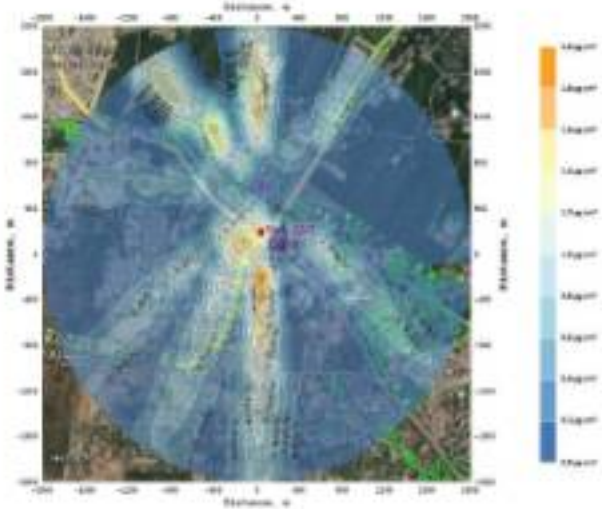


Figure-4.15: Isopleth of Maximum Predicted 24 hourly Ground – Level Concentrations for SO_2

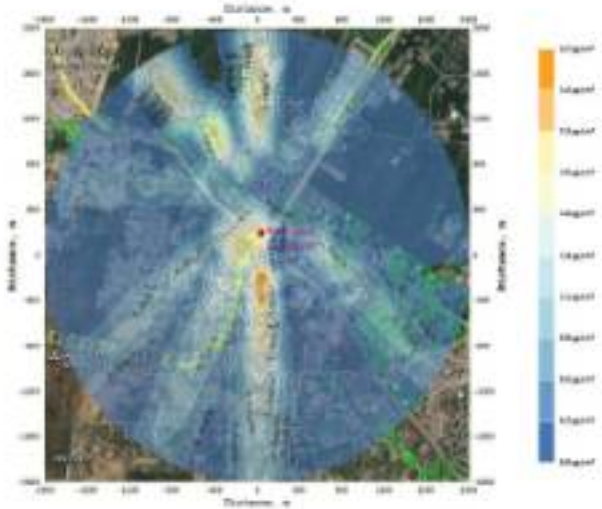


Figure-4.16: Isopleth of Maximum Predicted 24 hourly Ground – Level Concentrations for NO_2

Limitation:

The model should be revalidated after identification of batching plant, TBM segment, traffic route for muck disposal. There it is recommended to the authority to access the impact on environment they should run the Model again.

Mitigation Measures for Air Quality

Operation Phase

- Proper and prior planning and appropriate sequencing and scheduling of all major maintenance activities will be done, and timely availability of infrastructural supports needed will be ensured to shorten the construction period vis a vis reduce pollution.
- Vehicles with valid PUC shall only be allowed to enter the highway
- Water sprinkling shall be done at haulage road.
- Proper handling of the existing traffic and anticipated new traffic to prevent congestion near toll plaza and crossings
- Truck carrying raw material and muck will be duly covered to avoid spilling.

4.7 IMPACT ON NOISE LEVELS

The assessment of potential road noise impacts helps in understanding one of the most significant pollution, the noise pollution. Some salient features related to potential noise impact of a road development include: (i) the road noise impact is greatest where busy road passes through densely populated areas, townships and markets (ii) the range of noise level should be understood in relation to the habitation type also; for example, road noise in industrial area is not likely to be problematic but at sensitive location like schools and hospitals; its impact my be significant. (iii) mitigation of noise in urban areas is rather difficult, specially at the road intersections.

Environmental noise particularly highway traffic noise, is a complex phenomenon because its intensity and characteristics vary with time depending upon the frequency as well as type of vehicles on the road.

The impacts of noise due to the project will be of temporary significance locally in the construction phase and slight increase may occur during the operation stages. **Table No. 4-8** presents the source of noise pollution and the impact categorization.

Table No. 4-8: Source of the Noise pollution and its impact

Sr. No.	Phase	Source of Noise pollution	Impact categorization
1	**Pre-construction**	• Man, material & machinery movements • establishment of labor camps, onsite offices, stock yards and construction plants	• all activities will last for a short duration and also shall be localized in nature
2	**Construction Phase**	• **Plant Site** stone crushing, asphalt production plant and batching plants, diesel	• **Plant Site:** impact will be significant within 500m. • **Work zones:** Such impacts

Sr. No.	Phase	Source of Noise pollution	Impact categorization
		generators etc • **Work zones** Community residing near to the work zones	again will be of temporary nature as the construction site will go on changing with the progress of the works.
3	**Operation Phase**	• due to increase in traffic (due to improved facility)	• Will be compensated with the uninterrupted movement of heavy and light vehicles.

Although the baseline day & night time noise levels monitored at 8 locations along the proposed project are within permissible limits specified by the MoEF&CC. The noise levels varies from 52.4 to 59.7 dB (A) during daytime whereas during night time the noise levels varies from 43.7 dB to 51.0 dB (A). The Mathematical equation is used for noise prediction is L2 = L1-20 Log D2/D1.

4.7.1 Prediction of Noise Impact on Noise level

A noise propagation modeling study has been conducted to find out the impact from the noise generated because of the estimated total traffic flow as well as the significance of these impacts. The noise modeling has been done taking into account the design speed at various stretches and the stretches with restricted speeds have also been considered. Dhwani PRO is a computer program developed to undertake construction, industrial and traffic noise propagation studies for noise assessment.

Different operative speeds have been used for various horizon years in the design life to get a realistic picture of the noise levels. DhwaniPRO is used for noise modeling. Noise Modelling will be provided in Final EIA report.

4.7.2 Mitigation measures to reduce Noise levels

The following are the mitigation measures to reduce noise pollution:

- Noise standards will be strictly enforced for all vehicles, plants, equipment, and construction machinery. All construction equipment used for an 8-hour shift will conform to a standard of less than 90dB (A). If required, high noise producing generators such as concrete mixers, generators, graders, etc. must be provided with noise shields.
- Machinery and vehicles will be maintained regularly, with particular attention to silencers and mufflers, to keep construction noise levels to minimum.
- Workers in the vicinity of high noise levels will be provided earplugs, helmets and will be engaged in diversified activities to prevent prolonged exposure to noise levels of more than 90dB(A) per 8-hour shift.
- During construction vibratory compactors will be used sparingly within the urban areas. In case of complaints from roadside residents, the engineer will ask the site engineer to take suitable steps of restricting the work hours even further or use an alternative roller.

4.7.2 Impact on Vibration

Vibration is the important environmental issue. Vibration due to drilling by TBM can leads to problem on social and wildlife animal.

Impact of Vibration

- TBM also generates ground vibrations and instantaneous noise.
- Vibration can cause disturbance to wildlife also.

Mitigation measures

- The vibrations can be reduced considerably by ensuring and keeping correct track geometry by advanced measurement.
- Effective maintenance programs are essential for controlling ground borne vibrations.
- Controlling noise vibrations at the source.
- Proper maintenance of tunnel excavation equipments

4.8 IMPACT ON FLORA, FAUNA AND ECOSYSTEM

The project has marginal impacts on the Flora and surrounding ecosystem as predominant land use pattern is built-up and ridge forest. The proposed alignment passes through Aravali ridge, permission for which has already been taken from ridge Management Board, however there is no National Park/Sanctuary falling in the alignment.

The anticipated impact on flora will be –

4.8.1 Direct loss in the form of Removal of Trees

- The principal impact on flora involves the removal of trees for the creation of a clear zone within the Corridor of Impact. The felling of trees shall have manifold impact. Most visible impact is the loss of shade. Also, there is a possibility of the local people being deprived of tree products, such as wood, fruits, leaves, etc. A far less contentious issue, which normally takes the back seat, is the importance of the ecosystems supported by the trees. Not only would the removal of trees lead to erosion, it would also mean that the micro-ecosystems developed in the project region with the birds, animals and insects using the plantation over the years would be lost too. About 417 number of trees are located in the proposed RoW. Though the loss of these trees is an irreversible and long-term impact, the loss of the roadside plantations shall have to be compensated in accordance to the principles of the Forest (Conservation) Act and Forest Policy. Compensatory afforestation shall be undertaken with native species and proper care of the saplings will be taken to ensure survival.

Due to implementation of this project approximately 417 nos. of trees will be felled like Neem, Saptaparni, Pipal etc.

- The loss of trees may contribute the deterioration of ambient air quality.

4.8.2 Removal of herbal cover

The removal of herbaceous plants may lead to soil erosion. However, the degree of erosion will be of smaller magnitude. Yet, the loss of soil by erosion could be mitigated by regular watering and re-plantation of vegetative cover, i.e. turfing.

The detailed green belt plan and its maintenance prepared and mentioned in EMP Chapter No 9 Section No. 9.7. Minimum 10 times plantation as per FCA 1980 in form of Compensatory afforestation. The native species selected for plantations are **Neem**, ***Amaltas*** etc.

4.8.3 Flora and fauna Conservation and Mitigation Measures

Assessment of habitat quality, extent and analysis of usage and problems are essential prerequisite for Environmental Management Plan. Predicting barriers caused by local and state activities is critical. The following **measures** could be essentially practiced for the **environmental and biodiversity conservation** in the project area:

1. **Management of Activities**: The conservation need be practiced following local people centric decentralized participatory approach where bottom-up approach for generation of information and practices for conservation need be given priority. A collaborative management approach involving the Forest department, Wildlife wing, Park personnel, local people and knowledge partners, such as, academia and research, and interface institutions like non-profit organizations and trusts would be appropriate for this purpose.

Whenever possible, the Corporates may also be involved as stakeholder to perform their social responsibility in terms of their contribution as monetary support and technology for maintenance of wildlife habitat, habitat improvement and awareness generation. The establishment of project must be discouraged in those areas nearby to Park and eco-sensitive zone.

2. Habitat Management for Wildlife: Both regulatory (for human actions) and habitat management practices including engineering devices need be utilized for managing and improving habitats for wildlife. The landscape approach following decentralized collaborative management need be adapted for this purpose.

The habitat management practices such as, plantation, rain water harvesting, etc., can be adopted.

For good governance in the interest of wildlife conservation and sustainable economic development, the following regulatory measures need be practiced equitably in case of common citizens, authorities and very important persons:

- Wildlife (Protection) Act 1972 and amendments
- The Forest Conservation Act 1980
- The (Prevention and Control of Air Pollution) Act 1981
- The (Prevention and Control of Water Pollution) Act 1974
- The Environment (Protection) Act 1986

- The Biodiversity Act, 2002
- Discharge of effluents as per EPA, 1986
- Noise Pollution and Control Rules, 2000
- Construction and Demolition of Waste Management Rules, 2016
- Solid Waste Management Rules, 2016
- Plastic Waste Management Rules, 2016

4.8.3.1 Impact of Noise, Light and Power lines on Wild animals

The noise, light and human activity pressure due to proposed project may adversely affect the existing wildlife. Construction of tunnel will be under ground in Ridge area; hence no major effect will be seen on Wildlife. However, use of TBM creates vibration to some extend may cause disturbance to wildlife in Ridge area.

Mitigations Measures

- The contractors to establish environmental units and implement public awareness programs during construction regarding the impacts caused by the construction activity.
- The effect of construction activities on Wildlife will be for short time and minimum.
- Workers should be supplied with non-wood fuels such as kerosene or liquefied petroleum gas for the duration of the contract.
- No construction yard will be established at the forest area.
- No disposal of construction waste in the forest premises.

4.9 IMPACT ON PROTECTED MONUMENTS AND CULTURAL HERITAGE SITES

It has been observed that no archaeological site or monument and cultural heritage site is coming along the proposed alignment. Therefore, there would not be any kind of significant impact on the cultural heritage sites.

4.9.1 IMPACTS ON SOCIAL ENVIRONMENT

The construction of tunnel can cause impact to the nearby habitation. Hauling of construction materials and operation of equipment onsite may cause traffic congestion, obstruction and road safety. The impacts are negative but short term, sites specific within a relatively small area and reversible by mitigation measures.

Impairment of visual aesthetics on the general appearance of the area will occur from the clearing of trees, excavation of trenches, storage of excavated and construction materials, generation of solid wastes, and ponding of rainwater.

Mitigation Measures

- Construction tunnel does not require any land acquisition. So there is no impact on livelihood of people.

- In areas where the visual environment is particularly important or privacy concerns for surrounding buildings exist, the site may require screening. The tunnel is underground will not have major impact on visual environment.
- There is no structure is going to impact due to construction of underground tunnel.

4.10 MITIGATION MEASURES FOR PROJECT

The project is likely to bring some negative impacts on the environment and socio-economic structure of the region. While deciding the alignment from environment point of view, some negative potential impacts are unavoidable. In such cases, adoption of mitigation measures is the only solution. Mitigation should be focused on achieving goals within clear timeframes. Use of **SMART** approach is recommended to evaluate the likely effectiveness of alternative mitigation strategies or measures. The **SMART** refers to measures that are **S**pecific, **M**easurable, **A**chievable, **R**ealistic and **T**imely.

A brief description of the approach to mitigation measures on environmental issues is mentioned below.

4.10.1 Soil

The potential impacts, their mitigation, and the phase of implementation to topographic and soil characteristics were assessed and presented in **Table No. 4-9** below.

Table No. 4-9: Potential impacts and their mitigation on Soil

Potential impacts	Mitigation	Implementation Phase
A. Altered embankment	• Not Required	-
B. Borrow pit excavation	• Not Required	-

4.10.2 Water Resources

The potential impacts, their mitigation and the phase of implementation regarding water sources were assessed with regard to surface water bodies and underground water tables with reference to wells and tube wells has been presented in **Table No. 4-10** below.

Table No. 4-10: Potential impacts and their mitigation on Water Resources

Potential impacts	Mitigation	Implementation Phase
A. Surface water bodies	• Provision of proper drainage • Construction camps are properly located • Good engineering practices to be followed to reduce the impact on existing surface sources.	Pre-construction, construction, post-construction and operational phases
B. Underground water	• No appreciable impacts • Water to be used for construction	Per-construction and construction phase

	should have separate source	

4.10.3 Ambient Air Quality

The potential impacts and their mitigation on Ambient Air have been presented in **Table No.4-11** below.

Table No. 4-11: Potential Impacts and their mitigation on Ambient Air

Potential Impacts	Mitigation	Implementation Phase
Dust to construction activities and transport of material	• Machinery to be fitted with pollution control device • Asphalt plant will be equipped with dust collectors • Sensitive places like schools and hospitals to be avoided (at least 500 m away) for Asphalt plants and other generators	Pre-construction, construction and post-construction phases

4.10.4 Noise Levels

Noise particularly highway traffic noise, is a complex phenomenon because its intensity and characteristics vary with time depending upon the frequency as well as type of vehicles on the road. The potential impacts and their mitigation on Noise have been presented in **Table No. 4-12** below.

Table No. 4-12: Potential Impacts and their mitigation on Noise

Sl. No.	Item	Impact	Impact (Reason)	Mitigation/Enhancement
1	Sensitive receptors	Direct impact	Increase in noise pollution	• Noise barrier to be provided • Traffic calming devices to be used. • NO Horn Zone sign Post will be placed.
2a	Noise Pollution (Pre-Construction Stage)	Direct impact, short duration	Man, material & machinery movements Establishment of labor camps, onsite offices, stock yards and construction plants	• Area specific and for short duration • Machinery to be checked & complied with noise pollution regulations. • Camps to be setup away from the settlements, in the down wind direction.
2b	Noise Pollution	Marginal	stone crushing,	• Camps to be setup away from

	(Construction Stage)	Impact	asphalt production plant and batching plants, diesel generators etc. Community residing near to the work zones	the settlements, in the down wind direction. • Noise pollution regulation to be monitored and enforced. • Temporary as the work zones will be changing with completion of construction
2c	Noise Pollution (Operation Stage)	Marginal Impact	due to increase in traffic (due to improved facility)	• It will be compensated with the uninterrupted movement of heavy and light vehicles.
3	Noise Pollution Monitoring		Effectiveness / shortfall (if any) Any unforeseen impact	• Measures will be revised & improved to mitigate/ enhance environment due to any unforeseen impact.
4	Vibrations		Due to TBM drilling	• Controlling noise vibrations at the source

4.11 BIOLOGICAL CHARACTERISTICS

The most important negative impact that the project will cause is the loss of number of trees, leading to (a) enhanced degree of soil erosion, (b) loss of shade, fruits, timbers and other economic activities, and (c) the ecosystem. However, if re-plantation scheme is launched vigorously, it will help in restoring the ecological balance slowly. The effective mitigation measure will reduce the impact to a certain level keeping the developmental project in a sustainable way. The potential impacts and mitigation measures for biological Environment have been presented in **Table No. 4-13**.

Table No. 4-13: Details of potential impacts and mitigation measures for biological Environment

Potential Impacts	Mitigation Measures
Cutting of approx. 417 nos. of Trees	Minimum 10 times plantation as per FCA 1980 in form of Compensatory afforestation.

4.12 SUMMARY OF ENVIRONMENTAL IMPACT ASSESSMENT

Table No. 4-14 presents the summary of Environmental Impact Assessment along with the mitigation measures.

Table No. 4-14: Summary of Environmental Impact Assessment and its Mitigation Measures

S. No.	Parameters	Potential Impact	Mitigation Measures Suggested
1.	Fire & Other Hazards	• Fire accidents & other hazards during the construction.	• Tunnel ventilation will provided based on exhaust calculation by considering no of manpower, vehicle exhaust, construction dust etc. • Fire extinguishers and fire-buckets appropriate to the hazard should be conveniently located and identified • Suitable warning and "NO SMOKING" signs shall be posted in all such places.
2.	Topography and Soil	• Cut and fill operations during road construction	• Cutting will be done by TBM for the underground tunnel. Material/muck generated due to cutting will be used for levelling and rest of the material/muck will be disposed off at pre-identified muck disposal site.
3.	Air environment	• Generation of Dust	• Sprinkling of water at: • Earth handling site • Road construction site • Air pollution control at stone crusher • Provision of PPE for workers • Stone crushing units environment compliance • Regulation of construction timings near sensitive receptors and settlements

S. No.	Parameters	Potential Impact	Mitigation Measures Suggested
		• Gaseous Pollution	• Vehicles and machineries will be regularly maintained to conform to the emission standards. • Asphalt mixing sites should be 1 km away from residential area. • Asphalt plant will be equipped with pollution control equipment. • Use of PPE by workers engaged in construction and application of asphalt mix on road surface. • Responsibility of contractors and supervising officers to ensure that the workers use the PPE.
4.	Noise & Vibration environment	• Increase in Noise level during construction phase	• Properly maintained equipments to be used • Noise levels of machineries used shall conform to relevant standard prescribed in Environment (Protection) Rules, 1986. • Ear plugs and muffs will be used by workers as per requirement during construction activities. • Regulation of timing of construction work generating noise pollution near the residential areas. • 3Nos of 750KVA DG sets with the guidelines of CPCB will be used with acoustic enclosure.
5.	Water environment	• Drainage pattern	• Provision of proper drainage along the tunnel.

S. No.	Parameters	Potential Impact	Mitigation Measures Suggested
		• Siltation of water bodies	• Silt fencing around water bodies during construction to avoid silt laden runoff entering water body • Turfing or pitching of embankments of water bodies affected will be done where possible to prevent erosion that causes siltation. • No solid waste will be dumped in or near the water bodies or rivers.
		• Flooding due to siltation of drainages channel	• Excavated earth and other construction materials should be stored away from water bodies
		• Water for construction	• Water source would be selected so that local availability is not affected
		• Contamination from wastes	• Provision of septic tanks to prevent any untreated sewage discharge from construction workers camps • Oil interceptors at construction machine maintenance yards
		• Contamination from fuel and wastes	• Vehicle maintenance will be carried out in a confined area, away from water sources, and it will be ensured that used oil or lubricants are not disposed to water courses
		• Sanitation and water use in construction camps	• Construction camp will be organized in a planned manner. • Proper sanitation facilities will be provided including toilets. • Camps will have separate water supply facilities so that local water sources are not affected. • Adequate water should be provided to the camps for drinking and domestic use
6.	Land environment	• Loss of topsoil	No major loss of topsoil is anticipated as it is underground tunnel.

S. No.	Parameters	Potential Impact	Mitigation Measures Suggested
		• Loss of topsoil from borrowing	No borrow area is required in project. If needed, topsoil will be separated and refilled after excavation
		Loss of Land • No Effect	As the proposed project is of tunnel does affect any structure.
		Loss of structures No loss of structures	
		Loss of Common Property Resources (CPRs) None	-
7.	Ecological resources	• Loss of approx. 417 nos. of trees	Minimum 10 times plantation as per FCA 1980 in form of Compensatory afforestation.
8.	Impacts on wildlife	• Avoidance of Road by Animals • To avoid Injury and Mortality of animals	• Proposed project is of tunnel would not any impact on wildlife in operation phase.
9.	Public health and occupational safety	• Safety to public	Signs will be posted on highway before construction areas informing public about the work and safety provisions.
		• Restriction to Access	Safe and convenient passage for vehicles and pedestrians will be arranged during construction work
		• Occupational safety for workers	Contractor will arrange all safety measures for workers as per factories act.
		• Occupational safety for asphalt plant workers	All worker employed on mixing asphaltic material, cement, lime mortars, concrete etc. will be provided with protective footwear and protective goggles

CHAPTER-5: ANALYSIS OF ALTERNATIVES

5.1 INTRODUCTION

This chapter presents a comparative analysis of various alternatives considered to avoid, prevent or minimize impacts that would be inevitable if technically (based on design speed and geometrics) best-fit alignment is followed. The consideration of alternatives to a proposal is a requirement of the EIA report. During the scoping process, alternatives to a proposal can be generated or refined, either directly or by reference to the key issues identified. A comparative analysis of alternatives will help to determine the best method of achieving project objectives while minimizing environmental impacts. Various alternatives have been selected for analysis which usually includes the 'no project' or 'no action' alternative. The relative impact of each alternative is compared against the baseline environment to select a preferred alternative.

The proposed tunnel takes off from Shivmurti Interchange (Dwarka Expressway Package-1) to Nelson Mandela Marg. A Bypass to Rangpuri will connect Dwarka Expressway with Vasant Kunj through Nelson Mandela Marg. It has been proposed to extend the existing Nelson Mandela Marg via a tunnel towards Gurgaon/ Dwarka with an interchange near Shiv Murti to connect NH-8 and Dwarka Expressway. The entire alignment is green field till Nelson Mandela Marg. Proposed alignment were considered after finalization of various options such as realignments, bypasses and different construction material options keeping in view objectives of the project, traffic condition, obligatory points, geometric designs, congestions and socioeconomic viability and environmental safety aspects. The discussion in this chapter includes the project with alternatives. The objective of this chapter is to highlight some of the salient issues considered for exercising options.

5.2 SELECTION OF ALTERNATIVE

The NHAI had carried out preliminary desk studies using satellite imageries and as such an alignment for the proposed alignment was finalized. The detail of this selected alignment was handed over by the NHAI and the Consultant has been assigned the task of preparing the Feasibility and Preliminary Design Report for the proposed tunnel. The initial site visit and detailed ground reconnaissance by the consultants revealed that by and large this selected alignment is acceptable.

Three alternative alignments have been considered:

5.2.1 OPTION-1

The alignment starts from the proposed Shiv Murti Interchange and point via a tunnel which traverses for a length of 2 Km through southern ridge. The tunnel exits 700m before the end point of Nelson Mandela Marg and then a 594 m ramp and 74 m at glade surface road merges with the Nelson Mandela Marg end point. Salient Features of the Alignment are as follows.

- Total Length- 4983 m
- Tunnel Length-4308 m
- Approach Ramp to Tunnel End Portal- 594 m

- At Grade Surface Road- 74 m

Pros and Cons of option 1 are as follows:

Pros	Cons
• No Impact on Rangpuri Farm House and Ridge Forest Area • No land acquisition is proposed • Least Impact on Existing Utilities • No traffic hassles during construction period	• Long Tunnel Length will lead to increase in cost



Figure 5.1 Key Map of Alternative-1

6.2.2 OPTION-2

The alignment starts at the same point as discussed in earlier options after Shivmurti interchange with a tunnel which traverses beneath the Rangpuri Farm House Area and Rangpuri forest. The tunnel ends at Nelson Mandela Marg on the existing road and the approach ramps from tunnel will meet the existing road at a gradient of 3.3% before the Vasant Kunj Flyover Red light. This option does not involve any land acquisition but the construction on existing Nelson Mandela Marg which is coming on the end approaches of tunnel will lead to shifting of utilities, traffic hassles during construction as the Nelson Mandela Marg serves as the only connecting road to 4 nos. of DDA housing societies (Ganga, Yamuna, Narmada and Saraswati).

Salient Features of the Alignment are as follows:

- Total Length- 4795 m

- Tunnel Length- 4100 m
- Approach Ramp to Tunnel End Portal- 600 m
- At Grade Surface Road- 69 m

Pros and Cons of Option-2 are as follows:

Pros	Cons
• No Impact on Rangpuri Farm House and Ridge Forest Area • No Land Acquisition	• Long Tunnel Length will lead to increase in cost • Utility Shifting- A number of utilities i.e., IGL gas pipelines, HT Line, Water and Sewer Network are present at the existing Nelson Mandela Road which needs to be shifted. • Traffic Hassles during Construction as the Nelson Mandela Marg serves as the only connecting road to 4 nos. of DDA housing societies.



Figure 5.2 Key Map of Alternative-2

5.2.3 OPTION-3

The proposed alignment is similar to that proposed in Option-3, only the tunnel exits after the Rangpuri Ridge Forest Area reducing the tunnel length to 2800 m and then a 600 m approach ramp and 702 m at grade surface road merges with the Nelson Mandela Marg end point.

In addition to this newly proposed alignment, modifications in existing Nelson Mandela Junction are required to make the junction signal free and smooth flow of traffic. This will include blocking of right movement at the junction and providing a guided U Turn at the existing traffic light near Spinal Injury hospital towards Mahipalpur end. Apart from this, an additional flyover parallel to existing flyover at Nelson Mandela Junction would also be required. Strengthening and upgrading of Nelson Mandela Marg from the dead end till Junction has also been proposed in order to make it similar to the newly

proposed green field alignment. For the local societies, the two service lanes have been proposed which will be cater both ways traffic. No direct flow of traffic on the main 6 lanes carriageway is recommended.

Salient Features of the Alignment are as follows:

- Total Length- 4102 m
- Tunnel Length- 2800 m
- Approach Ramp to Tunnel End Portal- 600 m
- At Grade Surface Road- 702 m
- Up-gradation of Nelson Mandela Marg with 2 lanes service roads on both sides for local societies.
- New flyover parallel to existing flyover at Nelson Mandela Junction = 400m length
- Two lanes Guided U turn at traffic lights towards Mahipalpur near Spinal Injury Hospital
- Restricting right turn at Nelson Mandela Junction.

Pros and Cons of Option-3 are as follows:

Pros	Cons
• No Impact on Rangpuri Farm House and Ridge Forest Area • Least Tunnel Length will lead to decrease in project cost • Least Impact on Existing Utilities • No traffic hassles • Smooth traffic flow in and around Nelson Mandela Junction	• Least Land Acquisition- 7.812 Ha considering (1302 m length and 60m width of ROW) • Land Acquisition at one Farm House near the end point



Figure 5.3 Key Map for Alternative -3

5.2.4 OPTION-3.1 EXTENSION

The proposed alignment is similar to that proposed in Option-3.1, in which the tunnel exits after the Rangpuri Ridge Forest Area reducing the tunnel length to 2800 m and then a 600 m approach ramp is provided. After exiting the tunnel, a 1700m long viaduct is provided which passes on the Nelson Mandela Marg and crosses from above the Vasant Kunj Flyover. The flyover ends before the U turn on the Vasant Kunj Mall Road.

Salient Features of the Alignment are as follows:

- Total Length- 5111 m
- Tunnel Length- 2800 m
- Approach Ramp to Tunnel End Portal- 600 m
- Viaduct Length- 1700 m
- Approach Ramp to Viaduct- 700m
- At Grade Surface Road- 311 m

Pros and Cons of Option-3.1 Ext are as follows:

Pros	Cons
• No Impact on Rangpuri Farm House and Ridge Forest Area • Traffic coming out from tunnel towards Nelson Mandela will be through movement via the elevated viaduct	• Additional viaduct will lead to more capital cost • Land Acquisition- 7.812 Ha considering (1302 m length and 60m width of ROW) • Land Acquisition of one Farm House near the end point • Shifting of HT Line (3 Nos. of HT)



Figure 5.4: Key Map for Option -3.1 Extension

SHIV MURTI INTERCHANGE

The consultant has carried out the updated preliminary plan of the Shiv Murti Interchange with respect of the tunnels. Earlier, the interchange was designed with respect of elevated section towards Rangpuri Farm House Area and was a part of Dwarka Expressway Package-1. The interchange is now replanned keeping in view the land acquisition already done for the Dwarka Expressway so that minimum additional land is to be acquired for the modified interchange.

Salient Feebures of the interchange are given in the table 6.1 below:

Description	Length (M)
Total Length (m)	6400
Cut & Cover Length (m)	3220
Approach Ramp to Cut & Cover (m)	1490
Elevated Structure Length (m)	1360
Approach Ramp to Elevated (m)	330



Based on the above study the following observations are there: -

A. Option-2 and 3 most of the alignment passes through Ridge Forest.

B. The Option-1 is most suitable considering the connectivity to important cities and district towns. The Length of Option-1 is less as compare to option 2 & 3.

C. There are more no. of trees falling in option-2 &3.

D. Option- 3 leads to impact on Sultan Garhi Archeological Park.

E. Option-2 and 3 leads to larger impact on structure and families as number affected families are high as compared to Option-1.

F. Social impact is less in Option-1 as compared to other two options.

If any of alignment Option 2 or Option 3 is followed than it will lead to larger impacts on Environment & Social components, hence Option 1 is recommended and followed. The details of the three alternatives studied have been described in **Table No. 6.1**. The map showing the three alignments have been shown in **Fig. No. 6.1**.

Table No. 6.2 Details of alternatives studied

Parameter	Option-I (Combination of Tunnel and at grade roads)	Option-II	Option-III
Total length (in meter)	4983	4783	4102
Length of Tunnel (in m)	4306	4100	2800
Length in Ridge Boundary	1980	2030	3700
Impact at Surface in Ridge Area	NIL	Significant	Significant
Tree felling in Ridge area/ Non- Ridge area	Nil/417	2850/1200	3725/ 1418
Land acquisition (Ha)	NIL	24.62	7.812
Structures to be demolished (Nos.)	NIL	34	102
Utility shifting	Insignificant01 BSES 66 & 11 KV, 01 Indraprstha Gas Ltd. (MDP & Steel), 02 Water 02 Sewerage Pipeline, 01 220kV D/C O/H Transmission Line	Significant	Significant
Archeological	Nil	Nil	01 (Sultan Garhi

monument to be affected			Archeological Park)
Project cost (Cr.)	4099.39	2509.99	2022.79

5.3 WITH AND WITHOUT PROJECT SCENARIO

The proposed project will not only develop the surrounding area but will also provide smooth movement of traffic and linking with other roads of the country. Keeping in view, the site conditions and the scope of development of the area, the 'With' and 'without' project scenarios has been studied. **The details of the "with" and "without" Project has been presented in Table No. 5.3**

Table No.: 5.3 'With' and 'Without' Project Scenario

With Project		Without Project	
Positive Impacts	**Negative Impacts**	**Positive Impacts**	**Negative Impacts**
• The construction of new National Expressway will reduce the traffic congestion and wastage of fuel. • Flourish in trade and Commerce. • Providing better level of service in terms of improved riding quality and smooth traffic flow. • Reduction in accident rate. • Access to new Employment Opportunities. • Employment of local workers for the execution of project. • Better access to health care and other social services. • Improved quality of life of	• No of land shall be acquired in project. • Around 417 trees will be cut down due to development of green field alignment. • **Increase of traffic** will lead to air and noise pollution. • **Removal of trees** and vegetation due to construction of proposed project • **Changes in land use** pattern along the new green field alignment. • **Increase** in dust pollution and noise pollution during construction period. However, this will	• **No acquisition of** land or properties and hence no displacement of families. • **No felling of** existing trees and vegetation	• Travel time and fuel consumption level will be more due to bottlenecks • Increased air pollution in the close proximity of the existing roads due to slow moving traffic and congestion • Rise in noise levels due to more traffic congestion on the existing roads • Chances of accidents on existing transport infrastructure will be more in absence of the planned tunnel • **Further deterioration** of project road.

the local people. • Better way side, Amenities and other facilities like bus bays/shelters, truck lay byes and service roads. • Adequate underpasses flyovers for cross over	be for short term. • Displacement of families.		

Therefore, 'with' project scenario, with its insignificant adverse impacts is more acceptable than the 'without' project scenario, which would mean an aggravation of the existing problems. The potential benefits of the planned tunnel are substantial and far reaching both in terms of the geographical spread and time. Hence, it is clear that the implementation of the project will be a definite advantage in Delhi and its neighboring areas and especially South West Delhi districts in order to achieve all-round development of their economy and progress for their people.

The potential impacts on different environmental components would be avoided through good engineering design practices. Appropriate mitigation measures have been suggested where avoidances are not possible in various sections of the environmental assessment report.

CHAPTER-6 : ENVIRONMENTAL MONITORING PROGRAMME

6.1 ENVIRONMENT MONITORING PROGRAMME

The Environmental Monitoring Programme provides information on which management decisions may be taken during construction and operational phase. It provides basis for evaluating the efficiency of mitigation and enhancement measures, and suggested actions that need to be taken to achieve the desired effect. The monitoring includes:

(i) Visual observation,
(ii) Selection of environmental parameters at specific locations, and
(iii) Sampling and regular testing of Air, Noise, Soil and Water parameters.

The objectives are:

- Evaluation of the efficiency of mitigation and enhancement measures.
- Updating of the actions and impacts of baseline data.
- Adoption of additional mitigation measures if the present measures are insufficient.
- Generating the data which may be incorporated in the environmental management plan in future projects.

6.1.1 Ambient Air Quality (AAQ) Monitoring

The Ambient Air quality is recommended for monitoring through an NABL approved agency in the process of Construction of a Road Tunnel for NH-148AE connecting to NH-248BB in the NCT, Delhi. The sites for monitoring during construction will be selected in consultation with DPCC or as per EC Conditions. At this stage, the potential Air monitoring sites include inside tunnel, near batching plant, HMP, Stockyards Batching plant, Haul roads, etc. The monitoring will be done as per the CPCB guidelines. The parameters recommended for monitoring during construction are:

- Particulate Matter, PM_{10}, $PM_{2.5}$
- Sulphur Dioxide,
- Oxides of Nitrogen, and Carbon Monoxide

6.1.2 Water Quality

Water quality monitoring will be conducted through an NABL approved lab during the construction stage. The sites for water quality monitoring will be selected in consultation with DPCC or as per EC Conditions. At this stage, the potential water monitoring sites include – seepage water inside the tunnel, ground water quality near the human settlement and drinking water quality supplied to workers.

6.1.3 Ambient Noise Monitoring & Vibrations

Noise and vibration monitoring will be conducted through an NABL approved lab during the construction stage. The sites for noise and ground vibration monitoring will be selected in consultation with DPCC/ relevant authority and as per EC Conditions. The monitoring of noise will be conducted

batching plant, near TBM, HMP, haul road In addition vibration due to TBM will be measures especially at Ridge area and nearby habitation area.

6.1.4 Muck Quality

Muck generated during the construction of underground tunnel will be collected and analyzed for relevant physical and chemical characteristics.

The procedural details of monitoring of various components have been presented in **Table No. 6.1**

Table No. 6.1: Environmental Monitoring Plan

Environmental Components	Monitoring			Location	Frequency	Institutional Responsibility	
	Parameters	Specific Guidance	Standards			Implementation	Supervision
Air Quality	PM_{10}, $(PM_{2.5})$, SO_2, NO_2 & CO	As per CPCB Guidelines	The Air (Prevention and Control of Pollution) Rules, CPCB, 1982	At sites where work area hot mix plant/batching Plant, nearest habitation etc. Also the sites are selected After consultation/direction by SPCC or as per EC Condition.	Twice a week for three seasons in a year for 3 years during construction and for one year during operation	Contractor through approved monitoring agency	IC, MoEF, SPCC
Ground Quality	pH, temperature, BOD, Total Hardness, COD, TDS, TSS, DO, Total coliform, Conductivity, Oil & Grease etc	Soil/ Locally collected from source and sample as per standard methods for examination of water and waste water	Water quality standards by CPCB	As EC condition or in consultation with CSRIA.		"	IC, MoEF, SPCC
Noise Levels & Vibrations	Noise level for day and night in $dB(A)$ scale	As per CPCB guidelines	Noise standard by CPCB	Work Area, public like nurses, Chest etc. Also the sites were	Once in a month for three seasons in a	Contractor through approved	IC, MoEF, SPCC

				relocated. After consultation/direction by DPCC or as per EC Condition.	year for 3 years during construction and for one year during operation.	monitoring agency	
Muck	Inventory of NPK (Heavy metals and grease	As per CPCB Guidelines	As per CPCB Standards	Enclosed Shed	Once in a month for three seasons in a year for 3 years during construction and for one year during operation.	Contractor through approved monitoring agency	EC Work (Rs)
Plantation	Monitoring of felling of trees	It should be ensured that only marked trees are felled	As given in the Detailed Design for the project	All along the corridor	During the felling of trees	Forest deptt. Competent Agency	Developer to assist in co-ordination with deptt.
	Survival rate of trees	The number of trees surviving during each visit should be compared with the number of saplings planted	The survival rate should be at least 75% below which re-plantation should be done	All locations of compensatory afforestation and all along the corridor	Every month for 3 years	PIU	Developer & Forest Department

6.2 ENVIRONMENTAL MONITORING COST

The environmental monitoring cost is estimated on the basis of the length and existing environmental scenario of the proposed project. Environmental monitoring cost of Rs. **1,33,08,000/-** has been allocated for construction and operation stages. The details have been presented in **Table No. 6.2**.

Table 6.2: Environmental Monitoring Cost

Sl No.	Parameters / Components	Location	Guidelines	Unit cost / Sample (Rs.)	Total cost (Rs.)
1	**Ambient Air Monitoring:** **At construction Stage:** At 4 locations for three seasons in a year for 2 years (twice a week) **(Total 576 samples in 2 years)**	Monitoring at Construction sites, Near Hot mix plant, nearest habitation, and near labour camp or as per EC Conditions	PM2.5 and Respirable dust samplers to be used and located 50 m from the construction site	9,000	51,84,000
	At Operation Stage: At 4 locations for three seasons for a year (twice a week) **(Total 288 samples in 1 year)**	Along the Tunnel	-	9,000	25,92,000
2.	**Ground Water/Drinking water Monitoring:** **At Construction Stage:** At 3 locations for three seasons in a year for 2 years (Once in a month) **(Total 64 samples in 2 years)**	Ground water bodies along the project or as per EC Conditions	Analysis as per the standard methods for examination of water and waste water	6,000	3,24,000
	At Operation Stage: At one location Once in a month for one year (Total 12 samples in 1 year)	Drinking water facility, a toll plaza	Analysis as per the standard methods for examination of water and waste water	6,000	72,000
3.	**Surface Water Sampling:**	None	-	-	

	At Construction Stage: None water body near project				
	At Operation Stage: None	None	-	-	
4.	**Noise Monitoring:** **At Construction Stage:** At 4 locations for three seasons in a year for 2 years (Once in a month) **(Total 72 samples in 2 years)**	At equipment yards/construction sites identified by IC, nearest habitation etc. or as per EC Conditions	Using an integrated noise level meter kept at a distance of 15 m from the construction site	5,000	3,60,000
	At Operation stage: At 2 locations for three seasons for a year (Once in a month) **(Total 18 samples in 1 year)**	As directed by the Engineer	-	5,000	90,000
5.	**Muck:** **At Construction Stage:** At 2 locations for three seasons in a year for 2 years (Once in a month) **(Total samples 36 in 2 years)**	At Forest Area, Nearest Park area and working area & material storage area or as per EC Conditions	-	5,000	1,80,000
	At Operation Stage: Not requires	None	-	-	
6.	**Work Place Monitoring Air:** **At Construction Stage** At 2 locations for three seasons in a year for 2 years (twice a week) (Total 36 samples in 2 years)	Inside the tunnel/Work Area	Respirable dust samplers to be located near work area	9000	3,24,000
	At operation stage: Real time Potable	Entrance & exit of tunnel	-	-	40,00,000

	sampler with Display meter				
7.	**Work Area Noise monitoring:** **At Construction Stage** At 2 locations for three seasons in a year for 2 years (twice a week) (Total 36 samples in 2 years)	Inside the tunnel/Work Area	OSHA Standards	5,000	1,80,000
Total Monitoring Cost					**1,33,96,000/-**

CHAPTER-7: ADDITIONAL STUDIES

7.0 INTRODUCTION

As per the conditions of the Terms of Reference given by EAC for preparation of the EIA/EMP Report, several studies were to be conducted to provide a clear picture of the project area. The suggested studies/activities were:

- Public Consultation and Public Hearing
- Social Impact Assessment
- Road Safety Measures
- Other Features/Study of Project

7.2 PUBLIC HEARING

As per the EIA notification dated 14th September 2006, vide section 7(f) related to public hearing, the draft EIA/EMP report will be submitted to the Delhi Pollution Control Committee (DPCC) for conducting public hearings in South Delhi district in the state of Delhi.

7.3 COMPREHENSIVE SOCIO-ECONOMIC ASSESSMENT FOR THE PROPOSED PROJECT

The socio-economic profile of the project areas for the proposed project has been presented in Chapter 3.

7.4 SOCIAL IMPACT ASSESSMENT (SIA) STUDY IN THE PROJECT:

The proposed project is underground tunnel does not going to affect any structure. The Tunnel passes through the Ridge Forest area, there is no private land involve in the project. Hence No Social Impact Assessment is required. There is no land acquisition required for the project.

7.4.1 R&R Budget

Proposed tunnel project is not going to acquire any private land and also not going to affect any structure for the project. Hence R&R is not required.

7.5 SAFETY AND OTHER FEATURE OF TUNNEL

Indian Road Congress (IRC) codes will be followed in proposing and designing road safety features. Pavement markings will be done for traffic lane line, edge lines and hatching. The marking will be with hot applied thermoplastics materials. The pavement markings will be reinforced with raised RR pavement markers and will be provided for median and shoulder edge longitudinal lines and hatch markings. Tunnel lightings including high masts will be provided at intersections in order to improve the night time visibility.

All the urban locations as well grade separated structure locations will be provided lighting arrangements.

In addition, to avoid the accidents inside and outside the tunnel & for the smooth and safe flow of traffic it is required to provide the various safety features for the tunnel. In accordance to IRC: SP: 91, the tunnel is classified as long tunnel and therefore require ventilation system and associated MEP systems along with other facilities suitable to all possible tunnel operations modes.

The following section establishes design criteria of mechanical & electrical systems for Tunnel.

- Ventilation System
- Emergency Power supply System
- Fire Fighting system
- Lighting System
- Traffic Management and Controls Systems (TMCS) etc
- Noise & Vibration

7.6.1 Ventilation System

The work under tunnel ventilation system shall include the.

- Jet Fans
- Ductwork and Support Steelwork as per requirement.
- In - Tunnel and External Environmental Sensors and Monitoring Equipment

  In addition, the extent of work shall include following

- Interfacing with power supply systems, central monitoring & control system, fire services required for safety and traffic control surveillance system.
- Preparation of technical calculations to demonstrate ventilation system performance to meet environmental criteria and fire scenario.
- Preparation of control specification for jet fans based on traffic flow, traffic speed and pollutant levels.
- Preparation of emergency operation procedures for tunnel ventilation system.
- For each system, a complete commissioned, balanced and tested installation with Shop Drawings, As-built drawings, Operation and Maintenance Manuals, Factory Acceptance Tests and Site Acceptance Tests shall be submitted for owner's approval.
- Provision of terminal Cubical/MCC for connection to the Power Supply System cabling.
- Provision of terminal cubicle/MCC for connection to the Central Monitoring and Control System; Traffic Control and Surveillance System and Fire Services System cabling.

- Provision of emergency stop from remote and local for all exhausts jet fans

A. Design Criteria

The tunnel ventilation system shall be design to:

(i) To provide Ventilation during normal operating conditions in order to maintain air quality conditions below the maximum allowable emission limits inside tunnel.

(ii) Provide a means of smoke control during the event of a fire, in order to help with the safe evacuation of occupants as well as to provide a safe means of approach for firefighting and emergency services.

(iii) Maintain acceptable air quality inside the tunnel in accordance with latest PIARC/ pollution control authority recommendations.

(iv) To ensure that the ventilation system and its associated equipment meet the requirements of IRC SP: 91-2019, BD78/99, PIARC and NFPA guidelines.

(v) To install an effective, versatile and energy efficient ventilation system as per the latest code and guidelines.

(vi) To reduce the risk of incorrect operation of the ventilation system in an incident, involving fire.

(vii) To ensure required air quality and visibility levels are maintained.

(viii) To provide adequate tunnel ventilation during tunnel maintenance closures.

The Detailed study about the ventilation system of Tunnel is attached as **Annexure-8**.

7.6.2 Emergency Power supply System

Uninterruptible Power Supply (UPS) system shall maintain uninterrupted power to equipment continuously and during power failure. Dedicated UPS shall be provided for emergency lighting, exit signs and all essential services in the tunnel, escape culvert lighting.

UPS shall be provided to supply the following equipment:

- Emergency tunnel lighting, exit signs and strobe lights Computer system including:
- Both control centers
- All Remote-Control Units
- All sensors and associated control equipment All traffic control equipment, including:
- Variable message signs
- CCTV and surveillance system
- Advisory signs

- Loop detectors and vehicle height detectors
- All traffic lights
- Motorist emergency telephones
- Public address system
- Radio rebroadcast system
- Diesel generator control interfaces to other switchboards
- Fire detection and alarm
- Building access control

UPS shall be installed at Portal Control building, Electrical cross passages. The rating of the different UPS shall be sufficient to supply the connected loads for the specified backup period. The UPS for the emergency and exit sign lighting shall ensure uninterrupted power supply for a minimum period of 2 hours. The essential services UPS shall ensure uninterrupted power supply for a minimum period of 90 minutes.

7.6.3 Fire Fighting system

A. General

The Fire services shall be designed to meet with following key performance indicators as minimum:

- The systems to meet with high altitudes and sub-zero temperatures region;
- Tunnel equipment and operations and harsh environment at project sites;
- Comply with international, national and local standards & by-laws;
- Comply with current publication of the National Building Code of India; and
- Comply with operational and maintenance requirement of the tunnel operator

The Fire system within tunnel structure shall be designed in accordance with relevant international standards such as PIARC, NFPA and Indian standards-JS (JS applicable only to achieve the compatibility of equipment). Where Indian standards are not available, reputed international standards shall be used with prior approval from consultant.

The system shall be designed to meet with the following objectives summarized by PIARC to:

- save lives by making evacuation possible
- make rescue and firefighting possible
- avoid explosions
- limit damage to tunnel structure, equipment and surrounding buildings Following design criteria shall be complied with as minimum:

- At the hydraulically remotest hydrant landing valve minimum available pressure should be 7 bar when discharging minimum flow of 63 L/sec.
- Hydrant system to be capable to operate 3 hydrant points simultaneously with conditions
- Maximum pressure at hydrant point shall not exceed limit restrictions required by local fire brigade.
- The hydrant system shall be automatic and remain in pressurized conditions all the time.
- Fire detection system shall be provided throughout the tunnel roadways. Any fire conditions on roadways must be detected quickly and the location of fire point shall be pin pointed by the detection system and displayed on main Fire Indication and Control Panels (MFIP) and colour GUI (Graphic User interface). The location of fire point displayed on MFIP shall be in the range of 0 to 15m from the actual fire point.
- The emergency warning system shall be intelligible with speech clarity. The warning instructions should be clear audible enough to tunnel users in all conditions. Supplementary visual alarms shall be provided in tunnel.
- The Sub-Contractor must submit evidence that:
- Requirements of the relevant authorities relating to the work under the contract have been ascertained prior to the commencement of the hydraulic services installation
- Fees to relevant authorities, if any, have been paid and all types of approvals obtained.
- Certificates of compliance with regard to the extent of the installation. Such certificates have to be obtained on completion of the installation.
- All fittings, pipes, accessories and the like used in the works must bear approval marks where and as required by the relevant Authorities.
- Test certificates for all essential service fittings. Be provided prior to completion

B. Fire Safety Features of tunnel

The extent of work covered by these documents includes the detailed design, manufacture, supply, installation, testing and commissioning and subsequent maintenance of the Fire System for the tunnels as detailed in this Specification.

A detailed design shall be completed for the whole of the works described in this performance specification, together with coordination with other services and compliance with all Authorities having jurisdiction over the works. This performance specification describes the intent and extent of works and standards of work required.

The principal items of the Fire System for the Tunnel shall include:

- Linear heat detection System,
- Fire Detection and Alarm System
- Portable Fire Extinguishers
- Smoke Detection for Buildings and electrical niches
- Emergency Warning and communicating system
- Fire Hydrant pump system,
- Fire Hydrants and Hose Reel System,
- Tank filling arrangement and Pipework System, and
- Gaseous based Fire Suppression System,
- Hydrocarbon Gas detection system

C. Tactical Fire Plan

Provide a colour coded drawing indicating the fire services systems installed and features of the building.

The drawing shall be of approved scale and incorporate the following features:

- plan drawings of each floor level
- locations of all hydrants
- locations of all hose reels
- location and content of each emergency control cabinet
- locations of booster connections
- locations of valve assemblies
- locations of indicator panel
- location of hazardous areas
- colour coded areas covered by each alarm zone schematic detail of hydrant piping system
- location of special hazard fire extinguishing system protected areas fans, ducts and shafts
- fuel oil storage tanks
- town gas meters, boosters and controls and piping
- emergency control Centre(s) stand-by power plant fire walls and compartments emergency exit lights

The drawings shall be of approved scale, colour fast and mounted in a glazed frame in a location as directed on site.

7.6.4 Lighting System

Tunnel Lighting shall be as per the MoRT&H Guidelines for Expressway. Also for designing the lighting of tunnel IRC: SP:91 is followed.

The contractor shall design, supply and install a complete lighting system of the tunnel. All luminaries, fittings and accessories shall only be proprietary type. The contractor shall lamps in all luminaries verify correct operation before completion. Emergency supply shall be connected to the lighting in the Tunnel.

Contractors shall provide the following:

1. Lighting switches.
2. Dimmers.

The lighting system shall utilize fluorescent lighting with electronic ballasts.

A. Emergency Lightning

Design, supply and install a complete operational emergency evacuation lighting system, tested and commissioned in accordance with IEC/ISO standards for emergency lighting for the Portal Buildings and Control command and control Center.

Visual Indicator lights: Provide a red indicator, readily visible when the luminaire is in its operating location, which indicates that the battery is being charged.

Inverter system: Provide protection of the inverter system against damage in the event of failure, removal or replacement of the lamp, while in normal operation.

Local test switches: Provide a momentary action test switch, accessible from below the ceiling, on each luminaire to temporarily disconnect the mains supply and connect the battery to the lamp.

Common test switches: Provide a common test switch on the distribution board which disconnects main supply to the luminaries and tests for discharge performance, after testing; this switch must automatically revert to normal operating mode.

Type: Lead-acid or nickel-cadmium batteries capable of operating each lamp at its rated output continuously at least 2 hours during completion tests and 1.5 hours during subsequent tests.

Battery life: At least 3 years when operating under normal conditions at an ambient temperature of 25oC and subjected to charging and discharging at 6 monthly intervals.

Marking: Indelibly mark each battery with its date of manufacture.,

General: Provide an un-switched active supply to each luminaire and exit sign, originating from the test switch control panel.

7.6.6 Traffic Management and Controls Systems (TMCS) etc

TMCS consists of the followings:

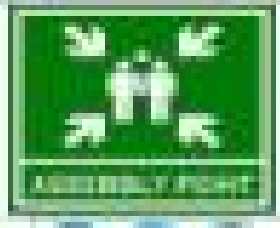
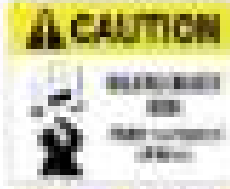
- Design, supply and install two variable message Signs (VMS), one on each tunnel portal.
- Design, supply and install pairs of variable Speed Limit Signs (VSLS) every 250m for both traffic directions along full length of the twin tube tunnels (both the tubes included).
- Design, supply and install Video Incident Detection System with cameras spaced at 60m staggered interval alternatively on both walls of the tunnel along the full length of the tunnel.
- Design, supply and install CCTV surveillance system with PTZ dome cameras located in every electrical/pump niches, Cross passages & Technical building/rooms.
- Design, supply and install an Emergency Telephone System along the twin tube tunnels (both the tubes included).
- Design, supply and install a Public Address System with loudspeakers installed at a maximum spacing of 30m along the twin tube tunnels (both the tubes included).
- Design, supply and install a Break-in to the Radio Rebroadcast Communications System.
- Design, supply and install a tunnel closure system comprising traffic signals and boom gates at both tunnel portals
- Design and supply and install traffic Management and Control System to monitor and control all the above systems and interface to the PMCS.
- Install the Traffic Management and Control System main servers and two workstations in the one portal control room, back-up servers and one workstation in the another portal control room, and workstations at the remote control centre.
- Design supply and install a fiber optic communications system to integrate the above systems.
- Full documentation, Design Report, As-built drawings, Testing Plans and procedures, operation and maintenance manuals for all supplied equipment.
- Testing and commissioning of all the above systems including factory acceptance testing for each component, integration testing, inspection testing, site acceptance testing and commissioning.

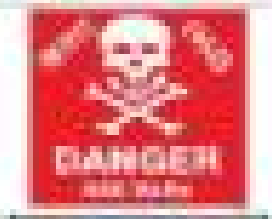
Operation and maintenance training for all the above systems

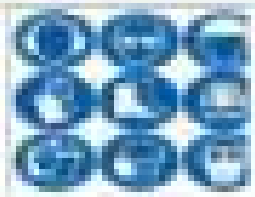
A. Traffic Signage

Adequate Signage / Marking at material storage in local language will be provided for the smooth flow of traffic. A sample of traffic sign is given in figure 7.1 below.

Table 7.1: Safety Signage

Description	Safety Signage	Description	Safety Signage
No Smoking		Fire Alarm	
Caution – Electricity		Caution: Danger of Tripping	
Emergency Assembly Point		Caution – Low Headroom	
Mandatory PPE Signage		Overhead Hazard	

Lifting material		Falling object	
		Electrical danger	
First Aid Box Location		Water Safety Operation	
Fire Extinguisher location			

[illegible]			 NOTICE
[illegible]	 DANGER DO NOT ENTER	[illegible]	

7.6.6 Noise and Vibration

The systems shall be installed to be quiet in accordance with the design criteria and in accordance with accepted practice and the requirements of local and Statutory Authorities. Acoustic treatment and vibration isolation devices shall be provided to ensure that no discrete frequencies or broad range noise or vibration enters occupied spaces at levels with may cause annoyance.

A. Structure Borne Noise and Vibration

The transmission of noise and vibration to the structure shall be minimized with the following requirements being met.

Balancing

Fans shall be balanced so that the out of balance does not exceed 0.7mm gram for fans, having wheel diameters less than 750mm or 1.3mm gram for fans 750mm and over, when connected for normal operation.

Equipment Mountings

Mountings shall be located to prevent excessive equipment motion, particularly on start-up. Mountings shall be easily visible and accessible for inspection and maintenance. When the mountings are carrying the static load, there shall be a clearance of not less than 50mm under the base.

Rubber In Shear Type

Mountings shall be of neoprene bonded to the metal housings or bases. Housings shall be provided with bolt holes for fixing as appropriate.

Pad Type

Pad type mountings shall be ribbed neoprene waffle type minimum thickness 6mm as particularly nominated.

Painting and Labeling

The jet fans shall be supplied with a shot blast and zinc spray finish, with any painting necessary to be done locally on site.

7.8 CONCLUSION

The report on additional studies such as Social Impact Assessment, Safety and other features of tunnel. Based on the findings during the study some measures have to be considered from the inception of the project, which will reduce the detrimental effects of project appreciably.

- The project has been explored in order to find a suitable alignment that has no impact on social aspects.
- The proposed project tunnel avoids schools, places of worships, public utilities and other common resources.
- The project has all facilities for the safe and smooth flow of traffic.

A detailed study was done regarding the design criteria of Mechanical & electrical system of tunnel is attached as **Annexure XIV.** With the above approach to design, construction and operation the project will be feasible.

CHAPTER-8: PROJECT BENEFITS

8.1 INTRODUCTION

The Ministry of Road Transport and Highways (MoRTH), a Ministry of the Government of India, is the apex body for formulation and administration of the rules, regulations and laws relating to road transport and transport research, in order to increase the mobility and efficiency of the road transport system in India.

The Ministry of Road Transport and Highways (MoRTH) / National Highways Authority of India (NHAI) have decided to develop Economic Corridors, Inter Corridors, Feeder Routes and Coastal Road primarily to improve the efficiency of freight movement in India under Bharatmala Pariyojana. The main objective of the proposed project is to reduce the distance and travel time and more efficient traffic dispersal surrounding NCT Delhi region.

The project road starts from Shiv murti Interchange (Dwarka Expressway Package-I) to Nelson Mandela Marg. A Bypass to Rangpuri will connect Dwarka Expressway with Vasant Kunj through Nelson Mandela Marg. It has been proposed to extend the existing Nelson Mandela Marg via a tunnel towards Gurgaon/ Dwarka with an interchange near Shiv Murti to connect NH-8 and Dwarka Expressway. The entire alignment is green field till Nelson Mandela Marg.

The proposed project would act as the prime artery for the economic flow to this region. It will enhance economic development, provide employment opportunities to locals, strengthen tourist development, ensure road safety and provide better transportation facilities and other facilities such as way side amenities. Vehicle operating cost will also be reduced due to improved road quality.

8.2 Project Benefits:

Table 8.1: indicates the typical benefits that occur on the construction of a highway project below:

Benefits to Consumers	Benefits to Producers	Social Benefits to the Society
Saving in Vehicle Operating Costs	Increased local industries/ business	Reduced Unemployment
Saving in Travel Time Cost of road users	Increased industrial incomes	Improved Income Distribution
Savings in Travel Time of Goods-in- Transit	Increased Tourism incomes	Improved health
Saving due to reduction in accident Costs		Improves education
Savings due to Reduction in pollution		Improved access to amenities

8.3 VEHICLE OPERATING COST SAVINGS

With the assumptions of existing alignment through the congested urban road section (7.5 km length) will be maintained with the existing maintenance practice at an average roughness value of about RG 4,000 during the analysis period. Under the 'without project' scenario, the projected traffic will use this existing alignment. However, under 'with project' scenario, the estimated traffic will be diverted to the new alignment (4.98 km) whose surface condition is assumed to maintain at average RG 3,000 during the operation. Accordingly, the vehicle operating cost (VOC) unit rates for different vehicle categories and assumed roughness and terrain conditions, suggested by Indian Roads Congress were adopted for the analysis.

Table 8.2 Vehicle Operating Cost Unit Rates (Rs/Km)

Vehicle Type	VOC (2019) Rs/Km		VOC (2022) Rs/Km		VOC (2022) including Urban congestion condition – Rs. / KM	
	4L Road RG 4000	6L Road RG 3000	4L Road RG 4000	6L Road RG 3000	4L Road RG 4000	6L Road RG 3000
CAR / VAN	5.53	4.52	6.95	5.68	8.34	6.82
Mini LCV	16.45	15.14	20.67	19.02	24.80	22.83
Bus	18.82	17.16	23.40	21.57	28.08	25.88
LCV	21.93	20.18	27.56	25.36	33.07	30.43
2 Axle Truck	25.61	22.48	32.18	28.26	38.62	33.91
3 Axle Truck (HCV)	23.28	20.44	29.26	25.69	35.11	30.83
MAV	31.21	26.96	39.22	33.88	47.07	40.66

Note:
1. Unit rates of 2019 are updated to 2022 using the Wholesale Price Index (WPI) and the fuel cost inflation
2. Considering urban traffic congestion at Mahipalpur junction and at other signals, the highway unit rates proposed are increased by 20%.

Source: IRC SP 30, 2019

8.4 TRAVEL TIME SAVING

The congested urban roads through Mahipalpur junction and urban section with bad road conditions, the vehicle users under 'without project' scenario will experience lesser travel speed with more travel time. The proposed project road with better road condition will increase the travel speed and lesser travel time. In addition, the reduction in travel length from 7.5km under 'without project' scenario to 4.9km under 'with project' scenario will further reduce the travel time. For estimating the value of travel time (VOTT) for passengers and goods in transit in both the with- and without-project scenarios and subsequently the time savings, taking into account speed including surface quality, road congestion, and road geometry, the unit time value for different vehicle travelers suggested by IRC (2019) with suitable update to 2022 was used in the analysis.

Table 8.3 Travel Time Cost Unit Rates (Rs/P.cu)

Vehicle Type	Time Cost (2019) Rs/Km		Time Cost (2022) Rs/Km		Time Cost (2022) including urban congestion condition - Rs/Km	
	4L Road RG 4000	6L Road RG 3000	4L Road RG 4000	6L Road RG 3000	4L Road RG 4000	6L Road RG 3000
CAR / VAN	10.79	7.26	13.56	9.12	16.27	10.95
Mini LCV	0.90	0.83	1.13	1.05	1.36	1.26
Bus	11.54	10.71	14.50	13.46	17.40	16.15
LCV	1.20	1.11	1.51	1.40	1.81	1.67
2 Axle Truck	4.80	4.42	6.03	5.56	7.23	6.67
3 Axle Truck (HCV)	4.36	4.02	5.48	5.05	6.58	5.06
MAV	4.98	4.56	6.26	5.73	7.51	6.88

Note:

1. Unit rates of 2019 are updated to 2022 using the Wholesale Price Index (WPI) and the fuel cost inflation
2. Considering urban traffic congestion at Mahipalpur junction and at other signals, the highway unit rates proposed are increased by 20%.

Source: IRC SP 30, 2019

8.5 ENVIRONMENTAL BENEFITS FROM THE PROJECT

The major environmental benefit will be –

CARBON EMISSION REDUCTION:

Improved road surface from four-lane bad urban roads to the six-lane better road condition under the project will result in increased travel speed and fuel reduction for the motorized vehicles using the project road. This reduction in the fuel consumption will lead to reduction in carbon emission into the atmosphere and this is a benefit to the project. With the arrived values of average RD4,000 road surface for 'without project' earthen road and RD 3,000 for 'with project' six-lane road surface, related fuel consumption quantity, carbon emission rate (0.0023 ton/ liter), carbon cost (Rs 2,975 per ton in 2022)8 and the traffic, annual carbon emission for the project under 'without' and 'with' project scenarios were estimated for the project road of 4.76 km. Resultant carbon emission is estimated to decrease by 12,950 ton for the project operation start year (2026). This is mainly due to the reduced carbon emission rate for the improved paved road surface with increased travel speed. Available guideline (***World Bank, 2017. 'Guidance note on shadow price of carbon in economic analysis Nov 12, 2017'***) was used to estimate the above discussed emission reduction benefit. This increased speed and reduction in the fuel consumption together are projected to reduce the carbon emission by 0.59 million tonnes during the 30 years operation period, converted into Rs 1,755 million.

8.6 SOCIO-ECONOMIC BENEFIT OF THE PROJECT

The socio-economic benefits from the proposed project have been described below:

- Enhanced connectivity between rural & urban population which will benefit the all sections of the society.
- Improved access to higher education facilities & modern health facilities.
- Strengthening of both rural & urban economies which in turn will improve economic scenario of the state and country.
- Faster transportation will strengthen tourist development of Delhi NCR.
- Improved road connectivity helps in better implementation and management of government schemes.
- With improvement in economy, more generation of employment opportunities.

8.7 Tunnel/ROAD SAFETY

The construction of green field alignment from Shiv murti Interchange (Dwarka Expressway Package-1) to Nelson Mandela Marg in the state of Delhi will ensure smooth flow of the traffic. Installation of proper road safety system through signage, barricades, and crash barriers will add to be safety to the traffic.

8.8 INDIRECT BENEFITS

In addition to the direct benefits, there are number of indirect benefits attributed to tunnel project. Lowering transportation cost for users and improving access to goods and services enables new and increased economic and social activity.

The indirect benefits include changes in land use and development, changes in decision on residential area or colonies where land are less expensive or more desirable, changes in development of business in order to take advantage of improved speed and reliability in the transportation system. These benefits hence lead to increase property values, increased productivity, employment and economic growth.

CHAPTER-9 : ENVIRONMENTAL MANAGEMENT PLAN (EMP)

9.1 INTRODUCTION

An Environment Management Plan (EMP) is framework for the implementation and execution mitigation measures and alternatives. It consists of a set of mitigation, monitoring and compensatory measures. These measures are to be taken during the pre-construction, construction and the operational phase of a project to reduce the adverse environmental & social impacts, to offset them or to reduce them to acceptable levels. It contains all the information for the proponent, the contractor, and the regulatory agencies to implement environment mitigation measures under the project within a specified time frame.

The objectives of preparing EMP of Tunnel are:

- To ensure that mitigation measures are properly implemented;
- To establish a scheme and procedures for this purpose;
- To monitor how effective are the mitigation measures;
- To ensure that proposed mitigation measures comply with environmental laws and regulations;
- An adequate action when unexpected impacts occur;
- To specify monitoring and institutional requirements for ensuring safeguard compliance

This section of the report identifies standard methods and practices as a part of the mitigation measures with respect to environmental, social and health impacts identified generically and specifically for the proposed construction, and operation of the project as discussed in Chapter 4. For each aspect, the EMP is prepared to minimize the impact on the surrounding environment during the pre-construction, construction, and operation phase.

Also, it is to be noted that the areas for Construction campsites, haul roads, workers' camps, etc. are not finalized. And hence the EMP will be further updated by contractor based on site-specific observations, potential impacts, and mitigation measures.

The design and pre-construction phase, construction phase, and operation phase EMP is summarized in Table 9.1, Table 9.2 and Table 9.3 respectively.

8.1.1 I Nile (CONSTRUCTION PHASE)

The Table 8.1 summarizes the potential environmental impacts and mitigation measures, roles and responsibilities during construction phase of the project.

Table No. 8.1: Environmental Management Action Plan –Pre-Construction Phase

Sr. No.	Activities	Potential Impacts	Significance (Criteria for determining significant impact (eg. any impacts shown on site, impact magnitude, the likelihood of meeting standard and duration or other requirement or international commitments)	Mitigation Measures	Responsibility
1.	Land acquisition	Loss of land, structure, standing crops, trees and other assets Removal and relocation of utilities and services Forgone Resources (CPR's) etc. Removal and relocation of Cultural and Religious Properties	Insignificant	No land acquisition is required for tunnel project as it is underground. Also no structure of any type is going to impacted.	MVVUL & Contractor
2.	Site preparation	Conversion of existing land into construction site as per design, removal of standing crop, felling of trees and removal of soil. No water & water pollution	Significant	As far as possible maximum efforts will be made to minimize the number of trees proposed to be felled by adopting of engineering designs. Trees shall be removed from the site and construction area before the commencement of construction. Prior Permission shall be obtained from the concerned authority for the trees	MVVUL & Contractor

				taking. There is no crop which are going to affect due to construction of underground tunnel. Construction of tunnel is underground will not affect top soil except at entry & exit point. ambient Air Quality monitoring will be performed by the contractor as per the Environmental Monitoring Program and in accordance with the general and specific condition as stipulated in Environment clearance letter, CTE and CTO	
3	Movement of machinery (Construction vehicles, equipment and machinery for casting plant, Hot Mix Plant & Batching Plant)	Disruption to traffic flow and disturbance to sensitive receptors and nearby community including road accidents. Air, noise & water pollution	Significant	Crushers, hot mix plants, and casting and batching plants shall comply with the requirements and specifications of the current emission control legislation and specifications. Consent / NOC for all such plants shall be submitted. Casting plant, batching plant, crushers, hot mix plants shall be located at least 1000m (1km) away from residential settlements, hospital, schools, and monuments establishments, preferably in the downwind direction. The Contractor shall submit a detailed layout plan for all such sites and seek prior approval of Engineer-in-Charge of Supervision Consultant before entering into a formal agreement with a landowner for setting-up such sites. Actions by Supervision Consultant and NHAI against any non-compliance shall be borne by the Contractor at his own cost. Arrangements to minimize dust pollution through the provision of windscreens, water spray, mist spray units, and	Contractor

				Start and completion shall be provided at all such sites. No such installation by the Contractor shall be allowed till all the required legal clearances are obtained from the competent authority and the same is submitted to the Metro and the Supervision Consultant. Noise limits for construction plant and equipment that are to be procured such as compactors, rollers, Tower hoarders, concrete mixers, power concentrators, vibrators etc. shall not exceed 75 dB (A) when measured at appropriate distance from the edge of the equipment in free field, as specified in the Environment (Protection) Rules, 1986. The Contractor shall maintain a record of Pollution under Control (PUC) certificate for all vehicles and machinery used during the contract period which shall be produced to the Metro and the Supervision Consultant for verification whenever required.	
5.	Consents, permits, clearances, NOCs, etc.	Failure to obtain necessary consents, permits, NOCs etc. can result in design revisions and/or stoppage of works	Significant	- Obtain all necessary consents (including CTE for casting yard, batching plant/ hot mix plant from SPCC), permits, clearances, NOCs, etc. prior to start of civil works. - Ensure that all necessary approvals for modifications to be obtained by contractor are in place before start of construction. - Acknowledge in writing to MAHA and provide report on compliance obtained under different statutes. - Also submit list of the necessary permissions/ clearances	Contractor

				possible shall have no nuisance.	
6.	Raw material sourcing	Extraction of materials can disrupt natural land contours and vegetation resulting in accelerated erosion. disturbance in natural drainage patterns, ponding and water logging and water pollution Increase in traffic load on existing infrastructure and increase road accidents	Significant	Arrangement for locating the source of supply of material for the Tunnel construction as well as compliance with environmental requirements, as applicable, shall be the sole responsibility of the Contractor. Fly ash utilization: To the extent possible the Contractor shall explore the possibilities of utilizing the Fly ash for the construction purposes as specified in the Notification 2021 on use of fly ash. To prevent dusting, at temporary stockpiles, water shall be sprayed and covered with tarpaulins. Contractor shall prepare traffic management and get it approved by NHAI and local authority.	Contractor
8.	Development of Construction encampment and construction activities	Improper storage and availability of storage space leads to soil erosion, air and water pollution.	Significant and reversible	- Dust suppression measures with sprinkling of water should be taken for all roads used for transport. - The location for storages for construction materials shall be identified at least 500 m from water courses or water body.	Contractor
7.	Construction of labour camp	Risk of social conflict	Significant	- Construction camps shall not be constructed within 500m from the nearest settlements to avoid conflicts and issues over the infrastructure facilities with the local community. - Contractor as per prevalent rules shall carry out negotiations with the landowners (private) for obtaining their consent for temporary use of labour camp	Contractor

				Contractor shall submit detour map. - The construction on tunnel is underground will not affect any existing road and path. However in case if any road blockage, it is advice and provide safe and convenient passage for vehicles, pedestrians, etc by providing temporary connecting road.	
6	Increasing approach road.	Traffic problems and conflict near project locations and haul road.	Significant		Contractor

9.1.2 CONSTRUCTION PHASE

The **Table 9.2** summarizes the potential environmental impacts and mitigation measures, roles and responsibilities during construction phase of the project.

Table 9.2: Environment Management Plan for Construction Phase

Sr. No.	Activities	Potential Impacts	Significance	Mitigation Measures	Responsibility
1	Tunnel Construction	- Use of muck slurry and other chemicals. - Drainage inside tunnel	Significant	- Use minimal slurry and additives and minimize impact of these materials to reduce risk of impact on groundwater quality. - Ensure that pressure applied to tunneling and ground treatment is controlled to prevent excessive pressure that will drive the slurry out of the desired range increasing the risk of water pollution. - The Contractor will pass all drainage water from the tunnel through a settlement tank. - If the drainage water meets drinking water standards it can be considered for reuse in any potentially	Contractor

				related with during the construction phase.	
3	Stripping, stacking and preservation of topsoil & Muck Disposal	• Land use Change and loss of productive (fy) soil. • Trigger erosion sediment and soil runoff/ erosion/slides.	Significant	• Construction of tunnel is underground so removal of top soil is not required. However fly soil may affect at entry and exit point of tunnel, so the top soil from construction sites shall be stripped to a specified depth of <20 mm and stored in stockpiles for reuse. • Stockpile shall be arranged such that the slope does not exceed 1:2 (vertical to horizontal), and height is restricted to 2m. If soil is stored for long time, provide silt screen to prevent erosion. • The muck generated due to excavation of tunnel will disposed off at well designated site at Delhi-Meerut Expressway.	Common
5	Auxiliary activities construction machinery and sourcing of resources	Depletion of resources and and ground water contamination, siltation and contamination of surface water, nuisance to public, deterioration of local ambient air and noise quality	Significant	• Requisite permissions shall be obtained for abstraction of groundwater if required. • Consent to make use (CTO) water from near CD. • There is no river in nearby project area. So no effect on surface water is anticipated. • Diesel Generators set shall be placed on a cement concrete platform with oil and grease trap to control the oil mixed into rainwater bodies. • All equipment (earthen) drives, and overhauled	Common

				[redacted] - [redacted] - [redacted] - [redacted] - [redacted] - [redacted] - [redacted] - [redacted]	

				[illegible] – Monitor ambient air quality and comply with the standards. – Noise Limits for construction equipment used in the project such as compactors, rollers, front loaders, concrete mixers, concrete movables, vibrators and saws shall not exceed 75 dB measured at one-meter distance from the edge of equipment to the free field, as specified in the Environment (Protection) Rules, 1986. – At the construction sites within 150 m of the nearest habitation, noisy construction work such as crushing, concrete mixing, blasting shall be stopped during the night time between 10:00 pm to 6:00am.	
5	Environment, Health and Safety	– Failure in safety measure leads to accidents – Occupational hazards – Stoppage of site work and risk of litigation	Significant	– Company shall appoint a qualified EHS personnel at the start of the project to monitor training, audit, EMP implementation, monitoring, and EHS compliance – EHS officer shall prepare an annual training calendar targeting workers, supervisors, visitors and waste management. – Project manager and workers shall be imparted regular training on EMP implementation including waste management, general site safety, Standard operating procedures for accidents prevention, emergency preparedness plan, first aid training, use of	Controlled

				[illegible] personal equipments for construction work. • Site shall follow a work permit system for working at heights, working in confined spaces, and hot jobs. • Signage board shall be used to create OHS awareness. • Provide eating-shelter at external installations, DG Set etc. along with Seat/Buckets. • Proper ventilation plan shall be prepared for smooth flow of traffic. • Site shall prepare accident prevention plan. • Prepare Standard Operating Procedures for the management of C&D waste and municipal waste. • Prepare Standard Operating Procedures for best stones, pavement achieved, gender quality and sexual harassment. • Protective goggles and clothing to workers engaged in stone breaking activities and workers shall be treated in sufficiently safe intervals. • Equipp no workers exposed to loud noise (above 70 dB(A)) and workers working in crushing conjunction or concrete mixing operation. • Develop Standard Operating Procedures for monitoring, recording and records keeping.	

				- The Contractor shall not employ any person below the age of 18 years for any work.	
5.	Labour employment welfare	- Gender-based violence - Gender equality and ensure rights of workers are compromised - Social security, Health, Hygiene	Significant	- Apply and obtain labour license under contract and migrant labour act. - Maintain Wage Register - Maintain a register of attendance and overtime at the site. - Site ensure that workers' working hours should not exceed more than nine hours in day or forty-eight hours a week. - Provide a day of rest every week. - Appropriate engagement of worker to ease human resource engagement - Engage women labour from different castes/class, provide equal remuneration, provide separate rest facilities for women workers. - Contractor shall ensure that all workers engaged in site construction must have insurance same is applicable to sub-contractor. - In every establishment where 50 or more women are ordinarily employed an contract labour there shall be provided two rooms of reasonable dimensions for the use of their children under the age of 6 years. One of such rooms would be used as a play room for the	Comment

				children and the other as bathroom for the children. For this purpose the contractor shall supply adequate number of toys and games in the play room including bed in the sleeping room. The standard of construction and maintenance of the creches as per the condition specified in the BOCW Act. – Every migrant workmen shall be registered and entitled for allowance, benefits etc., as prescribed in the Act. – No female migrant workmen shall be employed by any contractor before 6 a.m. or after 7 p.m. – Provide sanitary facility for the use of workers in case the workers workers are more than 100 (BOCW Rules). – Contractor shall provide accommodations, adequate sanitation and water supply.
5.	Labor Camp Management	Location of Construction labour camps Accommodations		– Camps must be located at least 100m away from settlement areas. – The location layout and basic facility provisions of each labour camp shall be submitted and approved by Nesco IE before their construction. – The Contractor shall provide, erect and maintain necessary temporary standard living accommodation and ancillary facilities during the progress of work. – Contractor shall provide electricity, water supply and

				ensure operation of the same). - Contractor shall ensure sanitation in labour camp once in week and ensure safety precautions are followed.	
		Drinking Water Sanitation and Sewage System		- Ensure sufficient water availability for drinking, cooking and washing. - Supply of sufficient quantity of potable water (as per IS) in every workplace/labour campsite at suitable and easily accessible places and regular maintenance of such facilities. - Regular Testing of water shall be done as per the parameters prescribed in IS:10500:12991. - Compliance with C&D shall be reported & shall be explained the labour many (workforce) to ensure compliance of the C&D. **The Contractor shall ensure that-** - The sewage system for the camp are designed, built and operated in such a fashion that no health hazards occur and no pollution to the air, groundwater or adjacent watercourses take place. - Separate and sufficient number of toilets /bathrooms for men provided as necessary and workers are to be provided. - Adequate water supply is to be provided in all toilets and urinals.	

		Water Channel		- STP of suitable capacity shall be installed to manage sewage generation and to maintain satisfied condition at camp site The complete shall provide garbage bins in the camps and ensure that these are regularly emptied and disposed of	
7	Community Relations	Community Grievance Process	Significant	- Contractor shall establish a community grievance redressal system to address the public complaints and misconducts. To make it effective, contractor shall also establish an information dissemination mechanism to inform different stakeholders - Spot follow up of complaints recorded in complaints register to assess whether the complaints has been closed or not. - Public meetings to assess whether appropriate information is being provided to communities and whether sufficient information collected from communities	
8	Archaeological & artefacts	Chance finds or discovery of any archaeological artefacts, resources etc during excavation	Insignificant	There are no archaeological resources present near project area	Impact Assessment & Mitigation measures
9	Traffic management	Traffic safety and flow management	Significant	The Traffic Control Plans shall contain details of temporary diversions, traffic safety arrangements, night safety measures, speed limit signage barriers, and flag men for traffic control etc.	Construction
10	Ecology and	Tree cutting	Significant	Compensatory afforestation/plantation. Proper care of	Construction

	biodiversity (Flora & Fauna) Aquatic Ecology			Backup must be taken as the backup dam is off to be taken by cattle.	under supervision of Forest department
		– Impact the habitats and wildlife	Significant	– The construction of tunnel is below the ground level will not affect any habitats and wildlife. – However the noise and vibration due to construction equipments and TBM may cause problem. So improved and well-maintained equipment and designs should be used to minimize the noise and vibration during construction. – There is no evidence of any surface water observed nearby project area. So no effect on aquatic life.	
10	Labor Employee Welfare & Safety	Risk of social conflicts due to religious, cultural, or ethnic differences or Gender-related issues	Significant	– Contractor should ensure that workers' working hours should not exceed more than nine hours a day or forty-eight hours a week and wage register must be maintained. – Provide a day of rest every week. – No female workmen shall be employed by any contractor before 6 a.m. or after 7 p.m. (law have provision under employment contract as refered POGRI rules 20 (3). – The standard of construction and maintenance of the utilities may be such as may be specified by the	

				- To ensure safety, health and hygiene of workers, the contractor shall develop and implement site specific health and safety plan and prepare a detail standard operating procedures (SOPs) for each activity which has potential to trigger injury and accident.	

8.1.2 OPERATION PHASE

The **Table 8.2** summarizes the potential environmental impacts and mitigation measures, roles and responsibilities during operation phase of the project.

Table 8.2 Environment Management Plan for Operation Phase

Sr. No.	Activities	Potential Impacts	Significance	Mitigation Measures	Responsibility
1	Energy conservation measures	Loss of natural resources	Significant	- Use energy-efficient electrical equipment - Dual horizontal cut off glass tint luminaries are installed at 3" width. These luminaries, in addition to reducing the glare, help to minimize visual intrusion within open reflective. - Where possible use fluorescent lamp fittings. - To prevent future pollution issues prohibit the use of sodium light bulbs is prohibited and use LED lights **with a "neutral" color temperature of <3500.**	PPHS & Contractor
2	Emergency response	Possibility of hazard	Significant	- Emergency telephone system shall be provided inside the tunnel for incidents. - Phone booth at regular intervals shall be provided. - Tunnel escape route shall be provided in case of	PPHS & Contractor

				emergency - Phone booth for accidental reporting and ambulance services with minimum response time for rescue of any accident victims if possible. - Install warning signs.	
3	Traffic Management	Traffic congestion and traffic safety	Significant	- Maintenance of all necessary boards and signages to keep road user aware for diversion and other instructions. - Regular maintenance and cleaning of waste such as pigtail-tails, bus stops, drains, etc. under the contractors. - Spot placement and control and emergency preparedness system. - Temporary facility for the livestock vehicles if possible.	Whole Site Activities

9.2 GREEN BELT DEVELOPMENT PLAN

To compensate the ecological loss for felling of trees and enhancement microclimatic conditions, about 4170 nos. of trees will be planted at NH-344 PKG-III. 4170 (ten times of total trees to be felled) shall be planted as compensatory plantation. A place of land will be required for compensatory plantation of 4170 saplings. It is found that the land is available for compensatory afforestation & tree transplantation at CH 33+700 to 37+300 RHS on project – **"Development of Urban Extension road-II, NH-344M PKG-III in the state of NCT of Delhi"**. On the other hand Ornamental plantation will be carried out at entry and exit of tunnel as there is very less scope of plantation in tunnel project.

Plantation Layout Plan and Pits digging:

Multiple row of plantation is advised for better protection against soil erosion and water purification. Plantation to be done in staggered manner. The plantation layout plan has been shown in **Figure 9-1** below.

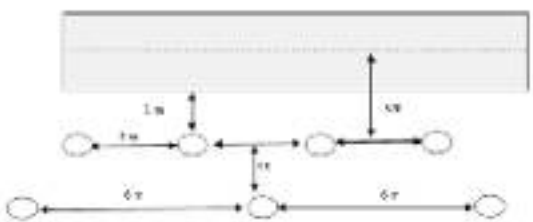


Figure 9-1: Plantation Layout Plan

Technical Specifications

The technical specifications specified here are just for understanding Green Corridor development approach. The site specific project report shall prescribe plantation pattern based on actual site conditions. The technical specifications of ornamental/flowering plants (Row I) and shade plants (Row II) have been presented in **Table 9-4** and **Table 9-5** respectively.

Table 9-4: Technical Specifications of Ornamental/ Flowering Plants (Row I)

Distance from embankment	1m or 3.3 ft away from the toe of embankment /55 ft from central traffic line
Spacing between plant to plant	3m
Canopy Shape & Size	Preferable Cylindrical/oblong with small CSA
Spacing between rows	3m
Size of the pits (normal soil)	60 X 60 X 60 cm
For Alkaline soil (usar)	By auger
Water logged areas	Mounds with height varying depending on the water level
No of plants per Km	333

Height of the plant	1.5 m to 2 m

Table 9-5: Technical Specifications of Shade Plants (Last Row)

Distance from preceding row	3m
Spacing between plant to plant	12m
Canopy Shape & Size	Preferable spreading with medium CSA
Size of the pits (normal soil)	60 X 60 X 60 cm
For Alkaline soil (usar)	By auger
Water logged areas	Mounds
No. of plants per line Km	84
Height of the plant	More than 2 m

Species Planned for Plantation:

The plants shall be at spacing of 3 X 3 m and size of the pits for planting shall be 0.6 m diameter and deep. . The species recommended for Compensatory plantation at "Development of Urban Extension road-II, NH-344M PKG-III in the state of NCT of Delhi" has been presented in **Table 9.6** below

Table 9.6: Species Recommended for Plantations

S. No.	Botanical Name	Local Name	Recommendation
1.	*Phyllanthus emolica*	Amla	Species recommended
2.	*Terminalia arjuna*	Arjun	
3.	*Acacia nilotica*	Babool	
4.	*Aegle marmelos*	Bael Patra	
5.	*Terminalia bellirica*	Baheda	
6.	*Ficus benghalensis*	Bargad	
7.	*Cordia dichotoma*	Lasora	

Abstract of estimated project cost:

The abstract of estimated cost of plantation is presented in **Table 9.7** below:

Table 9.7: Cost of Plantation

Sl No.	Type of Plantation	Plantation Cost per plant (Rs.)	Number of Plants	Cost (Rs.)
1	As per table 9.6 or recommended by Forest Department	1200*	4170	50,04,000
2	Maintenance of Green Belt	Rs 1800*/tree for 5 yrs.	4170	75,06,000
Total				**1,25,10,000/-**

*Rate as per Govt. of NCT Delhi, Department of Forest and wildlife letter No. F.11(28)/FAC/DSIR, File/SA/247/1-22 dated 09/01/18.

9.3 ENVIRONMENTAL MANAGEMENT PLAN BUDGET

The cost of environmental protection measures has been estimated **Rs 77.63 Cr** as per the following details. Total cost estimate on environment for present Section has been presented in **Table No. 9.6.**

Table No. 6.6: Environment Management Plan Budget

Components	Stage	Items	Estimated Rate	Total Cost (Rs)
Environmental Training	Construction	At regular Intervals	Lump Sum	3,00,000
Muck Disposal	Construction	Muck due to excavation= 2,22,972 Cum	Rs.300/Cum per Km	67,78,44,000
Environmental Monitoring	Construction and Operation Period	Monitoring of air, water, soil, noise and Soil (Refer Table 6.3)	As per environmental monitoring plan	1,08,01,000
Air	Construction	Dust Suppression at the project site @ Rs 3000/Km x 3Km/day x 365 days x 3 years	-	26,28,000
Solid waste	Construction	Bituminous waste disposal as per C&D rules 2016	Lump Sum	3,00,000
Plants	Construction & Operation	Plantation of trees i.e. n*25 trees in the planted	Rs. 1,000/tree including tree guard	50,04,000
		Maintenance for the period of 5 years	Rs. 180/tree for 5 yrs	72,36,000
		Ornamental Plantation & Maintenance at Entry and Exit	Lump Sum	5,00,000
Signage	Construction & Operation	Signage Board for safety and warning	Lump Sum	5,00,000
Safety	Construction	Provision of all health checks at construction sites	Lump Sum	3,00,000
		Provision for helmet, gumboots, jackets, goggles etc. to labours	Lump Sum	60,00,000
Compensation Camps	Construction	Sanitary Facilities and about Camps & Site	Lump Sum	30,00,000
Dust & Ground Water	Construction	Providing Dri interceptor, vehicle parking areas @ Rs/	Rs/ 21,000/vehicles	63,000
Total				**76,44,97,450**
Contingency @ 10%				**76,49,745**
Total				**77,53,95,445**
Say (Round off)				**77.53 Cr**

CHAPTER: 10 – SUMMARY AND CONCLUSIONS

10.1 INTRODUCTION

The Ministry of Road Transport and Highways (MoRTH), Government of India has proposed "Bharatmala Pariyojana" an Umbrella scheme of road development project through National Highways Authority of India (NHAI), National Highway, Industrial Development Corporation Ltd (NHIDCL) and State Public Works Departments (PWD). NHAI is engaged in the development of National Highways and as part of this endeavour, the Authority has decided to undertake the Economic Corridors, Inter-Corridors, Feeder Routes primarily to improve freight movement in the Country under Bharatmala Pariyojana Programme. Bharatmala Pariyojana focuses on optimizing efficiency of freight and passenger movement across the country by bridging critical infrastructure gaps through effective interventions like development of Economic Corridors, Inter Corridors and Feeder Routes, National Corridor Efficiency Improvement, Border and International connectivity roads, Coastal and Port connectivity roads and Green-field expressways.

The proposed project is a part of the Bharat Mala Project which has been envisaged as an umbrella program under the Ministry of Road Transport and Highways. The project involves constructions or improvement of national highways/ newly declared National Highways with an aim to improve road connectivity to border areas, backward areas, religious and tourist sites.

Delhi being National Capital generates and attracts huge quantum of traffic not only from within Delhi but also from surrounding region. In order to cater to this regional traffic, Inner and Outer ring roads were planned in 1962, of which only inner ring road could be completed whereas outer ring road is still not a full ring. Additionally, non-Delhi destined traffic i.e. traffic to/from North Indian States (which includes Punjab, Northern Haryana, Jammu & Kashmir) to remaining Indian states (which includes Rajasthan, Southern Haryana, Gujarat, Maharashtra) has to pass through Delhi due to absence of alternate network. This leads to heavy congestion on the existing ring roads.

The National Highways Authority of India has been assigned the work of "Construction of a road tunnel for NH-148E with its approach and connection to NH-248BB in NCT of Delhi."

The total length of the project is 4.983 Km with a PRoW of 45m. The main objective of the proposed project is decongestion of traffic. The proposed tunnel is completely Greenfield / underground and hence will have negligible impact on environment.

10.2 BRIEF ABOUT THE PROJECT AND ITS LOCATION

The project starts from Near Shivmurti Interchange NH-8 proposed Ch. 0+000 and ends at Nelson Mandela Marg at Vasant Kunj with Chattarpur-Mahipalpur Road proposed Ch. 4+983.

The proposed underground Tunnel is passing through New Delhi & South Delhi district in the NCT of Delhi. The main objective of the project is that NH-48 carries very heavy traffic to Chattarpur/ Vasant Kunj from Gurugram creates a heavy congestion at Mahipalpur due to very narrow city road, traffic to and from Delhi airport and Mahipalpur/ Rangpuri market.

The salient features of the proposed project are presented in **Table No. 10.1** below.

Table No 10.1: Salient features of the project

1.	Project Name	Construction of a road tunnel for NH-148E with its approach and connection to NH-248BB in NCT of Delhi.
2.	Location of the sub project road	The project NH-148AE starts from Shiv murti Interchange Ch. 0.000 Km (Dwarka Expressway Package-1/UER/NH248BB) at NH-48 and ends at Nelson Mandela Marg Ch. 4.983 Km in Vasant Kunj in New Delhi.
3.	Total design length of the project	4.983 Km
	3.1 Tunnel Length	4.306 Km
	3.2 Approach Ramp	0.594 Km
	3.3 At Grade	0.074 Km
	3.4 New Proposed Flyover	0.668 Km
4.	Geographical Location	Start 28°31'55.31"N, 77°06'27.34"E End 28°31'44.78"N, 77°8'53.25"E
5.	Start Point	NH-8 Near Shivmurti Interchange
6.	End Point	Nelson Mandela Marg Vasant Kunj
7.	Project Category (as under EIA Notification, 2006)	Category-A
8.	Total Civil cost	3426.38 Cr
9.	Total Capital Project Cost (including Civil, Utility Shifting and Forest, Environment)	4089.09 Cr
10.	**Resource Requirement**	
	i. Reinforcement	17,213.42 Tons
	ii. Concrete	**Item** / **Estimated Qty (m3)** Dry wet Cement Concrete (DLCC) / 14856.05 Plain Cement Concrete (PCC) / 33360 M30 / 48489 M25 / 7714
	iii. Water	**Thematic area** / **Quantity (m3/day)** Road construction (tunnel) / 300 KLD Road making Local surface/ground water / 20 KLD Dust suppression / 50 KLD Others (including drinking and domestic purposes) / 50 KLD

		Total	420 KLD
		10% Contingency	42 KLD
		Total	462 D
	iv. Estimated Manpower requirement (Skilled and unskilled)	400 – 450 per day	
11.	Transportation		
	i. Muck Disposal	122 trip per day	
	ii. Concrete	88025 m^3	
	iii. Segments (To be estimate TBM contractor)	10563 Nos	
12.	Power of Consumption		
	i. DG Set during construction phase	3 Nos x 750 KVA	
	ii. TBM Capacity	7371758 KWH	
13.	Terrain	Plain & rolling	
14.	Existing right of way (ERoW)	5-45 m.	
15.	Proposed Right of Way	30-45 m	
16.	Carriageway	10.5 m (3.5m + 3.5m + 3.5m)	
17.	Design Speed	60 Km/hr	
18.	Safety Measure	New Jersey Crash Barriers	
19.	Flyover	1 Nos	
20.	Proposed Toll Plaza	1 Nos (Ch 4+900)	
	Feature of EIA importance		
21.	Type of Mode	EPC	
22.	Location of Proposed Project Name	Construction of a road tunnel for NH-148E with its approach and connection to NH-248BB in NCT of Delhi.	
23.	Jurisdiction		

Sl No.	State	District	Village
1	NCT of Delhi	New Delhi	Sarnaika
2		New Delhi	Rajokari
3		New Delhi	Rangpuri
4		New Delhi	Masoodpur
5		South Delhi	Mehrauli

24.	Seismic Zone	Zone IV

25.	Forest Land Diversion	Forest land involving 5.8257 ha falling under Southern Ridge Reserved Forest and 1.6888 ha falling under Deemed Forest will be diverted. The Project involves 417 trees cutting at the exit point and U-turn Modification. **Permission for the same has been granted by Hon'ble** Supreme Court via diary no.(s) 34870/2023 in W.P (Civil) no. 467/1995 listed date on 18.10.2023 (Copy Attached as **Annexure II).**
26.	Water bodies Impacted	None
27.	Existing trees within ROW	417 at the exit point near Nelson Mandela Marg and modification of U-turn are given in **Annexure III.**
28.	Compensatory Plantation	Approx. 4170 (ten times of total trees to be felled) shall be planted as compensatory plantation.
29.	Wildlife Sanctuaries	NIL
30.	Nos of Structure Affected	NIL
31.	Total Area of Land Acquisition	Land Acquisition would not be required due to the project is an underground Tunnel

10.3 DESCRIPTION OF ENVIRONMENT

Study Area:

The base-line data has been collected for Core Zone [Corridor of Impact (COI)], an area covering 000 m on both sides of the proposed alignment and 10 km buffer zone for prominent environmental attributes like Ambient Air quality, Noise Level, Water quality and Soil profile. Primary and Secondary data has also been collected for other environmental attributes for the preparation of EIA/EMP report. The baseline study for the project was conducted during the months from March 2022 to May 2022 (Summer Season)

Baseline Study:

The findings of the baseline environmental status on land (topography, geology, soil quality, land use pattern), meteorology (Temperature, Relative Humidity, rainfall, wind speed, wind rose), air (ambient air quality- PM_{10}, $PM_{2.5}$, SO_2, NO_x and CO), water (surface & ground water), noise level, ecological environment (terrestrial and aquatic flora & fauna), socio-economic conditions (demographic profile and **households'** condition) were presented and interpreted with reference to environmental standards.

Meteorology:

The study area is located in New Delhi and South Delhi. The climate of district is mainly influenced by its inland position and prevalence of air of the continental type during major part of the year. Extreme

dryness with intensely hot summer and cold winter are characteristics of the climate. The cold season starts towards the latter half of November when both day and night temperatures drop rapidly with the advance of the season. January is the coldest month with the mean daily maximum temperature at 21.3°C and the mean daily minimum temperature at 7.3°C. May and June are the hottest months. In May and June, maximum temperature may sometimes reach 46 or 47°C.

Air Environment:

Ambient air quality monitoring has been done at 8 locations. Specific station-wise Ambient Air Quality (AAQ) data for PM 2.5, PM 10, SO2, NO2 and CO as recorded during the months from March 2022 to May 2022. The minimum and maximum values of, PM2.5, PM10, So2, NO2 and CO analyzed along the proposed project tunnel are 82.4(µg/m3) to 120.6(µg/m3), 111.5(µg/m3) to 216.5(µg/m3), 10(µg/m3) to 19.5(µg/m3), 17.8 (µg/m3) to 34.6 (µg/m3) and 0.69 (mg/m3) to 1.92 (mg/m3) respectively. All the parameters have been analyzed and show that all the parameters are well below the National Ambient Air quality standards, 2009.

Water Environment:

The development of any region is based on the availability of sufficient water resources, as developmental activities require water for irrigation, domestic and other purposes. 08 Ground water samples have been taken along the proposed project highway/tunnel. The pH varies from 7.3 to 7.4, Total dissolved solids vary from 325.6– 344.0 mg/l, and Total Hardness as CaCO3 varies from 116.5 – 161.0 mg/l, whereas no surface water body is presented near the alignment. All physical and general parameters were compared with the desirable and permissible limits as per IS10500:2012 for ground water and it is interpreted that all results are within Permissible limits and water can be used for drinking purpose.

Noise Environment:

Ambient noise level monitoring has been done at 8 locations along the proposed Expressway. The hourly recorded noise level at various locations in the study area shows fluctuations because of change in traffic movement, construction activities and other man-made sources. The noise levels vary from 52.4 to 59.7 dB (A) during daytime and whereas during night time the noise level varies from 43.7 dB to 51.0 dB (A), which are within the prescribed norms as defined in Noise standards, 200.

Soil Environment:

Soil sampling has been done at 8 locations near to the proposed highway. The pH of the soil samples ranged from 7.19 to 7.30 during the study period, indicating that soils are slightly neutral to slightly alkaline in nature. The soil Electrical Conductivity (EC) also varies from 18.6 µs/cm to 24 µs/cm. These parameters indicate that soils are neutral in reaction and having average EC. The Nitrogen content ranges from 2.88 kg/ha to 5.81 kg/ha, Bulk density ranges from 2.88 kg/ha to 5.81 kg/ha and Zinc content ranged from 1.88 mg/kg to 2.02 mg/kg during the study period. Based on soil analysis

data it is concluded that soil is rich in nutrient. The availability of Nutrients for the plant growth in the study area is good.

Ecological Environment:

The forest crop is dominant plants present in the study area were *Acacia nilotica, A. leucophloea, A. catechu and A. modesta, Capparis separia, C. decidua, Tribulus terrestris, Zizyphusoenoplia, Croton sparsiflorus, Tephrocia purpurea, Prosopis juliflore* etc. The major fauna species present in the study area are includes Nilgai, Jungle Cat, Small Indian Civet, Ruddy Mongoose and Small Indian Mongoose, Rufous Tailed hare, Per lizard cat etc. The detail list of flora and fauna in the project area has been provided in EIA/MP report.

The proposed alignment does not pass through any Wildlife Sanctuary/National Park and its eco sensitive zone.

Socio Economic Environment:

The primary purpose of socio-economic analysis is to provide an overview of the State's, socio-economic status and the relative status of the Project Influence Area (PIA) within the State.

The project alignment passes through New Delhi and South Delhi district in the state of Delhi.

District New Delhi

New Delhi with a density of 4,057 persons per km^2. According to the provisional results of the 2011 national census, New Delhi has a population of 1,42,004, making it one of most populated UT. The district occupies the eighth place in terms of area as it shares 2.4 per cent of the total area of the State. The district is fully urban. In terms of Population, it occupies the fourth position and shares 0.8 percent population of the State. It has no villages. No uninhabited villages of the State fall in this district. It's two tehsils are totally urban. In terms of density, it occupies the eighth position in the State. The Sex Ratio of the district is only 822 and it occupies 9th place amongst all the nine districts.

District South Delhi

South Delhi with a density of 11,060 persons per km^2. According to the provisional results of the 2011 national census, New Delhi has a population of 27,31,929, making it one of most populated UT. The district occupies the third place in terms of area as it shares 16.7 per cent of the total area of the State. In terms of Population, it occupies the fourth position and shares 16.3 percent population of the State. No uninhabited villages of the State fall in this district. It has only 3 villages and its two tehsil are totally urban. In terms of density, it occupies the sixth place in the State. The Sex Ratio of the district is only 862 and it occupies 7th place amongst all the nine districts.

10.4 IMPACTS AND MITIGATION MEASURES

The potential impact and their mitigation measures during of the Pre-Construction, Construction & Operation Phase have been presented in **Table No. 10.2**.

Table 5.1: S.E.C – Possible Impacts and their mitigation measures suggested for the proposed project

Pre-Construction					
Sr. No.	Activities	Possible Impacts	Significance criteria for determining significant impact (e.g. any impacts triggering loss of land, impacts irreversible, the likelihood of causing accidents and disorder of social regulations or transnational commitments)	Mitigation Measures	Responsibility
1	Land acquisition	- Loss of land, structure, standing crops, trees, and other assets - Removal and relocation of utilities and services - Property Resettlement (CPR) & Act. - Removal and relocation of Cultural and Religious Properties.	Insignificant	There is no land acquisition is required for tunnel projects as underground. Also no structure of any type is going to impact due to construction of underground tunnel.	NHAI & Contractor
2	Site preparation	- Conversion of existing land into construction site as per design, removal of standing crop, felling of trees and removal of top soils	Significant	- As far as possible maximum efforts shall be made to minimize the number of trees proposed to be felled by adopting of engineering designs. - Trees shall be removed from the Corridor of Impact	NHAI & Contractor

		• Air, noise & water pollution		(Civil and construction jobs) before the commencement of construction. Prior Permission shall be obtained from the concerned authority for the mass felling. • There is no crop which are going to affect due to construction of underground tunnel. • Construction of tunnel & underground will not affect HQ and except electricity as well (OSH) • Ambient Air Quality monitoring will be performed by the contractor as per the Environmental Monitoring Program and in accordance with the general and specific condition as stipulated in Environment clearance letter, CTE and CTO.	
2.	Movements of machinery (Construction vehicles, equipment and machinery for casting plant, Hot mix Plants & Batching Plants)	• Disruptions to traffic flow and disturbance to sensitive receptors and nearby community including road accidents • Air, noise & water pollution	Significant	• Crushers, hot mix plants, and casting and batching plants shall comply with the requirements and specifications of the current relevant control legislation and specifications. Consent / NOC for all such plants shall be submitted. • Casting yard, batching plant, crushers, hot mix plants shall be located at least 1000m (1km) away from residential settlements, forests, wetlands, and commercial establishments, preferably in the downwind direction. • The Contractor shall submit a detailed layout plan for all such sites and seek prior approval of Engineer-in-charge of Supervision Consultant before entering into a formal agreement with a landowner for setting up such sites. Actions by Supervision Consultant will apply against any non-compliance shall be taken by the Contractor at his own cost. • Arrangements to minimize dust pollution through the provision of windbreaks, water spray, road spray units, and dust encapsulation shall be provided at all such sites. • No work completion by the Contractor shall be	Contractor

				allowed for all the required legal clearances are obtained from the competent authority and the same is submitted to the Nodal and the Supervision Consultant. - Nodal body for construction plant and equipment that are to be procured such as manpower, rollers, hoist, loaders, concrete mixers, lorries (incinerator), vibrators etc. shall not exceed 70 dB (A) when measured at a perpendicular distance from the edge of the equipment or the limit as specified in the Environment (Protection) Rules, 1986. - The Contractor shall maintain a record of Pollution under Control (PUC) certificate for all vehicles and machinery used during the contract period, which shall be produced to the Nodal and the Supervision Consultant for verification whenever required.	
7.	Consents, permits, clearances, NOCs, etc.	Failure to obtain necessary consents, permits, NOCs, etc. can result in design revisions and/or stoppage of works.	Significant	- Obtain all necessary consents (including CTE/ for casting yard, batching plant/or the plant, Hot Mix), permits, clearances, NOCs, etc. prior to start of civil works. - Ensure that all necessary approvals for construction to be obtained by contractor are in place before start of construction. - Acknowledge in writing to NHAI and provide report on compliance (colored color different shades). - Non- overlap of the necessary permissions/clearances/permits shall lead to violations.	Contractor
8.	Raw material sourcing	- Excavation of materials can disrupt natural land contours and vegetation resulting in accelerated erosion, disturbance to natural drainage patterns, ponding and water logging, and water pollution.	Significant	- Arrangements for locating the source of supply of materials for the Tunnel construction as well as compliance with environmental requirements, as applicable, shall be the sole responsibility of the Contractor. - Fly ash utilization: To the extent possible, the Contractor shall explore the possibilities of utilizing	Contractor

		• Increase in traffic load on existing infrastructure and increase road accident		the fly ash for the construction purposed as specified in the Notification 2021 on use of fly ash. • To prevent dusting at temporary structures, water shall be sprayed and covered with tarpaulins. • Contractor shall prepare traffic management and get it approved by RMC and local authority.	
6.	Development of Construction structures and construction activities	Improper storage/ non availability of storage space leads to soil erosion, air and water pollution	Significant and reversible	• Dust suppression measures with sprinkling of water should be taken for all roads used for transport. • The location for stockyard for construction materials shall be identified at least 100 m from watercourses or water body.	Contractor
7.	Construction of labour camp	Risk of social conflict	Significant	• Construction camps shall not be proposed within 500m from the nearest settlements to avoid conflicts and issues over the infrastructure facilities with the local community. • Contractor as per provision rules shall carry out negotiations with the landowners/ private by obtaining their consent for temporary use of labour camp. Contractor shall submit labour camp.	Contractor
8.	Accessibility/approach road	Traffic problems and conflict near project locations and haul road	Significant	• The construction on tunnel is underground will not affect any existing road and LMR. However, in case if any road blockage, it is ensured and provide safe and convenient passage for vehicles, pedestrians, etc. by providing temporary connecting road.	Contractor

Construction Phase

Sr. No.	Activities	Potential Impacts	Significance	Mitigation Measures	Responsibility
1.	Tunnel Construction	• Use of toxic slurry and other chemicals • Drainage inside tunnel	Significant	• Use nontoxic slurry and additives and minimize impact of these materials to reduce risk of impact on ground water quality. • Ensure that pressure applied in tunneling and ground treatment is controlled to prevent excessive	Contractor

				pressure that will drive the slurry out of the desired range increasing the risk of water pollution. • The Contractor will pass all drainage water from the tunnel through a settlement tank. • If the drainage water meets drinking water standards it can be considered for re-use in any potentially depleted wells during the construction phase.	
3	Mapping, marking and preservation of Historic & Work Objects	• Land use Change and loss of productive top soil. • Trigger erosion, sediment and soil and fill landslides etc.	Significant	• Construction of tunnel is underground so removal of top soil is not expected. However top soil may affect all entry and exit point of tunnel, so the top soil from construction sites shall be stripped to a specified depth of 150 cm and stored in stockpiles for reuse. • Stockpile sites the averaged such that the slope does not exceed 1:2 (vertical to horizontal), and height is restricted to 3m. If soil is stored for long time, provide silt fences to prevent erosion. • The muck generated due to excavation of tunnel will disposed off at well designated site at Delhi Meerut Expressway.	Contractor
3	Auxiliary activities: construction machinery and sourcing of resources	Depletion of resources and water ground water contamination, siltation and contamination of surface water, nuisance to public, deterioration of local ambient air and noise quality	Significant	• Requisite permissions shall be obtained for abstraction of groundwater if required. • Contractor must use STP water from near STP. • There is no need to nearby project work. So, no effect on surface water is anticipated. • Diesel Generator set shall be placed on a cement concrete platform with oil and grease trap to control the oil ingress into soil/water bodies. • All equipment operators, drivers, and warehouse personnel will be trained in immediate response for spill containment and eventual clean-up. • Hazardous waste such as waste/used oil/oil filter/ oil soaked cotton from DG set and vehicles shall be disposed of through authorized recycler. Prior	Contractor

				authorized TSD MPCB should be obtained for the sewage and disposal. - Water quality to be monitored periodically as per the monitoring plan once in six months. - Ensure storm water drain all around periphery of making and manning plant including regular cleaning and maintenance. - Contractor shall prepare traffic management and dust suppression plan duly approved by RMC/SPCB. - Ensure that batching and asphalt mixing plants and crushers shall be located at downwind direction (if any) from nearest settlement. - Submit PUC certificates for all vehicles/ equipment/ machinery that are being used for the project. - Ensure regular water sprinkling and wet application of dust course by erection of sprinklers/tankers. Also water shall also be sprayed on haul road and where is required. - Vehicle delivering material shall be covered. Exit tyre/s in trucks shall be provided to prevent spillage. - Manpower employed as quality and comply with the standards. - Noise Limits for construction equipment used in the projects such as compressor, rollers, front loaders, concrete mixers, cranes (movable), vibrators and saws shall not exceed 75 dB measured at prescribed distance from the edge of equipment in the free field, as specified in the Environment (Protection) Rules,1986. - At the construction sites within 150 m of the nearest habitation, noisy construction work such as breaking, concrete mixing, batching shall be stopped during	

				the night time between 6:00 pm to 6:00am	
1	Occupational Health and Safety	- Failure in safety measure leads to accidents - Occupational hazards - Stoppage of site work and risk of litigation	Significant	- Contractor shall appoint a qualified EHS personnel in the start of the project to conduct training, audit, EMP implementation monitoring and EHS compliance - EHS officer shall organize an induction training calendar targeting workers, supervisors, middle and senior management - Project managers and workers shall be organized regular training on EMP implementation including waste management, general site safety, Standard operating Procedures for accident prevention, emergency preparedness plan, first aid training, use of personal protective equipments, for construction works - Site shall initiate a work permit system for working at heights, working in confined spaces, and hot jobs - Signage board shall be used to create EHS awareness - Provide extinguishers at electrical installations, DG set etc., along with bund structures - Proper ventilation plan shall be prepared for smooth flow of traffic. - Site shall prepare accident prevention plan - Prepare Standard Operating Procedures for the management of C&D waste and municipal waste - Prepare Standard Operating Procedures for labor issues, grievance redressal, gender quality and sexual harassment - Protective goggles and clothing to workers engaged in stone breaking activities and workers shall be trained in sufficiently safe manner	Contractor

				- Engage no workers exposed to loud noise (above 90 dB (A)) and workers working in confined compartment or concrete mixing operation. - Develop Standard Operating Procedures for monitoring, reporting and capacity building. - The Contractor shall not employ any person below the age of 18 years for any work.	
5	Labour/ employee welfare	- Gender-based violence - Gender equality and women rights of workers not compromised - Social security, health, hygiene	Significant	- Apply and obtain labour license under contract and migrant labour act. - Maintain Wage Register - Maintain a register of advance and overtime at the site. - Site ensure that workers' working hours should not exceed more than nine hours a day or forty-eight hours a week. - Provide a day of rest every week. - Proportionate engagement of women to total human resource engagement. - Engage women labour from different communities, provide equal remunerations, provide separate toilet facilities for women workers. - Contractor shall ensure that all workers engaged in site construction must have insurance, same is applicable to sub-contractors. - In every establishment where 50 or more women are ordinarily employed, one suitable room shall be provided and made of reasonable dimensions for the use of their children under the age of 6 years. One of such rooms would be used as a play room for the children and the other as bathroom for the children. For this purpose, the contractor shall employ adequate number of nurs and ayahs in the play room including two in the sleeping room. The	Currency

				standard of cleanliness and maintenance of the premises as per the condition specified in the BOCW Act • Every migrant workmen shall be registered and entitled for allowance benefits etc., as prescribed in the Act. • No female migrant workmen shall be employed for any work(s) between 6 a.m. to after 7 p.m. • Provide restroom facility for the use of workers in case the number workers are more than 250 (BOCW Rules) • Contractor shall provide accommodation, adequate sanitation and water supply.	
8.	Labour Camp Management	Location of Construction labour camp		• Camps shall be located at least 500m away from settlement areas. • The location, layout and basic facility provision of each labour camp shall be submitted and approved by Board of Authorities/ Corporation.	
		Accommodation		• The Contractor shall provide, erect and maintain necessary (temporary) standard living accommodation and ancillary facilities during the progress of work. • Contractor shall provide electricity, water supply and adequate sanitation in the camp. • Contractor shall ensure sanitation in labour camps once a week and ensure (anti) mosquitoes are followed.	
		Portable Water Sanitation and Sewage System		• Ensure sufficient water availability for drinking, cooking and washing. • Supply of sufficient quantity of potable water (as per IS) in every work/place/labour campsite or suitable and easily accessible places and regular	

				maintenance of such facilities. - Regular Testing of water shall be done as per the parameters prescribed in CPHEEO 1991. - Compliance with EMP shall be reported & shall be inspected the Mitigation measures mentioned in the EMP. - The Contractor shall ensure that: - The sewage outlets for the camp are designed, built and operated in such a fashion that no health hazards occur and no pollution to the soil, groundwater or adjacent water courses take place. - Adequate and sufficient number of toilets, bathrooms for male workers in each labor camp and women are to be provided. - Adequate water supply is to be provided in all toilets and urinals. - DSR of suitable capacity shall be installed to manage sewage generation and to maintain sanitation condition at camp site.	
		Waste Disposal		- The contractor shall provide garbage bins in the camps and ensure that these are regularly emptied and disposed of.	
7	Community Relations	Community Grievance Process	Significant	- Contractor shall establish a community grievance redressal system to address the public complaints and concerns/issue. To make it effective, contractor shall also maintain an information documentation mechanism to inform different stakeholders. - Such follow up of complaints recorded in complaints register to assess whether the complaints had been closed or not. - Public meetings to assess whether appropriate information is being provided to communities and whether sufficient information collected from	

				Construction	
9.	Archaeological artefacts	Chance finds or discovery of any archaeological artefacts, treasure etc. during excavation	Insignificant	• There are no Archaeological resources present near project area	Project Proponent & Site In charge
9.	Traffic management	Traffic safety and flow management	Significant	• The Traffic Control Plans shall contain details of temporary diversions, traffic safety arrangements, night safety measures, speed limit, signage, barriers, and flagmen for traffic control etc.	Contractor
10.	Ecology and biodiversity (Flora & Fauna, Aquatic Ecology)	Tree cutting	Significant	• Compensatory afforestation/plantation: Ensure new [illegible] must be taken, so the saplings don't die or are eaten by cattle.	Contractor under supervision of forest department Contractor &
		• Impact on habitats and wildlife	Significant	• The construction of tunnel is below the ground level will not affect any habitation and wildlife. • Increase the noise and vibration due to construction equipment and TBM may cause problem. So improved and environmental equipment and barrier should be used to minimize the noise and vibration during construction. • There is no evidence of any surface water influenced nearby project area. So no effect on aquatic life.	
11.	Labour/Employee Welfare & Safety	Risk or social conflicts due to religious, cultural or ethnic differences or Gender-based violence.	Significant	• Contractor should ensure that workers' working hours should not exceed more than nine hours in day or forty-eight hours a week and wages register must be maintained. • Provide a day of rest every week. • No female workmen shall be employed by any contractor before 6 a.m. or after 7 p.m. Also there provision under employment violence for women PCOM rules 2013. • The provision of construction and maintenance of	

				the UK/Other body for such as may be specified BDMC Act • To ensure safety, health and hygiene of workers, the contractor shall develop and implement site specific health and safety plan and prepare a detail Standard operating procedures (SOPs) for each activities, which has potential to trigger injury and accident	

Operation phase

Sr No.	Activities	Potential Impacts	Significance	Mitigation Measures	Responsibility
1.	Energy consumption/ emissions	Loss of natural resources	Significant	• Use energy efficient electrical equipment • Full functional LED (IP glass lens luminaires are installed at Sp path. These luminaires, in addition to reducing sky glow, help to minimize visual intrusion, when seen from above. • Where possible use lower lamp heights. • To prevent future problem never permit the use of sodium light bulbs in portholes and use LED lights with a "neutral" (3500 temperature of 4000K.	NHAI & Contractor
2.	Emergency Response	Incidents in tunnel	Significant	• Emergency Response system shall be provided inside the tunnel for accidents. • Phone booth at regular interval shall be provided. • Tunnel escape route shall be provided in case of emergency. • Phone booth for accidents reporting and ambulance serviced with minimum response time in case of any accident occurs, if possible. • Install warning signs.	NHAI & Contractor

5	Traffic Management	Traffic Congestion Traffic safety	Significant	– Maintenance of all informatory boards and signage to keep road user aware for direction and other instructions – Regular maintenance and cleaning of assets such as sign boards, bus stops, toilets, etc. shall be undertaken. – Spill prevention and control and emergency response system – Township facility for the beneficiary vehicles if possible	Bidder/ Site in charge

10.5 ANALYSIS OF ALTERNATIVES

Three alternative alignments have been considered.

10.5.1 OPTION-1

The alignment starts from the proposed Shiv Murti Interchange and point via a tunnel which traverses for a length of 2 Km through southern ridge. The tunnel exits 700m before the end point of Nelson Mandela Marg and then a 594 m ramp and 74 m at grade surface road merges with the Nelson Mandela Marg end point. Salient Features of the Alignment are as follows:

- Total Length- 4983 m
- Tunnel Length-4306 m
- Approach Ramp to Tunnel End Portal- 594 m
- At Grade Surface Road- 74 m

Pros and Cons of option 1 are as follows:

Pros	Cons
• No Impact on Rangpuri Farm House and Ridge Forest Area • No land acquisition is proposed • Least Impact on Existing Utilities • No traffic hassles during construction period	• Long Tunnel Length will lead to increase in cost

10.5.2 OPTION-2

The alignment starts at the same point as discussed in earlier options after Shivmurti interchange with a tunnel which traverses beneath the Rangpuri Farm House Area and Rangpuri forest. The tunnel ends at Nelson Mandela Marg on the existing road and the approach ramps from tunnel will meet the existing road at a gradient of 3.3% before the Vasant Kunj Flyover Red light. This option does not involve any land acquisition but the construction on existing Nelson Mandela Marg which is coming on the end approaches of tunnel will lead to shifting of utilities, traffic hassles during construction as the Nelson Mandela Marg serves as the only connecting road to 4 nos. of DDA housing societies (Ganga, Yamuna, Narmada and Saraswati).

Salient Features of the Alignment are as follows:

- Total Length- 4769 m
- Tunnel Length- 4100 m
- Approach Ramp to Tunnel End Portal- 600 m
- At Grade Surface Road- 69 m

Pros and Cons of Option-2 are as follows:

Pros	Cons
• No impact on Rangpuri Farm House and Ridge Forest Area • No Land Acquisition	• Long Tunnel Length will lead to increase in cost • Utility Shifting- A number of utilities i.e., IGL gas pipelines, HT Line, Water and Sewer Network are present at the existing Nelson Mandela Road which needs to be shifted. • Traffic Hassles during Construction as the Nelson Mandela Marg serves as the only connecting road to 4 nos. of DDA housing societies.

10.5.3 OPTION-3

The proposed alignment is similar to that proposed in Option-1, only the tunnel exits after the Rangpuri Ridge Forest Area reducing the tunnel length to 2800 m and then a 600 m approach ramp and 702 m at grade surface road merges with the Nelson Mandela Marg end point.

In addition to this newly proposed alignment, modifications in existing Nelson Mandela Junction are required to make the junction signal free and smooth flow of traffic. This will include blocking of right movement at the junction and providing a guided U Turn at the existing traffic light near Spinal Injury hospital towards Mahipalpur end. Apart from this, an additional flyover parallel to existing flyover at Nelson Mandela Junction would also be required. Strengthening and upgrading of Nelson Mandela Marg from the dead end till Junction has also been proposed in order to make it similar to the newly proposed green field alignment. For the local societies, the two service lanes have been proposed which will be cater both ways traffic. No direct flow of traffic on the main 6 lanes carriageway is recommended.

Salient Features of the Alignment are as follows:

- Total Length- 4102 m
- Tunnel Length- 2800 m
- Approach Ramp to Tunnel End Portal- 600 m
- At Grade Surface Road- 702 m
- Up-gradation of Nelson Mandela Marg with 2 lanes service roads on both sides for local societies.
- New flyover parallel to existing flyover at Nelson Mandela Junction – 400m length
- Two lanes Guided U turn at traffic lights towards Mahipalpur near Spinal Injury Hospital

- Restricting right turn at Nelson Mandela Junction.

Pros and Cons of Option-3 are as follows:

Pros	Cons
• No Impact on Rangpuri Farm House and Ridge Forest Area • Least Tunnel Length will lead to decrease in project cost • Least Impact on Existing Utilities • No traffic hassles • Smooth traffic flow in and around Nelson Mandela Junction	• Least Land Acquisition- 7.812 Ha considering (1302 m length and 60m width of ROW) • Land Acquisition at one Farm House near the end point •

10.6.4 OPTION-3.1 EXTENSION

The proposed alignment is similar to that proposed in Option-3, in which the tunnel exits after the Rangpuri Ridge Forest Area reducing the tunnel length to 2800 m and then a 600 m approach ramp is provided. After exiting the tunnel, a 1700m long viaduct is provided which passes on the Nelson Mandela Marg and crosses from above the Vasant Kunj Flyover. The flyover ends before the U turn on the Vasant Kunj Mall Road.

Salient Features of the Alignment are as follows:

- Total Length- 6111 m
- Tunnel Length- 2800 m
- Approach Ramp to Tunnel End Portal- 600 m
- Viaduct Length- 1700 m
- Approach Ramp to Viaduct- 700m
- At Grade Surface Road- 311 m

Pros and Cons of Option-3.1 Ext are as follows: Pros

Pros	Cons
• No Impact on Rangpuri Farm House and Ridge Forest Area • Traffic coming out from tunnel towards Nelson Mandela will be through movement via the elevated viaduct •	• Additional viaduct will lead to more capital cost • Land Acquisition- 7.812 Ha considering (1302 m length and 60m width of ROW) • Land Acquisition at one Farm House near the end point • Shifting of HT Line (3 Nos. of HT)

10.6 ENVIRONMENTAL MONITORING PROGRAMME

The Environmental Monitoring Programs are also suggested to provide information on which management decisions may be taken during construction and operational phase. The objective of this program is to evaluate the efficiency of mitigation and enhancement measures, updating the actions & impacts of baseline data and adaptation of additional mitigation measures. Total cost for environment monitoring plan is **Rs. 1,50,00,000**

10.7 ADDITIONAL STUDIES

10.7.1 Public Consultation & Public Hearing

As per the EIA notification dated 14th September 2006, vide section 7(f) related to public hearing, the draft EIA/EMP report is being submitted to the Delhi Pollution Control Committee (DPCC) for conducting public hearings in South Delhi district in the state of Delhi

10.7.2 Social Impact Assessment

The proposed project is underground tunnel does not going to affect any structure. The Tunnel passes through the Ridge Forest area, there is no private land involve in the project. Hence No Social Impact Assessment is required. There is no land acquisition required for the project

10.7.3 Road Safety Features

Indian Road Congress (IRC) codes will be followed in proposing and designing road safety features. Pavement markings will be done for traffic lane line, edge lines and hatching. The marking will be with hot applied thermoplastics materials. The pavement markings will be reinforced with raised RR pavement markers and will be provided for median and shoulder edge longitudinal lines and hatch markings. Tunnel lightings including high masts will be provided at intersections in order to improve the night time visibility.

All the urban locations as well grade separated structure locations will be provided lighting arrangements.

In addition to avoid the accidents inside and outside the tunnel & for the smooth and safe flow of traffic it is required to provide the various safety features for the tunnel. In accordance to IRC: SP: 91, the tunnel is classified as long tunnel and therefore require ventilation system and associated MEP systems along with other facilities suitable to all possible tunnel operations modes.

The following section establishes design criteria of mechanical & electrical systems for Tunnel.

- Ventilation System
- Emergency Power supply System
- Fire Fighting system
- Lighting System

- Traffic Management and Controls Systems (TMCS) etc
- Noise & Vibration

The Detailed study is given in Chapter-7 of EIA report.

10.8 PROJECT BENEFITS

As NH-48 carries very heavy traffic to Chattarpur/Vasant Kunj from Gurugram creates a heavy congestion at Mahipalpur due to very narrow city road, traffic to and from Delhi airport and Mahipalpur/Rangpuri market. Since, the road bears heavy traffic and have very heavy settlement enroute, heavy congestion along this route occurs during the peak hours of the day. Widening along this route is almost difficult due to heavy settlement, and therefore, it was proposed to connect NH-248BB with NH-148NE at Nelson Mandela Marg to avoid this congestion. The proposed alignment is a green field alignment and enroute posh area of Westend Green and across the Rangpuri Ridge.

The advantages of this project are as follows:

- Easy flow of traffic from Dwarka Expressway to Nelson Mandela Marg which remain heavily congested areas in Mahipalpur and Rangpuri. No major congestions on NH-48 in peak hours.
- Availability of 6 lane road at Nelson Mandela Marg meets the design configuration of tunnel that has also been proposed a 6-lane tunnel. Traffic flow would be easy without any major hassles.
- No land is being acquired for the construction of underground tunnel. However, Forest land of approx. 7.5145 ha of land will be diverted around the Southern ridge and Deemed forest area. Permission for which has already been applied through FCA proposal no. **FP/DL/OTHER/8/468848/2024 dated 22.01.2024.**
- It will create a short distance route that will take less travel time, and hence, resolve traffic congestions problem at the aforesaid places. In addition, it will improve local ambient air quality and reduction in carbon footprints during entire life cycle of the project.
- The project also does not trigger displacement, no structure are going to impact due to construction of underground tunnel, however, some public utility will be impacted at the Nelson Mandela area which is the exit point of the proposed Tunnel.
- And being a Greenfield project, it will envisage very less impact upon the environment.

10.9 ENVIRONMENTAL MANAGEMENT PLAN (EMP)

The Environmental Management Plan is prepared for avoidance, mitigation and management of the negative impacts of the project. It also covers remedial measures require to be taken **EMP** includes the list of all the project related activities, their impacts at different stages of project during construction phase and operational phase on environment and remedial measures to be undertaken to mitigate these impacts.

Total cost for environment management plan (including environmental monitoring plan) for the project is **Rs. 77.63 Cr.**

10.10 FINDINGS & CONCLUSSION

The Draft EIA report for this proposed project has been prepared after thorough interaction with the engineering section of the DPR consultant and contractor so that the negative impacts on the environment and human population could be avoided as far as possible. Some of the important findings of the study are as follows: -

1. There will be insignificant loss of bio-diversity as no rare plant or animal species are going to be affected by the present project.
2. The proposed alignment is not passing through any Sanctuary or National Park.
3. Precautionary measures such as Health & Safety, Proper Ventilation System, Mechanical & Electrical arrangement and emergency response system etc. have been proposed to mitigate the impact during construction and operation.
4. No monuments protected by the Archaeological Survey of India (ASI) are located within the ROW of proposed project
5. The most important factors, which need continuous attention and assessment during the construction phase, are the ambient air quality, health & safety, muck disposal and the noise & vibration level. A proper mitigation plan is prepared and will be implemented during the construction phase to maintain the Air & Noise Environment. Muck will be disposed at identified site and Health & safety plan is prepared.
6. Approximately 417 numbers of trees are recorded in corridor of impact to mitigate the impact the impact.
7. There are no structures recorded within the corridor of impact of proposed tunnel. However, the proposed project will definitely have some positive impact on the socio-economic environment of the people of surrounding area experiencing development in the area in specific and state and nation as a whole.

CHAPTER: 11 DISCLOSURES OF CONSULTANTS ENGAGED

11.1 ORGANIZATIONAL PROFILE

Ambiental Global Private Limited is a leading environmental consulting organization promoted by young professionals with experience and expertise in diverse sectors, thereby providing viable solutions and professional services to promote environmental sustainability.

Apart from its own resources, **Ambiental Global Private Limited** also has association with several leading consultancy firms who have competency and expertise in other areas. The associations with these firms have helped to address the deliverables in an integrated fashion. Each project is a value addition to the organization and hence results in environmental, economic and social upliftment.

Ambiental Global Private Limited is accredited by QCI/NABET having certificate no. **NABET/EIA/1922/IA0047 valid till dated 09.04.2025** for carrying out EIA/EMP study of seven sectors as per EIA Notification, 2006 released by Ministry of Environment Forest & Climate Change (MoEF & CC). Our Joint Venture firm includes Noida Testing Laboratories (NABL Accredited), Enviro Tech services (NABL Accredited).

Ambiental Global Private Limited provides integrated solutions to complex problems in diverse business areas of EIA, environment planning and site management. We thrive on quality, cost, effectiveness and timely delivery of projects and have hence in a short span of time, successfully accomplished a number of projects.

11.2 Consultancy Services

Environmental Impact Assessment	HAZOP Study
Air Quality Assessment and Control Measures	Environmental Remediation Consulting Engineering
Water and Waste Water Quality Assessment, Treatment and Management	EHS & Occupational Safety Management Consulting
Soil Quality Assessment	Preparation and Implementation for Various sectors
Source apportionment Study	Remediation Construction & Site Restoration
Carrying Capacity Study	Solid Waste Management Services
Environmental Management Plan	Natural resource management
Consent Management	ETP & STP Establishment and Operation
Socioeconomic & Impact Assessment	Environmental Research and Development
Environmental Legal Advice	Training and Skill Development

Declaration by Experts contributing to the EIA: Preparation of Detailed Project Report of including Pre-construction Activities for construction of a road Tunnel for NH – 148 AE with its Approach and connection to NH-248BB and existing Delhi internal road in the State of Delhi, hereby, certify that I was

a part of the EIA team in the following capacity that developed the above EIA.

EIA coordinator & Associate EIA Coordinator:

Name of EIA Coordinator	Mohan Sriram Bhagwat
Signature	
Period of involvement	March 2022 to till date

Name of Associate EIA Coordinator	Tarun Saharan
Signature	
Period of involvement	July 2022 to till date

Following Coordinators & Functional Area Experts:

Sl. No.	Name of Person	EC/FAE/FAA/TM	Area of Expertise	Signature
1.	Praveen Singh	EIA Coordinator & FAE	EB	
2.	Tarun Saharan	EIA Coordinator & FAE	HG, LU, NV, SC	
3.	Devendra Goyal	EIA Coordinator & FAE	AP, WP, SHW, AQ	
4.	Pradyumna Arvind Deshpande	EIA Coordinator & FAE	SC, WP	
5.	Ajeet Prasad	FAE	SE	
6.	Satwant Singh	FAE	AQ, SHW, WP	
7.	Urvashi Juyal	FAA	EB, WP	

Declaration by the Head of the accredited consultant organization/authorized person: I, Sourabh Tyagi, hereby, confirm that the above-mentioned experts prepared the EIA: Preparation of Detailed Project Report of including Pre-construction Activities for construction of a road Tunnel for NH – 148 AE with its Approach and connection to NH-248BB and existing Delhi internal road in the State of Delhi.

I also confirm that EIA Coordinator (EC) and experts have gone through the report, and the consultant organization shall be fully accountable for any misleading information.

It is certified that no unethical practices, plagiarism involved in carrying out the work and external data / text has not been used without proper acknowledgement while preparing this EIA report.

Ambiental Global Pvt. Ltd.

Signature: Authorised Signatory

Name: Mr. Sourabh Tyagi

Designation: Director

Name of the EIA consultant organization: M/s Ambiental Global Private Limited

NABET Certificate No.: NABET/EIA/2225/RA0259

11.3 ACCREDITION/ FROM QUALITY COUNCIL OF INDIA, QCI

Ambiental Global Private Limited has got accreditation from QCI NABET.



QUALITY COUNCIL OF INDIA

National Accreditation Board for Education and Training

Certificate of Accreditation

Ambiental Global Private Limited, Ghaziabad

Plot No.182, Gravens Plaza, Sector 7 Rajnagar, Ghaziabad

This organization is accredited as Category-A under the QCI-NABET Scheme for Accreditation of EIA Consultant Organizations, Version 2 for preparing EIA-EMP reports in the following Sectors –

S.No.	Sector Description	Sector (as per) NABET	Sector (as per) MoEF&CC	Cat.
1	Mining of minerals including opencast/ underground mining	1	1 (a) (ii)	A
2	Industrial estates/ parks/ complexes/areas, export processing Zones(EPZs), Special Economic Zones (SEZs), Biotech Parks/ Leather Complexes	31	7 (c)	B
3	Highways	34	7 (f)	A
4	Common Effluent Treatment Plants (CETPs)	36	7 (h)	B
5	Common Municipal Solid Waste Management Facility (CMSWMF)	37	7(i)	B
6	Building and construction projects	38	8 (a)	B
7	Townships and Area development projects	39	8(b)	B

Note: Names of approved EIA Coordinators and Functional Area Experts are mentioned in NABET website dated Aug 31, 2022 and posted on QCI-NABET website

This accreditation shall remain in force subject to continued compliance with the terms and conditions mentioned in QCI-NABET's letter of accreditation granting it QCI/NABET/ENVIS/ACO/20/0241 dated Dec 03, 2020. The accreditation needs to be renewed before the expiry date by Ambiental Global Private Limited, Ghaziabad following due process of assessment.

Dr. Director, NABET
Dated: Dec 03, 2020

Certificate No.
NABET/EIA/2023/IA 0059

Valid up to
April 05, 2023

For the updated list of the accredited EIA Consultant Organizations, kindly refer to the QCI/NABET website

LIST OF ANNEXURES

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Annexure – I
Term of Reference

File No. 10/6/2022-IA.III
[Proposal No. IA/DL/NCP/251268/2022]
Government of India
Ministry of Environment, Forest and Climate Change
(Impact Assessment Division)

Indira Paryavaran Bhawan,
Jor Bagh Road, Aliganj
New Delhi - 110 003
Dated: 25th March, 2022

To

Sh. Nirman K Jambhulkar
Project Director
M/s Ministry of Road Transport & Highways
National Highways Authority of India,
PIU Dwarka - 110075

Subject: Construction of a road tunnel for NH-148E with its approach and connection to NH-248BB in NCT of Delhi by M/s National Highways Authority of India PIU, Dwarka - Terms of Reference

Sir,

This has reference to your online proposal submitted to this Ministry on 12th January, 2022, seeking Terms of Reference (TOR) for the aforementioned project as per the provisions of the Environment Impact Assessment (EIA) Notification, 2006 and subsequent amendments under the Environment (Protection) Act, 1986.

2. The above mentioned proposal was considered by the Expert Appraisal Committee (EAC) for Infrastructure, CRZ and other miscellaneous projects in its 289th meeting during 17th – 18th February, 2022, in the Ministry of Environment, Forest and Climate Change, New Delhi.

3. The project proponent along with the DPR consultant M/s. SMEC International Pvt. Ltd and EIA consultant M/s. Ambiental Global Private Limited has made a presentation through Video Conferencing and provided the following information.

i. The National Highway Authority of India proposes to implement "Construction of a Road Tunnel for NH-148AE with its connection to NH-248BB in the NCT of Delhi." The project NH 148AE takes off from under construction underground Shivmurti Interchange (Dwarka Expressway Package-I/UER II NH 248BB) at NH 48 (28° 31'57.38" N 77°6'32.44"E) and ends at Nelson Mandela Marg in Vasant Kunj (28° 31'45.16" N 77°8'53.97"E). The proposed project NH-148AE is 4.78 km long which includes a 2.8 km long twin tube tunnels in ridge area and a surface road of 6-Lanes configuration. The proposed corridor is a green field alignment and will have minimal impact on environment.

Features of the Alignment	
Total Length	4783 m
Tunnel Length	2800 m
Approach Ramp to Tunnel End Portal	600 m
At Grade Surface Road	702 m

Existing Nelson Mandela Marg to be used	681 m

ii. The proposed project falls under Schedule 7(f), Highway, Category "A" of EIA Notification 2006. Total investment/cost of the project is about Rs. 1984.00 Crores.

iii. Land use/ Land cover (approx. area) of the project site is as following:

S.No.	Landuse/Landcover	Area (ha)	Percentage (%)	Remarks
1.	Private land	6.0368	88.8	None
2.	Government land	0.7561	11.1	None
3.	Forest land	5.464	-	None
	Total (excluding forest land)	**6.7929**	**100**	None

iv. Forest land, Eco sensitive area, National Park is not involved in the project site. The alignment does not pass through any Protected Area.

v. Terrain and topographical features: Geometric design standards are adopted keeping the above in view. The project road lies in plain and rolling terrain. The design is mainly prepared based on IRC: SP: 87 2019 "Manual of Specifications and Standards for six laning of Highways" and IRC: SP: 91 2019 "Guideline for Road Tunnels" besides adopting relevant standards from IRC SP:23 - Vertical Curves for Highways, IRC:38-Geometric Design for Horizontal Curves.

vi. Water Bodies: Rose Garden Kaccha Nala towards North East which is 4.76 km from the project site.

vii. Water requirement: The average water requirements is anticipated to be 22 KLD approximately. During construction stage water will be extracted from suitable surface sources (river/canals) or ground water will be used after obtaining necessary permissions from the competent authority.

viii. Tree Cutting: No trees are proposed to be cut within the boundary of Southern/ Morphological Ridge. About 1286 trees have been counted within the proposed RoW at the approaches of proposed tunnel and existing Nelson Mandela Marg which are out of Ridge boundary. Most of the trees falling along the alignment are the part of agroforestry/ avenue plantation and along the existing road. Efforts will be made to minimize the trees loss by restricting trees cutting within formation width. Avenue plantation shall be carried out as per IRC: SP:21:2009 on available land apart from statutory requirements.

ix. Land acquisition and R&R issues: The Project requires approx. 6.5 ha land. Approximately 28 nos. of structures are coming in the proposed RoW. Minimum land acquisition would be required in Mehrauli Village's agriculture land. The land will be acquired as per procedure laid down in NH Act, 1956 and RFCTLARR Act, 2013.

x. Employment potential: During the construction of the road project around 200 persons would be employed for a period of 3 years and preference will be given to local people for employment.

xi. Benefits of the project: The proposed access controlled project with new alignment has been envisaged through an area which shall have the advantage of simultaneous development as well as shall result in a shorter distance to travel. The junctions with

existing road will be planned in the form of interchanges and flyover to ensure uninterrupted flow of traffic. The proposed road would act as the prime artery for the economic flow to this region. It will enhance economic development, provide employment opportunities to locals, strengthen tourist development, ensure road safety, and provide better transportation facilities and other facilities such as way side amenities. Vehicle operating cost will also be reduced due to improved road quality. The compensatory plantation and road side plantation shall further improve the air quality of the region.

xii. Details of Court cases: No court case is pending against the proposed project.

4. The EAC based on the information submitted and clarifications provided by the project proponent and detailed discussions held on all the issues during 289th meeting during 17th - 18th February, 2022, recommended the project for grant of Terms of Reference (ToR) with stipulated specific conditions along with other Standard ToR Conditions.

5. The Ministry of Environment, Forest and Climate Change has considered the proposal based on the recommendations of the Expert Appraisal Committee (Infrastructure, CRZ and other Miscellaneous projects) and hereby decided to grant Terms of Reference for the "Construction of a road tunnel for NH-148E with its approach and connection to NH-248BB in NCT of Delhi by M/s National Highways Authority of India PIU, Dwarka" and for preparation of EIA/EMP report with public consultations under the EIA Notification, 2006 as amended, subject to strict compliance of the following specific conditions, in addition to all standard ToR conditions applicable for such projects.

SPECIFIC CONDITIONS

Specific Studies

i. Fresh base line monitoring data should be collected for preparing EIA/EMP studies.

ii. A comprehensive hydrological and hydrogeological investigation shall be conducted by a reputed institute for the site and should be incorporated in the EIA report.

iii. A comprehensive assessment of impact of seismicity on tunnel stability needs to be studied by a reputed institute and should be incorporated in the EIA report.

iv. Details regarding ventilation system envisaged for the tunnels need to be presented in the EIA report.

v. Detailed muck and dredge material disposal plan including specific earmarked locations be identified.

vi. Evacuation plans in case of fire, floods, earthquake etc be carefully studied with models and explanations be presented as a part of the EIA report.

Green Belt/Tree cutting

i. The alignment of road should be such that the cutting of trees is kept at bare minimum and for this the proponent shall obtain permission from the competent authorities. Alignment also should be such that it will avoid cutting old and large and heritage trees if any. All such trees should be geo-tagged, photographed and details

be submitted in the EIA - EMP report.

ii. A comprehensive plan for plantation of three rows of native species, as per IRC guidelines, shall be provided in consultation with state forest department including the costs involved. Such plantation alongside of forest stretch will be over and above the compensatory afforestation. Tree species should be same as per the forest type.

Compliance of Circulars/OMs

iii. As per the Ministry's Office Memorandum F. No. 22-65/2017-IA.III dated 30th September, 2020, the project proponent, based on the commitments made during the public hearing, shall include all the activities required to be taken to fulfil these commitments in the Environment Management Plan along with cost estimates of these activities in addition to the activities proposed as per recommendations of EIA Studiesand the same shall be submitted to the ministry as part of the EIA Report. The EMP shall be implemented at the project cost or any other funding source available with the project proponent.

iv. In pursuance of Ministry's OM is required to state in an additional annexure in the EIA report stating that all the commitments made by the PP to the public during public hearing and the same be submitted to the Ministry and the EAC.

v. The Action Plan on the compliance of the recommendations of the CAG as per Ministry's Circular No. J-11013/71/2016-IA. I (M), dated 25th October, 2017 needs to be submitted at the time of appraisal of the project and included in the EIA/EMP Report.

Rainwater Harvesting

vi. Rain water harvesting structures to be constructed at the either sides of the road with special precaution of oil filters and de-silting chambers.

GENERAL CONDITIONS

Project Description and Design

(i) A brief description of the project, project name, nature, size, its importance to the region/state and the country shall be submitted.

(ii) Details of any litigation(s) pending against the project and/or any directions or orders passed by any court of law/any statutory authority against the project to be detailed out.

(iii) Bridge design in eco sensitive area /mountains be examined keeping in view the rock classification hydrology etc.

(iv) Examine the road design standards, safety equipment specifications and Management System training to ensure that design details take account of safety concerns and submit the traffic management plan.

Forest/Green Belt

(v) In case the project involves diversion of forests land, guidelines under OM dated 20.03.2013 shall be followed and necessary action be taken accordingly.

(vi) The information shall be provided about the details of the trees to be cut including their species and whether it also involves any protected or endangered species. Measures taken to reduce the number of the trees to be removed should be explained in detail. The details of compensatory plantation shall be submitted. The possibilities of relocating the existing trees shall be explored.

(vii) Necessary green belt shall be provided on both sides of the highway with proper central verge and cost provision should be made for regular maintenance.

(viii) Land use map of the study area to a scale of 1: 25,000 based on recent satellite imagery delineating the crop lands (both single and double crop), agricultural plantations, fallow lands, waste lands, water bodies, built-up areas, forest area and other surface features such as railway tracks, ports, airports, roads, and major industries etc. alongwith detailed ground survey map on 1:2000 scale showing the existing features falling within the right of way namely trees, structures including archaeological & religious, monuments etc. if any, shall be submitted.

(ix) If the proposed route involves tunneling, the details of the tunnel and locations of tunneling with geological structural fraction should be provided. In case the road passes through a flood plain of a river, the details of micro-drainage, flood passages and information on flood periodicity at least of the last 50 years in the area shall be examined and submitted.

Project alignment passing through ESA/ESZ etc

(x) If the project is passing through/ located within the notified ecologically sensitive zone (ESZ) around a notified National Park/Wildlife Sanctuary or in the absence of notified ESZ, within 10 km from the boundary of notified National Park/Wildlife Sanctuary, the project proponent may simultaneously apply for the clearance for the standing committee of NBWL. The EC for such project would be subject to obtaining the clearance from the standing committee of NBWL.

Flora /Fauna

(xi) Study regarding the animal bypasses/underpasses etc. across the habitation areas shall be carried out. Adequate cattle passes for the movement of agriculture material shall be provided at the stretches passing through habitation areas. Underpasses shall be provided for the movement of Wild animals.

(xii) Study regarding in line with the recent guidelines prepared by Wildlife Institute of India for linear infrastructure with strong emphasis on animal movement and identifying crossing areas and mitigation measures to avoid wildlife mortality.

(xiii) If there is a possibility that the construction/widening of road may cause an impact such as destruction of forest, poaching or reduction in wetland areas, examine the impact and submit details.

Alignment

(xiv) Detailed alignment plan, with details such as nature of terrain (plain, rolling, hilly), land use pattern, habitation, cropping pattern, forest area, environmentally sensitive areas, mangroves, notified industrial areas, sand dunes, sea, rivers, lakes, details of villages, tehsils, districts and states, latitude and longitude for important locations falling on the alignment by employing remote sensing techniques followed by "ground truthing" and also through secondary data sources shall be submitted.

(xv) Describe various alternatives considered, procedures and criteria adopted for selection of the final alternative with reasons.

(xvi) If the proposed route is passing through a city or town, with houses and human habitation on either side of the road, the necessity for provision of bypasses/diversions/under passes shall be examined and submitted. The proposal should also indicate the location of wayside amenities, which should include petrol stations/service centres, rest areas including public conveyance, etc.

(xvii) Details about measures taken for the pedestrian safety and construction of underpasses and foot-over bridges along with flyovers and interchanges shall be submitted.

(xviii) The possibility that the proposed project will adversely affect road traffic in the surrounding areas (e.g. by causing increases in traffic congestion and traffic accidents) shall be addressed.

(xix) If the proposed route is passing through any hilly area, the measures for ensuring stability of slopes and proposed measures to control soil erosion from embankment shall be examined and submitted.

(xx) In case of river/creek crossing, details of the proposed bridges connecting on either banks, the design and traffic circulation at this junction with simulation studies.

(xxi) If there will be any change in the drainage pattern after the proposed activity, details of changes shall be examined and submitted.

(xxii) In case of bye passes, the details of access control from the nearby habitation/habitation which may come up after the establishment of road.

(xxiii) Details to ensure free flow of water in case the alignment passes through water bodies/river/streams etc.

Recycle/Reuse of Material

(i) The details of use of fly ash in the road construction, if the project road is located within the 100 km from the Thermal Power Plant shall be examined and submitted.

(ii) The possibilities of utilizing debris/waste materials available in and around the project area shall be explored.

(iii) The details on compliance with respect to Research Track Notification of Ministry of Road, Transport and Highways shall be submitted.

(iv) The details of sand quarry and borrow area as per OM No.2-30/2012-IA-III dated 18.12.2012 on "Rationalization of procedure for Environmental Clearance for

Highway Projects involving borrow areas for soil and earth" as modified vide OM of even No. dated 19th March 2013, shall be examined and submitted.

Data Collection

(v) Climate and meteorology (max and min temperature, relative humidity, rainfall, frequency of tropical cyclones and snow fall); the nearest IMD meteorological station from which climatological data have been obtained to be indicated.

(vi) The water bodies including the seasonal ones within the corridor of impacts along with their status, volumetric capacity, quality and likely impacts on them due to the project along with the mitigation measures shall be examined and submitted.

(vii) The details of water quantity required and source of water including water requirement during the construction stage with supporting data and also classification of ground water based on the CGWA classification, shall be examined and submitted.

(viii) Accident data and geographic distribution shall be reviewed and analyzed to predict and identify trends - in case of expansion of the existing highway and provide Post accident emergency assistance and medical care to accident victims.

Pollution Control

(i) The air quality monitoring shall be carried out as per the notification issued on 16th November, 2009. Input data used for Noise and Air quality modelling shall be clearly delineated.

(ii) The project activities during construction and operation phases, which will affect the noise levels and the potential for increased noise resulting from this project, shall be identified. Discuss the effect of noise levels on nearby habitations during the construction and operational phases of the proposed highway. Identify noise reduction measures and traffic management strategies to be deployed for reducing the negative impact if any. Prediction of noise levels shall be done by using mathematical modelling at different representative locations.

(iii) The impact during construction activities due to generation of fugitive dust from crusher units, air emissions from hot mix plants and vehicles used for transportation of materials and prediction of impact on ambient air quality using appropriate mathematical model, description of model, input requirement and reference of derivation, distribution of major pollutants and presentation in tabular form for easy interpretation shall be examined and carried out.

(iv) The details about the protection to existing habitations from dust, noise, odour etc. during construction stage shall be examined and submitted.

(v) If the proposed route involves cutting of earth, the details of area to be cut, depth of cut, locations, soil type, volume and quantity of earth and other materials to be removed with location of disposal/ dump sites along with necessary permission.

(vi) If the proposed route is passing through low lying areas, details of filling materials and initial and final levels after filling above MSL shall be examined and submitted.

Safety

(vii) The details of measures taken during constructions of bridges across rivers/ canals/major or minor drains keeping in view the flooding of the rivers and the life span of the existing bridges shall be examined and submitted. Provision of speed breakers, safety signals, service lanes and foot paths shall be examined at appropriate locations throughout the proposed road to avoid accidents.

(viii) The details of road safety, signage, service roads, vehicular under passes, accident prone zones and the mitigation measures, shall be submitted.

(ix) IRC guidelines shall be followed for widening & upgradation of roads.

(x) Details of blasting if any, methodology/technique adopted, applicable regulations/permissions, timing of blasting, mitigation measures proposed keeping in view mating season of wildlife.

Other Details

(xi) Rain water harvesting pit shall be at least 3 - 5 m above the highest ground water table. Provisions shall be made for oil and grease removal from surface runoff.

(xii) The details of social impact assessment due to the proposed construction of the road shall be submitted.

(xiii) If the proposed project involves any land reclamation, details shall be provided of the activity for which land is to be reclaimed and the area of land to be reclaimed.

(xiv) Details of the properties, houses, business activities etc likely to be effected by land acquisition and an estimation of their financial losses, shall be submitted.

(xv) Detailed R&R plan with data on the existing socio-economic status of the population in the study area and broad plan for resettlement of the displaced population, viz for the resettlement colony, alternative livelihood concerns/employment and rehabilitation of the displaced people, civil and housing amenities being offered, etc and the schedule of the implementation of the specific project, shall be submitted.

(xvi) The environment management and monitoring plan for construction and operation phases of the project shall be submitted. A copy of your corporate policy on environment management and sustainable development shall also be submitted.

(xvii) Estimated cost of the project including that of environment management plan (both capital and recurring) and source of funding. Also, the mode of execution of the project, viz, EPC, BOT, etc, shall be submitted.

(xviii) Details of litigation pending against the project, if any, with direction/order passed by any Court of Law against the Project should be given.

(xix) The cost of the Project (capital cost and recurring cost) as well as the cost towards implementation of EMP should be clearly spelt out.

(xx) Any further clarification on carrying out the above studies including anticipated impacts due to the project and mitigative measure, project proponent can refer to

the model ToR available on Ministry website "http://moef.nic.in/Manual/Highways".

GENERAL GUIDELINES

(i) The EIA document shall be printed on both sides, as far as possible.

(ii) All documents should be properly indexed, page numbered.

(iii) Period/date of data collection should be clearly indicated.

(iv) Authenticated English translation of all material provided in Regional languages.

(v) The letter/application for EC should quote the MoEF&CC File No, and also attach a copy of the letter prescribing the TOR.

(vi) The copy of the letter received from the Ministry on the TOR prescribed for the project should be attached as an annexure to the final EIA-EMP Report.

(vii) The final EIA-EMP report submitted to the Ministry must incorporate the issues in TOR and that raised in Public Hearing. The index of the final EIA-EMP report, must indicate the specific chapter and page no. of the EIA-EMP Report where the specific TOR prescribed by Ministry and the issue raised in the P.H. have been incorporated. Questionnaire related to the project (posted on MoEF&CC website) with all sections duly filled in shall also be submitted at the time of applying for EC.

(viii) Grant of TOR does not mean grant of EC.

(ix) Grant of TOR/EC to the present project does not mean grant of approvals in other regulations such as the Forest (Conservation) Act 1980 or the Wildlife (Protection) Act, 1972.

(x) Grant of EC is also subject to Circulars and Office Memorandum issued under the EIA Notification 2006 and subsequent amendments, which are available on the MoEF&CC website: www.envfor.nic.in.

(xi) The status of accreditation of the EIA consultant with NABET/QCI shall be specifically mentioned. The consultant shall certify that his accreditation is for the sector for which this EIA is prepared.

(xii) On the front page of EIA/EMP reports, the name of the consultant/consultancy firm along with their complete details including their accreditation, if any shall be indicated. The consultant while submitting the EIA/EMP report shall give an undertaking to the effect that the prescribed TOR (TOR proposed by the project proponent and additional TOR given by the MoEF) have been complied with and the data submitted is factually correct (Refer MoEF office memorandum dated 4th August, 2009).

(xiii) While submitting the EIA/EMP reports, the name of the experts associated with/involved in the preparation of these reports and the laboratories through which the samples have been got analysed should be stated in the report. It shall clearly

be indicated whether these laboratories are approved under the Environment (Protection) Act, 1986 and the rules made there under (Please refer MoEF office memorandum dated 4th August, 2009). The project Coordinator of the EIA study shall also be mentioned.

(xiv) All the TOR points as presented before EAC shall be covered.

6. A detailed draft EIA/EMP report shall be prepared in terms of the above additional TOR and should be submitted to the State Pollution Control Board for Public Hearing. Public Hearing to be conducted for the project in accordance with the provisions of Environmental Impact Assessment Notification, 2006 and the issues raised by the public should be addressed in the Environmental Management Plan. The Public Hearing shall be conducted based on the TOR letter issued by the Ministry and not on the basis of Minutes of the Meeting available on the website.

7. The project proponent shall submit the detailed final EIA/EMP report prepared as per TOR including issues raised during Public Hearing to the Ministry for considering the proposal for environmental clearance before expiry of validity of ToR.

8. The consultants involved in preparation of EIA/EMP report after accreditation with Quality Council of India/National Accreditation Board of Education and Training (QCI/NABET) would need to include a certificate in this regard in the EIA/EMP reports prepared by them and data provided by other Organization(s)/Laboratories including their status of approvals etc. vide notification of the MoEF dated 19th July, 2013.

9. The prescribed TOR would be valid for a period of four years for submission of the EIA/EMP Reports.

10. This issues with the approval of Competent Authority.

(Amardeep Raju)
Scientist 'E'

Copy to

1. Member secretary, Delhi Pollution Control Committee, 6th floor, C wing, Delhi Secretariat, I P Estate, Delhi-110002.

2. Addl. Principal Chief Conservator of Forests (C), Ministry of Env., Forest and Climate Change, Regional Office (CZ), Kendriya Bhawan, 5th Floor, Sector 'H' Aliganj, Lucknow -226020.

(Amardeep Raju)
Scientist 'E'

Annexure-I (a)
Term of Reference Amendment Letter

F. No. 10/6/2022-IA.III
Proposal No. : IA/DL/NCP/290868/2022
Government of India
Ministry of Environment, Forest and Climate Change
(IA-III Section)

3rd Floor, Vayu Wing,
Indira Paryavaran Bhawan
Jor Bag Road, Aliganj
New Delhi – 110 003

Dated: 5th December, 2022

To

M/s National Highways Authority of India
G-5&6, Sector-10,
Dwarka, New Delhi – 75.

Subject: Development of a road tunnel for NH-148E with its approach and connection to NH-248BB in NCT of Delhi by M/s National Highways Authority of India PIU, Dwarka – Amendment in Terms of Reference reg.

This has reference to your online proposal submitted to this Ministry on 26th September, 2022 seeking the amendment in Terms of Reference (ToR) for the aforementioned project as per the provisions of the Environment Impact Assessment (EIA) Notification, 2006 and subsequent amendments under the Environment (Protection) Act, 1986.

2. The above mentioned proposal was considered by the Expert Appraisal Committee (EAC) for Infrastructure, CRZ and other miscellaneous projects in its 310th meeting during 11th October, 2022, in the Ministry of Environment, Forest and Climate Change, New Delhi. The MoEF&CC granted Terms of Reference (ToR) vide letter No. 10/6/2022-IA.III dated 25th March, 2022.

3. The project proponent had applied online vide proposal no. IA/DL/NCP/290868/2022 dated 26th September, 2022 seeking the following amendment in the ToR vide letter File No. 10/6/2022-IA.III dated 25th March, 2022.

S. no	As per the Approved ToR	Request for amendment
1	The proposed project NH-148AE is 4.78 km long which includes a 2.8 km long twin tube tunnels in ridge area and a surface road of 6-Lanes configuration.	The proposed project NH-148AE is 4.982 km long which includes a 4.300 km long twin tube tunnels in ridge area and a surface road of 6-Lanes configuration.

<table>
<tr><td>2</td><td>Total length of the proposed alignment is approx. 4783m and proposed Right of Way (RoW) of the project varies from 45-60m.

Total land acquisition will be approx. 6.79 ha (excluding forest land)</td><td>Total length of the proposed alignment is approx. 4982 m and proposed Right of Way (RoW) of the project varies from 30-45 m.

No land acquisition is proposed for the highway alignment.</td></tr>
<tr><td>3</td><td>The proposed project falls under 7(f), Category-A, Highway as per EIA notification 2006. Total investment/cost of the project is Rs. 1984Crores.

<table><tr><th>S. No</th><th>Land use/ Land cover</th><th>Area (ha)</th><th>Percentage %</th></tr><tr><td>1</td><td>Private land</td><td>6.0368</td><td>88.8</td></tr><tr><td>2</td><td>Government land</td><td>0.7561</td><td>11.1</td></tr><tr><td>3</td><td>Forest land</td><td>5.464</td><td>-</td></tr><tr><td>4</td><td>Total(excluding forest area)</td><td>6.7929</td><td>-</td></tr></table>
About 1286 trees are likely to be affected.</td><td>The proposed project falls under 7(f), Category-A, Highway as per EIA notification 2006. Total investment/cost of the project is Rs. Rs. 2102 Crores.

<table><tr><th>S. No</th><th>Land use/ Land cover</th><th>Area (ha)</th><th>Percentage %</th></tr><tr><td>1</td><td>Private land</td><td>0.00</td><td>-</td></tr><tr><td>2</td><td>Government land</td><td>0.00</td><td>-</td></tr><tr><td>3</td><td>Forest land</td><td>5.98
2</td><td>-</td></tr><tr><td>4</td><td>Total</td><td>0.00</td><td>-</td></tr></table>
About 1266 trees are likely to be affected.</td></tr>
<tr><td>4</td><td>Land acquisition and R&R issues. The project requires approx. 6.76 ha. Land. Approx. A total number of approx.28 structures will be affected due to proposed highway.

The NHAI Shall Compensate The Affected title holder as per prevailing policy/ guideline.</td><td>Land acquisition and R&R issues. No land acquisition is required and No structures will be affected for the construction of the proposed highway as the alignment is an underground tunnel.</td></tr>
</table>

4. Reason for the Amendment: Due to change in the length of the tunnel.

5. Based on the deliberations in the meeting and information provided by the proponent in support of the project, the EAC recommended for the amendment in Terms of References during its 310th meeting during 11th October, 2022. As per the recommendation of the EAC, the Ministry of Environment, Forest and Climate Change hereby accords Amendment in Terms of References(ToR) for 'Construction of a road tunnel for NH-148E with its approach and connection to NH-248BB in NCT of Delhi by M/s National Highways Authority of India PIU, Dwarka' as mentioned at Para no.4 above.

6. All the other conditions stipulated in the Ministry's Terms of Reference letter of even number dated 25th March, 2022 shall remain the same.

7. This issue with the approval of the Competent Authority.

(Amardeep Raju)
Scientist 'E'

Copy to:

1. Member secretary, Delhi Pollution Control Committee, 6th floor, C wing, Delhi Secretariat, I P Estate, Delhi-110002.
2. Addl. Principal Chief Conservator of Forests (C), Ministry of Env., Forest and Climate Change, Regional Office (CZ), Kendriya Bhawan, 5th Floor, Sector 'H' Aliganj, Lucknow 226020.

(Amardeep Raju)
Scientist 'E'

Annexure – II
Ridge Management Board NOC

भारतीय राष्ट्रीय राजमार्ग प्राधिकरण
(सड़क परिवहन और राजमार्ग मंत्रालय, भारत सरकार)
NATIONAL HIGHWAYS AUTHORITY OF INDIA
(MINISTRY OF ROAD TRANSPORT AND HIGHWAYS, GOVT. OF INDIA)
परियोजना निदेशक कार्यालय, परियोजना कार्यान्वयन इकाई
201ई/ई, द्वितीय तल, सी-21, कॉर्पोरेट पार्क, (नजफगढ़ द्वारका सेक्टर-8 मेट्रो स्टेशन) सेक्टर-21, द्वारका, नई दिल्ली-110075
OFFICE OF THE PROJECT DIRECTOR, PROJECT IMPLEMENTATION UNIT
201E/A, Second Floor, C21, Corporate Park (Near Dwarka Sector-8 Metro Station), Sector-21, Dwarka New Delhi-110075
दूरभाष/Phone No. : +91-9717892100, +91-8717623100 ई मेल/E-mail : piudwarka@nhai.org, piudwarka@gmail.com

PIU/DWE/20/06/3453

Date: 27.10.2023

To,

Dy. Conservator of Forest,
West Forest Division
Mandir Marg, Delhi-60,

Sub: Construction of a road tunnel for NH-148AE with its approach and connection to NH-248BB in the NCT of Delhi: **Permission of Ridge Management Board (RMB) for the Construction of underground Road Tunnel under the Southern Ridge-reg.**

Ref: (i) NHAI letter no. 3177 dated 20.07.2022
(ii) CEC letter no. 62 dated 06.06.2023

Sir,

This is in reference to the CEC REPORT NO. 22 OF 2023 for application no. 1564 submitted by NHAI seeking permission of the Hon'ble Supreme Court for construction of subject project having 4.3 km long underground twin tunnels for NH-148 AE with its approach and connection to NH-248 BB and existing internal roads in the NCT of Delhi.

2. In this regard, it is to mention that the subject proposal has been accepted by Hon'ble Supreme Court. (Order Copy Enclosed).

This is for kind information and further necessary action.

Yours Sincerely,

(Dhruv Gupta)
Manager (Tech.)

Encl.: As above

Copy to:

i. **The Member Secretary,** Ridge Management Board (RMB), Department of Forests and Wildlife, Govt. of NCT of Delhi, A-Block, 2nd Floor, Vikas Bhawan, I.P. Estate, New Delhi-110002.
ii. PCCF, Department of Forests and Wildlife, Govt. of NCT of Delhi, A-Block, 2nd Floor, Vikas Bhawan, I.P. Estate, New Delhi-110002.
iii. **M/s SMEC International Pvt. Ltd.,** 1st Floor, Novus Tower, West Wing, Plot No. 18, Sector-18, Gurgaon-122015, Haryana

ITEM NO.8 +28,29 COURT NO.2 SECTION PIL-W

S U P R E M E C O U R T O F I N D I A
RECORD OF PROCEEDINGS

Writ Petition(s)(Civil) No(s). 4677/1985

M.C.MEHTA Petitioner(s)

VERSUS

UNION OF INDIA & ORS. Respondent(s)

(1) IA NOS. 210773 AND 210774/2023 (APPLNS. FOR IMPLEADMENT AND DIRECTIONS ON BEHALF OF CARVANSERAI LTD.)2) I.A. NOS. 125238/2023 AND 169599, 169602/2023 IN I.A. NO. 125238/2023 (CEC REPORT NO. 22/2023 AND APPLS. FOR IMPLEADMENT AND DIRECTIONS ON BEHALF OF NHAI)IN W.P. (C) NO. 4677/1985 "ONLY" ARE LISTED NAMES OF FOLLOWING ADVOCATES MAY BE TREATED TO HAVE BEENSHOWN IN THE LIST :MR. S GURU KRISHNA KUMAR, SR. ADVOCATE (A.C.)MS. ANITHA SHENOY, SR. ADVOCATE (A.C.)MR. A.D.N. RAO, SR. ADVOCATE (A.C.)MR. SIDDHARTHA CHOWDHURY, ADVOCATE (A.C.) PETITIONER-IN-PERSONMR. G.S. MAKKER,MR. ANRISH KUMAR,MR. PRAVEEN SWARUP,MR. NISHIT AGRAWAL,MR. CHIRAG M. SHROFFMR. ABHINAV AGRAWALMR. QUBRATULAIN, ADVOCATES)

WITH

CONTEMPT PETITION (CIVIL) Diary No(s). 34870/2023 IN W.P.(CIVIL) NO. 4677/1985
([TO BE TAKEN UP ALONG WITH ITEM NO.8 I.E. W.P.(C) No. 4677/1985.]....LIST ALONGWITH OTHER APPLICATIONS WHICH ARE LISTED ON 18.10.2023 IN W.P. (C) NO. 4677/1985
IA No. 191171/2023 - APPLICATION FOR EXEMPTION FROM FILING THE RESIDENTIAL ADDRESS OF RESPONDENT/CONTEMNOR WITH AFFIDAVIT
IA No. 204866/2023 - PERMISSION TO FILE ADDITIONAL DOCUMENTS/FACTS/ANNEXURES)

CONTEMPT PETITION (CIVIL) Diary No(s). 34872/2023 IN W.P.(CIVIL) NO. 4677/1985

([TO BE TAKEN UP ALONG WITH ITEM NO.8 I.E. W.P.(C) No. 4677/1985.]...LIST ALONGWITH OTHER APPLICATIONS WHICH ARE LISTED ON 18.10.2023 IN W.P. (C) NO. 4677/1985
IA No. 191172/2023 - APPLICATION FOR EXEMPTION FROM FILING THE RESIDENTIAL ADDRESS OF RESPONDENT/CONTEMNOR WITH AFFIDAVIT
IA No. 204869/2023 - PERMISSION TO FILE ADDITIONAL DOCUMENTS/FACTS/ANNEXURES)

Date : 18-10-2023 This petition was called on for hearing today.

CORAM :

HON'BLE MR. JUSTICE SANJAY KISHAN KAUL
HON'BLE MR. JUSTICE SUDHANSHU DHULIA

Mr. S Guru Krishna Kumar, Sr. Adv.(A.C.)
Mr. A.D.N. Rao, Sr. Adv. (A.C.)
Ms. Anitha Shenoy, Sr. Adv.(A.C.)
Mr. Siddhartha Chowdhury, Adv. (A.C.)

For Parties Petitioner-in-person (NP)

Mr. Yoginder Handoo, AOR

Mr. Anil Kumar Mishra, AOR

Ms. Aishwarya Bhati, A.S.G.
Mr. Gurmeet Singh Makker, AOR
Ms. Suhashini Sen, Adv.
Mr. Rajat Nair, Adv.
Ms. Ruchi Kohli, Adv.
Mr. B K Satija, Adv.
Ms. Swarupama Chaturvedi, Adv.
Ms. Shagun Thakur, Adv.
Ms. Chitrangda Rastravara, Adv.

Ms. Aishwarya Bhati, A.S.G.
Ms. Suhashni Sen, Adv.
Mr. Rajesh Kr. Singh, Adv.
Mr. Rajat Nair, Adv.
Mr. S.S. Rebello, Adv.
Mr. T.S. Sabarish, Adv.
Mr. Amrish Kumar, AOR

Mr. Praveen Swarup, AOR
Mr. Ajay Bansal, Adv.
Mr. Praveen Swarup, Adv.
Mr. Gaurava Yadava, Adv.
Ms. Payal Swarup, Adv.
Mr. Devesh Maurya, Adv.
Mr. Ravi Kumar, Adv.
Dr. Vivek Verma, Adv.
Mr. Rajatdeepsharma, Adv.

Mr. Nishit Agrawal,AOR

Mr. Chirag M. Shroff, AOR

Mr. Parag P Tripathi, Sr. adv.
Mr. Ankur Saigal, Adv.
Mr. Anunaya Mehta, Adv.
Mr. Abhinav Garg, Adv.
Mr. Abhinav Agrawal, AOR

Ms. Qurratulain, AOR
Mr. Anil Kumar Goyal, Adv.

UPON hearing the counsel the Court made the following

O R D E R

IA NO. 210773 AND 210774/2023

It is informed that the de-sealing has taken place as confirmed by the counsel for the co-owner. Thus the orders have been finally complied with.

We put the municipal authorities to notice that the order passed by this court dated 13.09.2022 should be given full effect and such eventualities should not arise in future.

IAs stand disposed of.

IA NO. 214896/2023

Heard learned counsel for parties.

In the given facts of the case, no ground is made out to interfere with the order passed by the Judicial Committee.

The application stand dismissed.

I.A. NOS. 125238/2023 AND 169589, 169602/2023 IN I.A. NO. 125238/2023 (CEC REPORT NO. 22/2023)

The report of CEC is accepted by learned counsel

for NHAI.

That being the position, NHAI can proceed with the construction, subject to compliance of the conditions as set out in the report.

Applications stand disposed of.

C.P (CIVIL) D. No(s). 34870/2023 & D.No(s). 34872/2023 IN W.P.(CIVIL) NO. 4677/1985

The contempt petitions are disposed of in terms of the signed order.

Pending applications stand disposed of.

[CHARANJEET KAUR]
ASTT. REGISTRAR-cum-PS

[POONAM VAID]
COURT MASTER (NSH)

[Signed order in C.Ps. is placed on the file]

Annexure – II (a)
Recommendation of Ridge Management Board

CENTRAL EMPOWERED COMMITTEE

(CONSTITUTED BY THE HON'BLE SUPREME COURT OF INDIA)

II Floor, Chanakya Bhawan, Chanakyapuri, New Delhi – 21, Tel: 2161 8812, 2161 8613
Email: cecindia2012@gmail.com, Website: www.cecindia.nic.in

F. No: 1-19/CEC/SC/2023-Pt. (82) Dated: 6th June 2023

To

The Registrar
Supreme Court of India
New Delhi-110001
(Attn: PIL Section)

SUB: CEC REPORT NO. 22 OF 2023 – REPORT OF CEC IN APPLICATION NO. 1564 OF 2023 FILED BY THE NATIONAL HIGHWAYS AUTHORITY OF INDIA (NHAI) SEEKING PERMISSION OF THE HON'BLE SUPREME COURT FOR CONSTRUCTION OF ROAD 4.983 KM IN LENGTH WHICH INCLUDES 4.3 KM LONG UNDERGROUND TWIN TUNNELS FOR NH-148 AE WITH ITS APPROACH AND CONNECTION TO NH-248 BB AND EXISTING INTERNAL ROADS IN THE NATIONAL CAPITAL TERRITORY OF DELHI.

Sir,

The Report No. 22 of 2023 filed in W.P. (C) No. 4677 of 1985 on the above subject is enclosed (Four copies). It is requested that the Report may please be placed before the Hon'ble Court.

Yours faithfully

(Amarnatha Shetty)
Member Secretary

Copy to:

1. Mr. Harish N. Salve, Sr. Advocate & Amicus Curiae
2. Mr. A.D.N. Rao, Sr. Advocate & Amicus Curiae
3. Mr. Siddhartha Choudhary, Advocate & Amicus Curiae
4. Mr. K. Parameshwar, Advocate & Amicus Curiae
5. The Secretary, MOEF&CC, New Delhi
6. Chief Secretary, Government of NCT of Delhi, Delhi
7. Principal Chief Conservator of Forests, Department of Forest & Wildlife, Govt. of NCT of Delhi, Delhi
8. Chairman, National Highways Authority of India
9. Standing Counsel for the MoEF&CC
10. Standing Counsel for the NCT of Delhi

CENTRAL EMPOWERED COMMITTEE

REPORT No. 22 of 2023

IN

Application No. 1564 of 2023

IN

W.P. (C) No. 4677 of 1985

Filed by:-
NATIONAL HIGHWAYS AUTHORITY
OF INDIA (NHAI)

Dated: 6th June 2023

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CENTRAL EMPOWERED COMMITTEE

REPORT OF CEC IN APPLICATION NO. 1564 OF 2023 FILED BY THE NATIONAL HIGHWAYS AUTHORITY OF INDIA (NHAI) SEEKING PERMISSION OF THE HON'BLE SUPREME COURT FOR CONSTRUCTION OF ROAD 4.983 KM IN LENGTH WHICH INCLUDES 4.3 KM LONG UNDERGROUND TWIN TUNNELS FOR NH-148 AE WITH ITS APPROACH AND CONNECTION TO NH-248 BB AND EXISTING INTERNAL ROADS IN THE NATIONAL CAPITAL TERRITORY OF DELHI.

The Ridge Management Board has recommended the proposal submitted by the National Highways Authority of India seeking approval of this Hon'ble Court for construction of road 4.983 kms in length which includes 4.3 km long underground tunnel for NH-148 AE with its approach and connection to NH-248 BB involving 5.82 ha falling under Southern Ridge Reserved Forest and 1 ha falling under Deemed Forest and around 3 ha of non-forest land required for the surface work of the project involving felling of 685 trees limited to non-forest land.

2. This Report is being submitted after the meeting taken by the CEC on 16.03.2023 with the officials of Forest Department of Delhi Government, Integrated Regional Office of MoEF&CC and

NHAI and after the site visit on 12.05.2023 and after going through the relevant records and documents.

SALIENT FEATURES OF THE ROAD PROJECT SUBMITTED BY NATIONAL HIGHWAYS AUTHROTIY OF INDIA (NHAI)

CONSTRUCTION OF UNDERGROUND TWIN TUNNEL

3. The National Highways Authority of India (NHAI) has submitted a proposal through Ridge Management Board for road project involving construction of a road 4.983 km in length which includes 4.3 km long underground twin tunnels 30 m width (15m + 15m) at a depth of around 20m. The project road takes off from proposed Shivmurti interchange (Dwarka Expressway Package - 1) and provides connectivity directly from Gurugram Expressway (NH-248 BB and NH-48) to Nelson Mandela Marg by way of an underground road tunnel (NH 148 AE) involving 5.82 ha falling under Southern Ridge Reserve Forest and 1 ha falling under Deemed Forest. A Bypass to Rangpuri will connect Dwarka Expressway with Vasant Kunj through Nelson Mandela Marg. Around 3 ha of non-forest land is required for the surface works of the Project involving felling of 685 trees. A map showing the alignment of the proposed road and sketch of the intersection at

Shivmurti along Gurugram Delhi Road is enclosed as ANNEXURE R-1 (COLLY) to this Report.

TRAFFIC CONGESTION

4. There is heavy traffic congestion on the Delhi – Gurugram Expressway near Mahipalpur / Rangpuri thereby significantly delaying the commuters and also increasing pollution because of slow moving traffic. Widening along the route has been found to be difficult because of heavy settlements. The proposed road when completed would act as the prime artery and will reduce both the distance and travel time and resolve the problems of traffic congestion at the above mentioned places and will also improve the local ambient air quality resulting in reduction in carbon footprints.

TRAFFIC SURVEY

5. Traffic surveys have been conducted at Nelson Mandela Marg, Ghitorni at MG Road and at Rao Tula Ram Marg. The base year traffic i.e. year 2021 is 28547 PCUs which is a four lane configuration triggered during the year 2021 itself. In the year 2030, traffic is projected to exceed 41211 PCUs which is a 6 lane

configuration. The Approach Road will be required to be widened to 6 lane configuration by the year 2045 when traffic is projected to cross 59686 PCUs mark.

INTERCHANGES AND FLYOVER

6. The junction with the existing road will be planned in the form of interchanges and flyover to ensure uninterrupted flow of traffic. For instance the proposed twin tunnels run parallel to each other and are followed by a 670 m long approach ramp towards Masoodpur flyover, which is also planned for improvement. The improvement works at Masoodpur junction will include construction of an one way flyover and a dedicated U turn. The junction is proposed to be developed as a signal free interchange and thereby reducing the current traffic hassles at the junction. Geometric design standards are adopted keeping the above in view.

IMPACT ON HYDROLOGY

7. The Project Road lies in plain and rolling terrain. The twin tunnels are proposed at shallow depth of around 20 m. The proposed depth of the twin tunnels is governed by the entry and

exist gradient of the tunnel road. Geotechnical Investigations have revealed that the ground water table is below the tunnel invert level as none of the bore holes intersected water table to the depth of 40 m. As per CGWB-Ground Water Yearbook 2019-2020, the ground water table is at 62m below the surface level in Mehrauli area, which is significantly below the tunnel level, and therefore, any impact on the hydrology, aquifers, etc. is not envisaged.

TREE FELLING LIMITED TO NON-FOREST LAND

8. The total ridge area falling under the proposed project alignment is 5.82 ha, whereas the proposed project area under the deemed forest area (non-ridge) is 1.00 Ha. The major portion of the project is underground for which no flora and fauna would be harmed. The 6.82 Ha forest cover including the ridge and non – ridge area above the proposed tunnel will remain intact and no harm will be caused to over 7000 trees above the underground structure in that region. Around 3 ha of non-forest land is required for the surface work of the Project for which it has been proposed to fell 685 trees. As such felling of trees is limited to non – forest land.

EXCAVATION OF TWIN TUNNELS WILL BE CARRIED OUT BY TUNNEL BORING MACHINES

9. The excavation of twin tunnels will be carried out by Tunnel Boring Machine (TBM). The length of the Southern Ridge involved in this project is about 2.03 km. In this stretch underground tunnels are proposed to be constructed without any surface intervention. Though tunnel through TBM is quite expensive as compared to the traditional Drill and Blast method, tunnelling through TBM brings vast range of merits over the latter. Tunnelling through TBM significantly reduces the potential environmental impacts in terms of noise and dust and restricts the impact close to launching and retrieval shafts. It also reduces the disturbance to the local traffic and environment. It also significantly reduces the quantity of C&D material generated. In addition the impact of vibrations over the ground caused due to tunnelling with TBM is quite negligible and bears no impact to the ecology over the ground.

MUCK GENERATED AND ITS DISPOSAL / UTILIZATION

10. During construction of the various components of the project, muck will be generated both from soil or slide material and from rock excavation as detailed below:

Total Length of Tunnel	:	4309 m
Excavated Dia of Tunnel	:	15.10 m
Excavated tunnel length in rock	:	2100 m
Excavated tunnel length in soil	:	2209 m
Volume of Muck generated (Rock)	:	751749 cum
Volume of Muck generated (soil, tunnel)	:	790768 cum
Volume of Muck generated (soil, open)	:	96120 cum

The total quantity of muck that will be generated is estimated to be 18,68,047 cum as detailed below:

QUANTITY OF MUCK BEING GENERATED			
Particulars	Muck Generated (Cum.)		
	Ridge Area	Non – Ridge Area	Total
Excavation in Rock	751749	-	751749
Add Swell Factor (14%)	105245	-	105245
Total Quantity (Rock)			856994
Excavation in Soil	-	886888	886888
Add Swell Factor (14%)	-	124164	124164
Total Quantity (Soil)			1011053
Grand Total (Rock and Soil)			**1868047**

Based on requirement of construction materials, approx. 46% quantity of rock muck (394752 cum) and 19% quantity of soil muck (191407 cum) has been planned to be reused in the

construction of this project. **The remaining 54% quantity of rock muck (470765 cum) and 81% of soil quantity (1344597 cum) would need to be shifted to another project site of NHAI (Connector Corridor from Delhi Meerut Expressway).**

MUCK DISPOSAL SITES

11. The selection of muck disposal sites was carried out considering the quantity of the muck, landscape, cost effectiveness, nearness to source of generation, absence of ground and surface water, relief and scope for afforestation works. Muck dumping sites have been identified matching the criteria. The details of dumping sites along with their total capacity and amount of muck to be disposed are enumerated below:

Details of Muck Disposal Site					
S. No.	Name of Dumping Site	Location of Dumping Site	Type of Muck	Requirement in cum	Volume of muck to be dumped in cum
1.	Connector corridor from Delhi Meerut Expressway	75 km from Dwarka Project	Soil	2910629	819646
			Rock	684622	470765

12. The balance unutilised muck generated from the proposed Dwarka Tunnel Project will be carried to the 8.50 KM long proposed Delhi Meerut Expressway Package V. The said section of the Delhi Meerut Expressway is proposed with 4 lanes and paved shoulder. The project is proposed as a Greenfield corridor with high embankments. The unutilised muck from the Dwarka Project will be transported to this site of NHAI for effective utilization.

TRANSPORTATION OF MUCK GENERATED

13. The generated muck will be carried in dumper trucks covered with heavy duty tarpaulin properly tied to the vehicle in accordance with best international practices. All precautionary measures will be followed during the dumping of muck. All dumpers will be well maintained to avoid any chances of loose soil from falling during the transportation. All routes will be periodically wetted with the help of sprinklers prior to the movement of dumper trucks. Dumping would be avoided during the high speed wind, so that suspended particulate matters (SPM) level could be maintained. Further, the dumping will be avoided during heavy traffic. After the dumping the surface of

dumps will be sprayed with water with the help of sprinklers and then compacted. Regular inspection by environmental expert of contractor and authority engineer (AE) shall be made to ensure complete avoidance of spilling of muck outside the boundary. Bio-engineering is the technique of utilizing vegetation in addressing geotechnical problems. Slope of muck disposal sites after completion of dumping to a particular site should be stabilized by stone pitching and turfing with geo mats (Coir Geotextile) and indigenous species of soil stabilizing legumes and Vetiver grasses. Natural geotextiles degrade quicker than man-made counterpart but facilitate growth of vegetation quicker and better due to its inherent characteristics.

Total muck to be transported	:	1344597 cum
Muck carrying capacity of single dumper	:	6 cum
Total no. of trips envisaged	:	224100 trips
Project Schedule	:	5 years
Trips per day	:	122

RECOMMENDATIONS OF RIDGE MANAGEMENT BOARD

14. The Ridge Management Board at its meeting held on 25.11.2022 considered the proposal of NHAI for construction of a road tunnel for NH-148 AE with its approach and connection to NH-248 BB in NCT of Delhi and recommended as below:

"The proposal of NHAI for construction of a road tunnel for NH-148 AE with its approach and connection to NH-248 BB in NCT of Delhi through the construction of underground Road Tunnel under the Southern Ridge was place before the Board.

It was informed that the entire length of the tunnel is 4.983 km, the starting point being Near Shivmurti on NH-8 and the end point being at Masoodpur Village (Nelson Mandela Marg) involving construction of a twin tube tunnel of 30m (15m + 15m). The proposed alignment of the road tunnel shall run 20 m below the ground level and shall not involve any breaking of forest land on surface. 5.82 ha project area is falling under Southern Ridge Reserved Forest and 1 ha is falling under Deemed Forest.

As the construction of tunnel involves no breaking of land on surface no damage to flora and shall run below the ground in the Forest areas, the Board decided to recommend the proposal for consideration of Central Empowered Committee subject to the following condition:

i. The User Agency shall obtain necessary prior permission under Forest (Conservation) Act, 1980 from MoEF&CC, GoI for diversion / utilization of Notified Forest area and Deemed Forest area.

ii. The proposed construction shall not involve any breaking of Forestland on surface, no damage to flora and the alignment shall remain underground throughout the forest area."

OBSERVATIONS AND RECOMMENDATIONS

15. Keeping in view the facts and discussions in the preceding paragraphs and considering that

i) the road project is in public interest;

ii) the road project takes off from proposed Shivmurti interchange and provides connectivity directly from Gurugram Expressway (NH 248 BB and NH-48) to Nelson Mandela Marg by way of underground twin tunnel (NH 148 AE);

iii) junctions with the existing roads will be planned in the form of interchanges and flyovers to ensure uninterrupted flow of traffic;

iv) widening along the existing route is difficult because of heavy settlements;

v) the project road will resolve the problems of the heavy traffic congestion on the Delhi – Gurugram Expressway near Mahipalpur / Rangpuri and reduce the distance and travel time for commuters;

vi) the project road will improve local ambient air quality and reduction in carbon footprints;

vii) major portion of the project is underground for which no harm will be done to over 7000 trees standing above the underground structure on the 6.82 ha forest cover on surface in Southern Ridge Reserved Forest and Deemed Forest and same will remain intact;

viii) felling of 685 trees will be restricted to around 3 ha of non- forest land;

ix) excavation of twin tunnels will be carried out by Tunnel Boring Machines which significantly reduces both potential environmental impacts and disturbance to local traffic;

x) the ground water level is significantly below the tunnel level and therefore any impact including on the hydrology and aquifers is not envisaged;

xi) about 46% of rock muck and 19% of soil muck has been planned to be reused in the construction of this project. The remaining unutilized muck will be transported to the site of NHAI project Delhi - Meerut Expressway Package V;

xii) the muck that is generated will be carried in dumper trucks and all precautionary measures will be followed during the dumping of muck;

xiii) the Ridge Management Board has recommended the proposal

this Hon'ble Court may consider permitting the NHAI to undertake the road project involving construction of a road 4.983 km in length which includes 4.3 km long underground twin tunnels 30 M width (15m + 15m) at a depth of around 20m providing connectivity directly from Gurugram Expressway (NH 248 BB and NH-48) to Nelson Mandela Marg by way of the underground tunnel (NH 148 AE) involving 5.82 ha falling under Southern Ridge Reserve Forest and 1 ha falling under Deemed Forest and felling of 685 trees is limited to 3 ha non – forest land subject to the following conditions:

a) The applicant will deposit 5% of the project cost proportionate to the area falling within the Southern Ridge with the Ridge Management Board Fund and which amount under the close supervision of the Ridge Management Board will be used by the Forest Department of Delhi Government for conservation and protection of Delhi Ridge;

b) The Applicant shall obtain necessary prior permission under the Forest (Conservation) Act, 1980 for 5.82 ha falling under Southern Ridge Reserve Forest and 1 ha falling under Deemed Forest;

c) The proposed construction of road project shall not involve any breaking of forest land on surface, no damage to flora and the alignment shall remain underground throughout the forest area;

d) The Applicant shall obtain necessary approvals under the Delhi Preservation of Trees Act, 1994 from the competent authority before felling of 685 trees standing on non – forest land;

e) Compensatory plantation of 6850 plants of indigenous species, being ten times in lieu of 685 trees standing on non – forest land and proposed to be felled will be undertaken by the Forest Department of Delhi Government on the land to be made available by the NHAI at the cost of the agency;

f) The cost of raising 6850 plants including chain-link fencing of the compensatory plantation land shall be deposited in advance with the Forest Department of Delhi Government by the Applicant;

g) The felling of trees will be limited to the bare minimum required for execution of the project; and

h) With a view to minimize the impact of transport of the muck on both the traffic and the environment in general the applicant shall use dumpers having higher carrying capacity in place of 6 cum capacity dumpers.

VIEWS OF MAHENDRA VYAS, MEMBER, CEC

16. Mr. Mahendra Vyas, Member has suggested that instead of charging 5% of the project cost CEC may consider recommending charging 50% of 5 % i.e. 2.5% because the entire project will be below the ground and there will be no breaking of soil or felling of the trees in the Reserve Forest and the deemed forest. After all huge expenditure is being incurred by the project proponent in taking the road underground and saving the forest/trees. It would be reasonable to consider giving some relief rather than mechanically adhering to the recommendation of charging 5% of the project cost. Frankly, it is a fit case to be waived altogether.

17. CEC has examined the above suggestion of Mr. Mahendra Vyas and finds that CEC has been recommending contribution of 5 % of the project cost to the Ridge Management Board Fund in respect of all projects including the underground Projects of DMRC passing through Delhi Ridge. For example, in I.A. No. 169030 of 2019 regarding the proposal of Delhi Metro to construct the Metro Corridor from Aerocity to Tughlakabad, it is

seen that out of 23.62 kms a stretch of 19.34 kms of the Metro Corridor is underground and CEC has recommended that Delhi Metro Rail Corporation will deposit 5 % of the project cost proportionate to the area falling within the Southern Ridge, South Central Ridge and Morphological Ridge, with the Delhi Ridge Management Board Fund. It would therefore not be appropriate to make a deviation in respect of the present project of NHAI.

The Hon'ble Court may please consider the above Report and may please pass appropriate orders in the matter.

(Amarnatha Shetty)
Member Secretary

Dated: 6th June 2023





Annexure – II (b)
Minutes of Meeting Ridge Management Board

GOVERNMENT OF NCT OF DELHI
DEPARTMENT OF FORESTS &
WILDLIFE
2ND FLOOR, A-BLOCK, VIKAS BHAWAN, I.P. ESTATE, NEW DELHI-02

F. No.11(26)/PA/DCF/95/Vol. X/Part 6/ 14062-65 **Date:** 24/10/22

MINUTES OF THE MEETING OF RIDGE MANAGEMENT BOARD HELD ON 25.11.2022 AT 2:30 PM UNDER THE CHAIRMANSHIP OF CHIEF SECRETARY, DELHI & CHAIRMAN, RMB

The meeting of Ridge Management Board was held on 25.11.2022 at 2:30PM under the chairmanship of Chief Secretary cum Chairman RMB. The list of attendees is attached.

At the outset, PCCF & Member Secretary, RMB welcomed all the BoardMembers. Thereafter each agenda was discussed by the Board and decisions were taken as listed below:

1. **Agenda Item 1: Development of Phase-I of Delhi Cyclewalk by DDA**

The Board was briefed that a proposal has been submitted by DDA for development of Delhi Cyclewalk, divided into 5 Phases, with a total length of201 Km.

Phase 1 - 36 km

Phase 2 - 65 Km

Phase 3 - 46 Km

Phase 4 - 25 Km

Phase 5 - 29 Km

The current proposal is for seeking permission for development of Phase-I with a length of 36 km (29 Km on ground and 7 Km elevated). The Cyclewalk tracks comprise 4 strips; a 2.1 m moorum track for walking, a 1.8 m paved track for universal accessibility and two tracks of 2.5 m for cyclists. DDA has proposed that they will upgrade the existing tracks/ pathways into cyclewalks/ footwalks with minimal breaking of Forest land falling in Ridge Reserve Forest/ Protected Forest/ Morphological Ridge/ Deemed Forest/ Eco Sensitive Zone.

In the meeting of RMB held on 31.12.2021, the Chairman had desired that DDA in consultation with the Forest Department should prepare a Management Plan of the entire layout of Cyclewalk which is in compliance with all the rules and regulations as well as the orders issued by Hon'ble High Court and Hon'ble NGT. The Management Plan should then be placedbefore the Ridge Management Board for

further consideration.

The Comprehensive Management Plan for 06 stretches (Leg A Nilgai for 15 Km) - Sangam Vihar, Archeological Park, Biodiversity Park, Jahanpanah City Forest, Monkey Park and M.B. Road submitted by DDA in June 2022 was evaluated and found in accordance with the suggestions made by the Forest Department regarding inclusion of provisions for safety of Wildlife in the Management Plan.

The details of alignment passing through Forest area is as below:

Location	Length through Forest area (in Km)	Forest Area involved (in ha)	Type of forest & legal status	No. of trees proposed tobe transplanted
Sangam Vihar	0.8	0.48	ESZ (Revenue Land)	20
Archaeological Park	0.736	0.4416	Southern Ridge-Reserved Forest	7
	0.513	0.3078	Morphological Ridge (MR)	
Biodiversity Park	1.756	1.0536	Morphological Ridge	29
Jahanpanah City Forest	5.1	3.06	Deemed Forest	36
MB Road	2	1.2	ESZ (Revenue Land) (1.549 Km length is also falling in MR with area 0.92 ha)	
Monkey Park 2	0.35	0.21	ESZ (Revenue Land)	
Total	**11.255**	**6.753**		**92**

The summary of proposed alignment falling in Forest area:

Type of Forest	Area in ha	Permissions required
Southern Ridge	0.44	Forest (Conservation) Act, 1980, RMD, CEC & Hon'ble Supreme Court

Deemed Forest	3.06	Forest (Conservation) Act, 1980
Morphological Ridge	2.28	RMB, CEC & Hon'ble Supreme Court
ESZ	1.89	National Board of Wildlife, if applicable

As DDA has incorporated the suggestions of Department of Forests & Wildlife in preparation of the Comprehensive Management Plan, the Board decided to recommended the proposal for consideration of Central Empowered Committee subject to the following conditions:

I. The User Agency shall obtain necessary prior permission under Forest (Conservation) Act, 1980 from MoEF&CC, GoI for diversion/ utilization of Notified Forest area and Deemed Forest area.

II. The User Agency shall deposit 5% of the project cost proportionate tothe area falling within Ridge area to RMB fund on the lines of conditions imposed by Hon'ble Supreme Court of India in WP (C) 202/1995 titled T. N. Godavarman Thirumulpad Vs Union of India & Ors. for management of the ridge.

III. The User Agency shall obtain necessary permission from the National Board of Wildlife for utilizing the area falling within the Eco-Sensitive Zone of Asola Bhatti Wildlife Sanctuary, if applicable.

2. **Agenda Item 2: Construction of a road tunnel for NH-148 AE with its approach and connection to NH-248BB in NCT of Delhi.**

The proposal of NHAI for construction of a road tunnel for NH-148 AE withits approach and connection to NH-248BB in NCT of Delhi through the construction of underground Road Tunnel under the Southern Ridge was placed before the Board.

It was informed that the entire length of the tunnel is 4.983 Km, the starting point being Near Shivmarti on NH-8) and the end point being at Masoodpur village (Nelson Mandela Marg) involving construction of a twin tube tunnel of 30 m (15m + 15m). The proposed alignment of the road tunnel shall run 20 m below the ground level and shall not involve any breaking of forest land on surface. 5.82 ha project area is falling under Southern Ridge Reserved Forest and 1 ha is falling under Deemed Forest.

As the construction of tunnel involves no breaking of land on surface no damage to flora and shall run below the ground in the Forest areas, the Board decided to recommend the proposal for consideration of Central Empowered Committee subject to the following condition:

I. The User Agency shall obtain necessary prior permission under Forest (Conservation) Act, 1980 from MoEF&CC, GoI for diversion/ utilization of Notified Forest area and Deemed Forest area.

II. The proposed construction shall not involve any breaking of Forestland on surface, no damage to flora and the alignment shall remain underground throughout the forest area.

3. Agenda Item 3: Concept Plan for MMI of Phase-I and Phase-II Metro Stations- Rajendra Place and Jhandewalan.

The Board was informed that DMRC has submitted a proposal for Development of Multi Modal Integration (MMI) Schemes of Delhi MRTS project for Rajendra Place Metro Station and Jhandewalan Metro Station. As per the analysis of KML files provided by the User Agency the following details have emerged:

Metro Station	Forest area involved (in ha)	Legal Status of Forest land
Rajendra Place	7 (North Division)	Morphological Ridge
Jhandewalan	2.33 (West Division) 3.35 (Central Division)	Morphological Ridge
	0.41 (West Division)	Central Ridge area / area as per1997affidavit

In a Joint Survey conducted by the officials of Forest Department along with the representatives of DMRC, it was verified that the proposed MMI activities will be restricted to the existing infrastructure of the metro station and no development activity is planned on any unbroken area as per the design. The works majorly include upgradation/ realignment of existing bus stand, development of car/ auto/ rickshaw pick/ drop bay or parking, modification/ refurbishing of existing carriageway and footpaths, installation of street lights.

The Board observed that such proposals which involve upgradation/ realignment of existing infrastructure and do not involve breaking on the surface of any fresh forest land can be undertaken by the User Agency with prior information to the Forest Department. The Forest Department shall ascertain the same and obtain an undertaking from the User Agency that no fresh Forest land shall be broken up on surface beyond the already built up areas. Thereafter, the User Agency can go ahead with the project. Such proposals would not require permission from the Ridge Management Board.

4. Agenda Item 4: Modification in Minutes of meeting of RMB held on28.06.2022.

The Board was apprised that DDA has requested certain modifications in the minutes of the meeting of RMB held on 28.06.2022 for agenda-1 legal sanctity and protection accorded to Morphological Ridge area. The following corrections have been suggested by DDA:

Minutes recorded:

..... '**These layers** shall then be superimposed **and the overlapping areas contiguous to notified Ridge in the Morphological area as indicated by GSI may be considered as the Ridge area.**' ....

Corrections suggested by DDA:

.... '**The two layers** shall be superimposed **to examine the land use as per Master Plan, of the areas outside the notified area but within the map as provided by the GSI.** The findings **of the exercise** shall be brought before the RMB for further **decision in the matter**. This exercise shall be completed by the Department, within a month's time with the help of GSDL, GSI **and DDA**.'....

The Board was also informed about the progress in delineation of Denuded hills/ rocky surface in NCT of Delhi as detailed below:

A. A committee was constituted consisting of representatives from GSDL, GSI and Forest Department to delineate the denuded hills/ rocky surface in NCT of Delhi.

B. Five meetings of the committee have been held till date. DDA has also been

invited to 3 meetings as a special invitee. GSI has provided fresh KML files of denuded hills/ rocky surface in NCT of Delhi and it has been found that there is inconsistency/ mismatch in the data of Geomorphology landform as provided by GSI in 2013 and 2022. The layer of 2022 does not include all the areas marked as Morphological Ridge in the 2013 map of GSI submitted by this Department before theHon'ble High Court & Hon'ble Supreme Court. GSI has been requested to submit detailed justification for variation in geomorphology landform submitted in 2013 & 2022. However, no communication has been received from their end which is hampering the progress in the matter.

C. MCD, MoHUA and DDA were requested to provide the KML files of their developmental projects. No response has been received from MCD and MoHUA. DDA has committed to submit the information at the earliest.

After deliberations, the Board agreed to the suggestions made by DDA and desired that a corrigendum may be issued in this regard.

5. Agenda Item 5: Modification in proposal for purchase of 05 nos. Field vehicles as approved by RMB in its meeting held on 31.12.2021.

The Board in its meeting held on 31.12.2021 has approved the proposal for purchase of 05 field vehicles (Diesel vehicles SUV of 2000 cc and above)for regular patrolling of Ridge Forest areas. However, the Finance Department, GNCTD vide OM dated 25.02.2021 has issued instructions to all Department, autonomous bodies and grantee institutions of Govt. of NCT of Delhi to shift their existing hired petrol/ diesel/ CNG vehicles to electric vehicles.

In view of the functional limitations of electric vehicles for use in patrolling & field visits, and the threat to field staff during encroachment removal drives, the Board was requested to approve purchase of diesel vehicles which are suitable for such terrains. The Board approved purchase of 03 nos Mahindra XUV 500 and 02 nos Thar vehicles in its meeting held on 28.06.2022.

As XUV-500 is not under production & Mahindra has recently launched XUV 700, which is the recent version available under XUV platform, the Board agreed to

allow purchase of Mahindra XUV 700 instead of XUV-500.

The Chairman also directed that Force Urbania vehicles (10 seater) may also be purchased by the Forest Department (01 for each division & 01 for HQ; Total no. being 05) for the purpose of carrying out field inspections.

6. **Agenda Item 6: Strengthening of Wildlife Wing of the Department.**

The proposal for strengthening of the Wildlife Wing (HQ) at Department of Forest & Wildlife, Govt. of NCT of Delhi was placed before the Board. The Board was apprised that there is a shortage of sufficient staff to deal with the various works pertaining to enforcement of Wildlife Protection Act (1972), various guidelines on CITES and Biodiversity Act, 2002.

The following proposal for strengthening of Wildlife wing of theDepartment was approved by the Board:

Post	Essential Qualification	Essential Work Experience	Remuneration including ICSIL charges
Senior Project Associate-Wildlife (02 nos.)	PG in Zoology/ Environment/Forest/ Wildlife/ Biodiversity Conservation/ allied Sciences/ PG Diploma in Wildlife Management	Minimum experience of 04-06 Years of working with implementing agencies/ autonomous bodies/ reputed organizations in matters pertaining to environmental policies/ forest and wildlife conservation. Experience with any Forest Department would be given preference	Rs.80,000
Data Entry Operator (02)	As per ICSIL norms		

7. **Modification in the RMB minutes of meeting held on 09.05.2018 in respect of eco-restoration of Central Ridge.**

The Ridge Management Board in its meeting held on 09.05.2018 had granted "in-principle" approval to the project for eco-restoration of the Central Ridge covering an area of 423 ha through Biodiversity enrichment tobe carried out by Prof. C.R. Babu and the expenditure for the same to be borne from RMB funds. The

proposal amounting to Rs.12.21 crores was approved by the Cabinet vide its decision No. 2935 dated 29.01.2021. However, due to certain reasons Prof. C.R. Babu recused himself from the project and the project is now proposed to be executed by the Departmentof Forests & Wildlife.

The proposal to authorize Forest Department to carry out this projectcovering an area of 423 ha in Central Ridge as per the earlier approved proposal with financial expenditure of Rs.12.21 crores has been agreed to subject to the following conditions:

A. The project should be executed by the Department of Forests & Wildlife in accordance with the earlier project plan approved by the Cabinet with the financial expenditure of Rs.12.21 crores.

B. The timeline for execution of the project shall be 3 years instead of 5 years as earlier.

8. Agenda Item 8: Capacity building for newly recruited Frontline ForestryStaff.

The Board was informed that the Department has recruited frontline forestry staff- Range Officers (04 nos.) against 6 Forest Ranges who are undergoing training in Odisha and will be joining in April 2023. The appointment on deputation of 04 nos Asst. Conservator of Forests is also under process.

For effective execution of protection and monitoring measures, it was proposed to purchase field vehicles as detailed below:

	Name of items	Specification	Nos.	Estimate (Rs. In Lakh)	Remarks
1	Field Vehicle @ Rs. 15 Lakh each	Diesel vehicle SUV of 1500 cc and above (Bolero)	06	90	04 Range Officers are undergoing training and will be joining the Department in April 2023. It is proposed to purchase these vehicles for patrolling, protection and other field works of Ridge Forest areas where EVs are not found suitable.

2	Field Vehicle @ Rs. 25 Lakh each	Diesel vehicle SUV of 2000 cc and above (Scorpio/ Tata Safari type vehicle)	04	100	Regular patrolling is required to be done in Forest areas where vehicles of slightly more ground clearance are required, keeping in view the threat to field staff due to encroachment removal drives, purchase of such vehicles is mandatory. The vehicles shall be assigned to newly appointed ACFs. Electric Vehicles cannot be purchased as it is unsuitable for field operations as their range is limited and no charging points are available inside Forest areas.
			Total	**190**	

The above proposal of the Department was approved by the Board with the condition that instead of purchasing the above vehicles, the Department will undertake hiring of these vehicles. Also, instead of Bolerovehicles, 06 nos Thar vehicles shall be hired for field duties.

9. Agenda Item 9: Construction of office complex, officer's mess andcamp for HQ IDS at Survey No. 176, Mehram Nagar, Delhi Cantt.

The Board was informed that a proposal has been received from HQ Integrated Defence Staff, Ministry of Defence for construction of office complex, officer's mess and camp for HQ IDS at Survey No. 176, Mehrannagar, Delhi Cantt. The proposed area for construction i.e. 4.28 ha is falling within Morphological Ridge. A joint inspection of the site was conducted by the officials of the Forest Department along with the representatives of the User Agency on 24.11.2022 and the following was observed:

i. An area of 1.2 ha has been excavated up to a depth of approximately5 ft. and in the remaining area the upper layer of soil has been disturbed/ removed, certain no. of trees have also been damaged/ uprooted. The exact number of trees which are damaged/ uprooted shall be determined after

the analysis from GIS and ground truthing, which are falling under the category of tree as per DPTA, 1994.

ii. The User Agency has also raised temporary/ permanent structures over the land adjacent to the project area.

After discussing all aspects of the proposal, the Board decided to recommend the proposal for consideration of Central Empowered Committee subject to the following conditions:

I. The User Agency shall deposit 5% of the project cost proportionate to the area falling within Morphological Ridge area to RMB fund on the lines of conditions imposed by Hon'ble Supreme Court of India in WP (C) 202/1995 titled T. N. Godavarman Thirumulpad Vs Union of India &Ors. for management of the ridge.

II. Action as per provisions of Delhi (Preservation) of Trees Act, 1994 for illegal felling of trees by the User Agency shall be taken by the concerned Dy. Conservator of Forests/ Tree Officer.

The meeting ended with a vote of thanks to the Chair.

23/09/2022

(C.D. Singh)
PCCF & Member Secretary
Ridge Management Board

Distribution:

1. All RMB members.
2. All representatives of User agencies as per list of participants.
3. Member Secretary, Central Empowered Committee for kind information.

23/09/2022

(C.D. Singh)
PCCF & Member Secretary
Ridge Management Board

GOVERNMENT OF NCT OF DELHI
DEPARTMENT OF FORESTS & WILDLIFE
A-BLOCK, 2ND FLOOR, VIKAS BHAWAN, IP ESTATE, NEW DELHI 110002

ATTENDANCE SHEET

Meeting of the Ridge Management Board
Venue: Conference Room of the Chief Secretary, GNCTD
Date: 25.11.2022
Time: 02:30 PM

S.No.	Name/Dept. & Designation	Contact No.	E mail id	Signature
1.				
2.	MANISH GUPTA VC DDA.	9958562553		
3.	A.K Singh Pr. Secy (EF&F)			
4.	C.D. Singh PCCF			
5.	T. C. Mauliyal CCF	9873933938	tcmauliyal@gmail.com	
6.	ABHINAV KUMAR DCF(HQ)	8974121911	dcfhq.gnctd@gov.in	
7.	NAVNEET SRIVASTAVA	8413847177		
8.	VIDUL PANDEY DCF(N)	9971566106		
9.	Chandra Singh (DCF-E)	8130658418	dcfcentral-gnctd@delhi.gov.in	
10.	Manoj Kumar DCF(S)	9899403645	dcfsouth-delhi@gov.in	
11.	GURMEET SINGH (CDF/DDA)	9711121775	gurmeet.dfo@gmail.com	

GOVERNMENT OF NCT OF DELHI
DEPARTMENT OF FORESTS & WILDLIFE
A-BLOCK, 2ND FLOOR, VIKAS BHAWAN, IP ESTATE, NEW DELHI 110002

ATTENDANCE SHEET

Meeting of the Ridge Management Board
Venue: Conference Room of the Chief Secretary, GNCTD
Date: 25.11.2022
Time: 02:30 PM

S.No.	Name/Dept. & Designation	Contact No.	E mail id	Signature
1.	Deepankar Singh SA-VBDIHF, DDA	9599430118		
2.	Ms Gopar Chief Engineer/PCCF DDA	9910268491		
3.	P. K. AGGARWAL SE/SCCS/DDA	9999220556		
4.	D. C. 4052, EMDDA	9971733852		
5.	DR. B. MUKHOPADHYAY SHAH, HQ.	9868957251		
6.	AKASH PADMI DFO NNAZ	9406112791		
7.	RASHMI BHARDWAJ DyCA-I / DMRC	9650199489	TUSH_204@yahoo.in	
8.	Sanjeev Aggarwal Chief Project Manager	9599469362	Sanjeev@ddaenet.com	
9.	ARUNESH Palash Changuwal Manager / ARUNEM	9413147345	palash@arunem.com	
10.	Deputy. IGFSE CE(P)	9522111104		
11.	COT Anurag COT (Admn Cord) HQ, IDI	8199937147		

Annexure – III
Abstract of Tree Cutting along with U-Turn

Sl No.	Segment	Revenue Village	Survey No.	Side	Nos of Tree
1	Ali Nelson Mandela Marg	Masoodpur	37, 110, 112, 108, 109	LHS	93
				RHS	72
				Median	123
			Segment 1 Total		**288**
2	New Proposed Flyover	Masoodpur	14, 112	Median 2	28
				Median 1	33
			Segment 2 Total		**58**
3	U-Turn Modification	Malikpur Kohi (Rangpuri)	1791, 1525, 1579	LHS	22
			1524	Median	17
			1811, 1810	RHS	31
			Segment 3Total		**70**
			Total		**417**

Annexure – IV
Hydrological Study



Ground Water Year Book
National Capital Territory, Delhi
2017-18

GOVERNMENT OF INDIA

CENTRAL GROUND WATER BOARD

STATE UNIT OFFICE, DELHI

MINISTRY OF JAL SHAKTI

DEPARTMENT OF WATER RESOURCES, RIVER DEVELOPMENT & GANGA REJUVENATION

December - 2019

FOREWORD

Ground Water Year Book is based on the information generated through field studies. The data has been analyzed by Officers of Central Ground Water Board, State Unit Office, Delhi and presented in the report. The reports, annexure and maps have been generated using GEMS Software, Version-2.1, developed indigenously by Central Ground Water Board.

Depiction of ground water conditions in Delhi provides information on availability of groundwater in terms of quantity and quality, development prospects and management options. I am happy to note that the scientific information in this report is presented in a simplified form. I sincerely hope this report will be of immense help not only to planners, administrators, researchers and policy makers in formulating development and management strategy but also to the common man in need of such information to make himself aware of the ground situation in NCT Delhi.

The untiring efforts made by Shri Prakash R Gupte, Senior Hydrogeologist (Scientist D) for bringing out this report is highly appreciated. Apart from this the contribution made by Shri Faisal Abrar, Assistant Hydrogeologist , Shri Ashok Kumar & Praveen Kumar, STA (Hydrogeology) is also duly acknowledged.

(S K Jain)
Officer In charge
Central Ground Water Board
State Unit Office, Delhi

EXECUTIVE SUMMARY

GROUND WATER YEAR BOOK 2017-18: NCT DELHI

National Capital Territory (NCT) of Delhi occupies an area of 1483 sq. km. and lies between 28° 24' 15" and 28° 53' 00" N latitudes and 76° 50' 24" and 77° 20' 30" E longitudes. The population of NCT Delhi, as per the census 2011 is 167.87 lakhs with a density of 11320 persons / sqkm area.

The normal annual rainfall of NCT Delhi is 611.8 mm. The rainfall increases from west to east. About 80% of the annual rainfall is received during the monsoon months July, August and September. The rest of the annual rainfall is received in the form of winter rain. Long-term rainfall data 1984 to 2017 shows that the rainfall in Delhi is highly variable and which in turn affects the natural recharge to ground water from year to year. The probability of rainfall exceeding normal rainfall of 611 mm is up to 62 % whereas there are 90 % chance that rainfall would limit to 450 mm.

The ground water availability in NCT Delhi is controlled by the hydrogeological characteristics of its varied geological formations namely Delhi Quartzite, Older & Younger Alluvium. Central Ground Water Board (CGWB) is monitoring groundwater levels and quality through its monitoring stations spread over both Alluvial as well as quartzitic area of NCT of Delhi. Total 93 hydrograph monitoring stations data (2017-18) have been analysed for this report, out of which 19 are dug wells and 74 are Piezometers.

District wise distribution of hydrograph network stations is highly uneven and varies from one monitoring station per 1.4 sq. km in New Delhi district to one monitoring station per 10 sq. km in North East district. Considering this unevenness in distribution of monitoring stations, Central Ground Water Board is striving to increase the number of stations for better monitoring of the ground water regime in the diverse hydrogeological terrain.

An analysis for numbers of monitoring wells in the different categories of the water levels for all four monitoring periods of year 2017-18 reveals that water level depth up to 5 m varies considerably over two monitoring periods (May & other months) which shows that dynamic changes in ground water levels are conspicuously deciphered in shallow water zones. For depth range of 5 to 10 m and 10 to 20 m and more at few locations, changes in numbers of monitoring wells in August, November & January compared to May period not pronounced. This may be interpreted as stressed water level conditions suppressing dynamic fluctuation in water levels. Whereas numbers of monitoring station showing water level below 40 m remain almost same in all four monitoring period, indicate stressed water conditions in deep aquifers of NCT Delhi.

The depth to water level recorded in NCT Delhi during 20017-18, in general varies from less than 2 m in areas of Yamuna Flood plain and parts of Northwest & West district to more than 70 m, mainly in areas underlain by Ridges rocks in Central, New Delhi and South districts. Water level in **May-2017** range from 1.13 to 78.1 m and around 10% of area have shallow water level up to 5 m bgl while deep water levels of 20 to 60 m are observed in around 30% area. In rest of NCT Delhi, 54 % Areas water level range from 5 to 20 m bgl. In **August-2017** water level range from 0.42 to 64.25 m. bgl and around 10% of NCT Delhi areas have shallow water level up to 5 m bgl while deep water levels of 20 to 60 m observed in around 30% of NCT Delhi. In rest of NCT Delhi, 52 % areas have water level in range of 5 to 20 m bgl. In **November-2017** water level range from 0.32 to 60.06 m. bgl and around 10% of

NCT Delhi areas have shallow water level up to 5 m bgl while deep water levels of 20 to 60 m observed in around 32% of NCT Delhi, in rest of NCT Delhi, 49 % areas have water level in range of 5 to 20 m bgl. In **January-2018** water level range from 0.35 to 60.21 m. bgl and around 36% of NCT Delhi areas have shallow water level up to 5 m bgl while deep water levels of 20 to 60 m observed in around 30% of NCT Delhi. In rest of NCT Delhi, 54 % areas have water level in range of 5 to 20 m bgl.

Analysis of seasonal water level fluctuation comparing **May 2017** period show rise in range of 0 to 4 m in 73 % monitoring stations during **August 2017**, 85% in **November 2017** and 70% in **January 2018**. Very few monitoring stations, 14% to 6% show rise in range of 2 to 4 m. Whereas nearly 26% to 20% monitoring stations show decline in range of 0 to 4 m and rest 2% to 5% in range of 2 to 4m, which reflect overstress conditions.

The fluctuation of water level between **May-2016 and May-2017** of NCT Delhi show rise in 46 % of wells, up to 3.0 m while other 47 % of monitoring wells show fall in range of 0 to 2 m ; rest of 7 % monitoring stations shows fall up to 4 m. Similarly, comparing August-2016 water level with August-2017 reveals that rise in the range of 0 to 2m in nearly 25% of the wells, while 66 % wells shows falls in range of 0 to 2 m. Fall of more than 4 m is observed in small pocket of South district (4 % wells). Comparing water level data of **November 2016** with **November 2017**, it is revealed that 24 % wells show rise in range of 0 to 2 m whereas 4% show rise more than 2 m; max up to 10.06 m in Delhi Cantonment area. Rest 61 % wells shows fall, mostly in range of 0 to 2 m except small pockets of New Delhi & South district shows fall more than 2 m. Comparing water level data of **January 2017** with **January 2018**, it is revealed that 41 % wells shows rise, mostly in range of 0 to 2 m whereas small pockets in Southwest & South district has rise up to 5.6 m at Mehroli area; whereas rest 49 % wells shows fall in range of 0 to 2 m.

Long-term behaviour of water levels was studied by comparing water level data of May-2017 with 10 year mean water level of May (2006 to 2016) reveals change in water level range from -8.8 m to 8.0 m. Nearly 71 % of monitoring wells show increase in fall of water level whereas rest 29 % wells show increase in rise of water levels. Comparing water level data of August-2017 with 10 year mean water level of August (2007 to 2016) reveals change in water range from – 7.8 m to 10.6 m. Nearly 31 % of monitoring wells show increase in rise of water level whereas rest 69 % monitoring wells show increase in fall of water level. Comparing water level data of November-2017 with 10 year mean water level of November (2007 to 2016) reveals change in water level range from -7.6 m 9.2 m. Nearly 31% of monitoring wells show increase in rise of water level whereas rest 69 % monitoring wells show increase in fall of water level. Comparing water level data of January-2018 with 10 year mean water level of January(2008 to 2017) reveals change in water level range from – 7.9 m to 9.81 m. Nearly 44 % of monitoring wells show increase in rise whereas rest 56 % monitoring wells show increase in fall.

Most of western part of NCT Delhi, in areas around Yamuna flood plain and Delhi Quartzite Ridge zones has EC within permissible range of 0 to 2250 µS/cm at 25°C where as rest of NCT Delhi, except some pockets of Najafgarh and West District, has EC value of more than 3000 uS / cm at 25 °C. It is also observed that water from deeper aquifers have greater EC value than the water from shallow aquifer. The EC value increases with depth.

Chloride concentration in groundwater of NCT Delhi is related with EC content. It is observed that in areas having EC values within permissible limits (2250 to 3000 µS/cm), the chloride

content also lies within permissible limit of 250 mg/l. In areas having high EC more than 3000 µS/cm, chloride value is also high upto a maximum of3000 mg/l.

Chemical analysis of ground water samples collected during May 2018 shows that nitrate content in groundwater of Delhi is within permissible limit of 45 mg/l at almost all places. Similarly, except 15 locations in Central & Western half of NCT Delhi, all 53 locations show fluoride concentration within permissible limit of 1.5 mg /l.

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1. INTRODUCTION

The State Unit Office of Central Ground Water Board has jurisdiction over the National Capital Territory (NCT) of Delhi, covering an area of 1483 sqkm and lies between 28°24'17" & 28°53'00" *North Latitudes* and 76°50'24" & 77°28'30" *East Longitudes*, covered under Survey of India Toposheet Nos. 53D and 53H. The NCT of Delhi is surrounded on three sides by two States, i.e., on North, West and South by Haryana and in the East across the river Yamuna by Uttar Pradesh.

1.1 Administrative Setup of NCT Delhi

NCT of Delhi is divided in 11 Revenue District and one non-revenue unit along river Yamuna, named as *Nazul Land*. Each district is headed by a Deputy Commissioner and assisted by Additional District Magistrate & Sub Divisional Magistrates. The District Administration in Delhi is the *de-facto* enforcement department for all kinds of Government Policies and exercises supervisory powers over numerous other functionaries of the Government. As per District Census Hand Book[1], 11 districts of NCT of Delhi are further sub-divided into 3 Tehsils for each district and there are total 33 Tehsils, with 112 villages, 110 Census Town and 3 Statutory Towns. Administrative map of NCT of Delhi is shown in figure 1 and list of districts, tehsils is presented in table 1 and detailed list of urban / rural areas given in annexure I.

Figure : 1



Table 1 : Details of Administrative Units - NCT of Delhi

Sr No.	District Name	Tehsil Name
1	CENTRAL	CIVIL LINES
		KOTWALI
		KAROL BAGH
2	EAST	GANDHI NAGAR
		MAYUR VIHAR
		PREET VIHAR
3	NEW DELHI	CHANAKYA PURI
		DELHI CANTONMENT
		VASANT VIHAR
4	NORTH	ALIPUR
		MODEL TOWN
		NARELA
5	NORTH EAST	KARAWAL NAGAR
		SEELAMPUR
		YAMUNA VIHAR
6	NORTH WEST	KHAUHASWALA
		ROHINI
		SARASWATI VIHAR
7	SHAHDARA	SEEMAPURI
		SHAHDARA
		VIVEK VIHAR
8	SOUTH	HAUZ KHAS
		MEHRAULI
		SAKET
9	SOUTH EAST	DEFENCE COLONY
		KALKA JI
		SARITA VIHAR
10	SOUTH WEST	DWARKA
		KAPASHERA
		NAJAFGARH
11	WEST	PATEL NAGAR
		PUNJABI BAGH
		RAJOURI GARDEN
Non Revenue Unit Area		NAZUL LAND

1.2 Population & Land use

As per Census of India Report[2] total population of NCT of Delhi is 167,87,941 persons. Out of total 1483 sqkm areas, only 25 % constitutes rural areas spread in 112 villages, which is sparsely populated having population density of 1135 persons / sqkm, where as rest 75 % is urban areas spread in 110 Census Towns and 3 Statutory Towns and it is densely populated with population density of 14,698 persons / sqkm. Details of villages & towns and its area & populations and land use pattern is given in table 2a & 2b respectively.

Population of Delhi has increased at a rate of 2.1% per annum during the decade 2001-2011[2]. Considering the same growth rate for the present decade, it is estimated that the population of Delhi in 2010 will be about 184 lakhs and it would be about 188 lakhs in 2011, 206 lakhs by 2021. In order to evaluate the changes in ground water regime effect due to ever growing demand for ground water and the increasing numbers of abstraction

structures in the city, CGWB has been continuously monitoring the water level variation with its own network stations spread over the entire area of NCT Delhi.

Table 2a: Area , Population & Details of Towns and Villages : NCT of Delhi

Area & Population

Total Area 1483 sqkm : Total Population 167,87,941 persons

- Urban Area : 1114 sqkm (75 %) Urban Population 1,53,68,899 (91 %)
- Rural Area : 369 sqkm (25 %) Rural Population 14,19,042 (9 %)

Details of Towns - Urban Area

- Statutory Towns : 3
  - New Delhi Municipal Council : Area 42.74 sqkm Population 2,57,803
  - Delhi Cantonment Board : Area 42.97 sqkm Population 1,00,559
  - Delhi Municipal Corporation : bifurcated into
    - North Delhi Municipal Corporation (NDMC)
    - South Delhi Municipal Corporation (SDMC)
    - East Delhi Municipal Corporation (EDMC)
- Census Towns : 131 (List - Details Annexure I)

  DMC & Census Town Area : 1108 sqkm Population 1,50,10,285

Details of Villages - Rural Area

- Villages : 112 (nil - Details Annexure I)

  Village Area : 361.35 sqkm Population 4,19,042

Source[1] : Delhi Statistical Handbook 2016- www.delhiplanning.nic

Land utilization data for year 2015-16 reveals that out of 1474.8 sqkm areas accounted for Land Records in NCT of Delhi, more than 65 % area is not available for cultivation where as only 92.70 sqkm is available for cultivation and nearly 34.75 sq km is gross cropped / agriculture areas. Nearly 6 % of total area is under forest, covering mostly notified ridge areas and other forest pockets under DDA & government forest land . Break up of land utilization is presented in table 2b and depicted graphically in figure 2a figure 2b.

Table : 2b Utilization of Land in Delhi (2015-16) (sqkm)

Area according to Land use Records (Excludes Forest)		1474.8
Area not Available for Cultivation		967.08
(a) Land Put to Non Agricultural Use	76218	
(b) Barren and Uncultivated Land	19492	
Other Uncultivated Land		111.24
(a) Permanent Pasture & Other Grazing Land	63	
(b) Land Use Under Miscellaneous Trees	1130	
(c) Cultivable Waste Land	9815	
Fallow Land		33.75
Net Area Sown		237.58
Area Sown more than once		116.68
Total Cropped Area		347.58
Area Under Forest		84.53
(a) Forest Under DDA	1201	
(b) Notified Ridge Forest	7194	
(c) Other Forest Area	108	

Source[2] : Joint Director of Agriculture, Govt of NCT

Table : 3 Sources of Irrigation and Irrigated Area 2015-16

Source		Area Irrigated (in Hectares)	
Canals			2225
Tanks			0
Wells	TWs	18586	19563
	Others	915	
Net Area Irrigated			21786
Area Irrigated More Than Once			7900
Gross Area Irrigated			29686

Source[2] : Joint Director of Agriculture, Govt of NCT of Delhi

Main source for irrigation in NCT of Delhi is groundwater whereas surface water is also available from Trans Yamuna Canal Network. Details about sources of irrigation and areas under irrigation is presented in table 3.

Figure : 2a

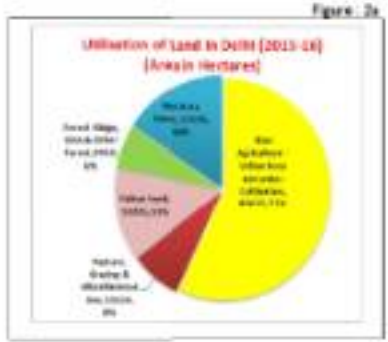


Figure : 2b



1.3 Climate and Rainfall

1.1.1. Climate

The climate of NCT Delhi is mainly influenced by its inland position and the prevalence of air of the continental type during the major part of the year. Extreme dryness with the intensely hot summer and cold winter are the characteristics of the climate. Only during the three-monsoon months July, August, and September does air of oceanic origin penetrate to this state and causes increased humidity, cloudiness and precipitation. The year can broadly be divided into three seasons (Table 4). Data on long-term average climatologic parameters covering monthly maximum / minimum temperature, relative humidity, evaporation and rainfall for NCT of Delhi is given in table 5 and presented graphically in figure 3.

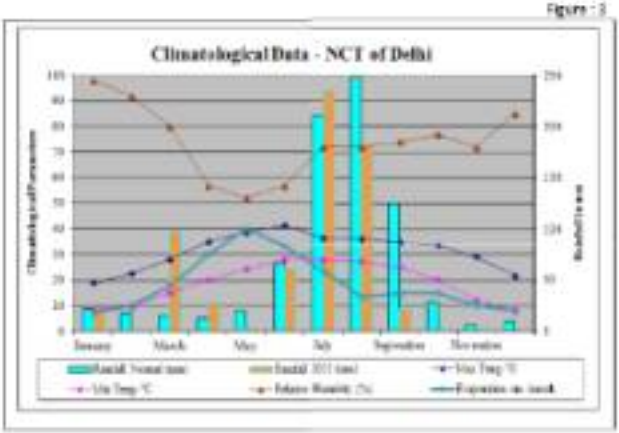
Table 4 : Climate Seasons in NCT of Delhi

Season	Begin	End
Cold/Winter	End of November	Middle of March
Summer	Middle/End of March	End of June
Rainy season	Early July	September

Table : 5 Climatological Parameters – NCT of Delhi (Source [7])

Month	Max Temp (°C)	Min Temp (°C)	Relative Humidity (%)	Rainfall (mm) Normal	Rainfall (mm) 2010	Rainy Days	Sun (Hours)
January	19.8	5.2	80%	32.4	24.1	2.1	7.1
February	22.5	7.7	65%	29.8	7.6	2.1	8.1
March	28.6	13.1	45%	21.9	16.5	1.9	7.4
April	34.8	19.6	31%	12.7	21.7	1.5	9.0
May	38.5	23.6	30%	19.9	3.1	2.1	10.3
June	37.3	26.1	55%	60.6	57.7	4.6	8.4
July	34.1	26.0	74%	210.9	192.2	10.7	5.5
August	32.9	25.3	77%	187.2	103.8	9.1	5.3
September	34.0	23.0	62%	88.1	44.2	3.5	7.7
October	30.7	16.6	51%	18.6	1.4	0.5	8.7
November	25.6	10.6	60%	6.6	0.4	0.3	8.0
December	21.8	6.1	80%	8.8	0.0	0.9	7.8
Total				779.9	484.7	38.1	3214
Average	31.3	16.4	62%				

Figure : 3



3.1.2. Rainfall

For calculation of normal rainfall of NCT Delhi, rainfall records from 1930-1980 for 13 stations (Table : 7) were considered. The normal annual rainfall in NCT Delhi is 611.8 mm. The rainfall in NCT Delhi increases from the southwest to the northwest (Figure 4). About 81% of the annual rainfall is received during the monsoon months July, August and September. The rest of the annual rainfall is received as winter rains and as thunderstorm rain in the pre and post monsoon months. The variation of rainfall from year to year is large.

3.1.1. Rainfall Analysis

Rainfall analysis of 24 years annual rainfall of data and probability analysis data is plotted in figure 5 & 6 and its finding, about probability of occurrence of quantum of rainfall with various probability is presented in table 6. (data analyzed for probability graph Annexure II).

Figure : 4



Figure : 5

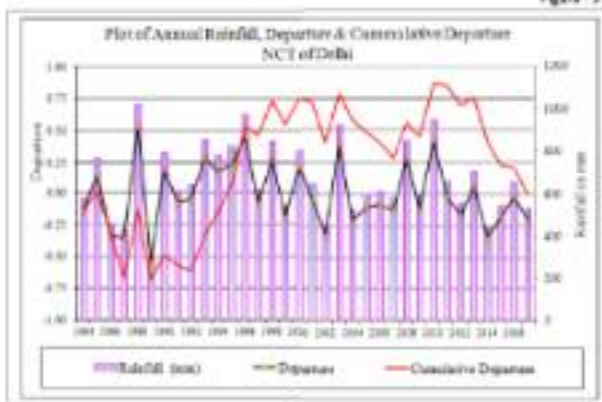


Figure : 6

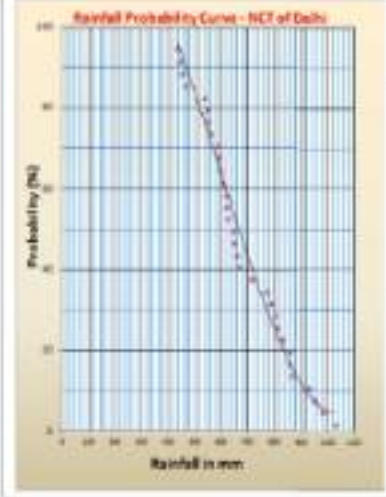


Table 5 : Rainfall Probability Analysis

Probability %	Annual Rainfall in mm
10%	922
20%	840
30%	778
40%	718
50%	664
60%	618
70%	562
80%	520
90%	476
Probability of exceeding of Normal RF	58%

A perusal of rainfall data from 1984 to 2017 shows that NCT Delhi received deficient rainfall during last 21 years corresponding to mild to severe drought conditions (Table 5 & Fig 5b and annexure >>>). Severe drought with departure of 50 % was experience in 1988. Normal drought, departure 25 to 50 % was experienced during year 1986,1987, 2002 and recently during 2014. Whereas, Mild drought, departure up to 25 %, was experienced during the year 1984, 1991, 19192, 19197, 1999, 2001, 2004 to 2007, 2009, 2100, 2012 and 20015 to 2017. The probability analysis shows that probability of rainfall exceeding normal rainfall of 660 mm is up to 48 % whereas there are 90 % chance that rainfall would limit to 476 mm.. Overall, thus the rainfall in Delhi is highly variable and which in turn affects the natural recharge to ground water from year to year.

1.1.2. Other Climatic Parameters

- Temperature

The cold season starts after second week of November when both day and night temperature drop rapidly with the advance of the season. January is the coldest month with the mean daily maximum temperature at 21.2°C and the mean daily minimum at 7.3°C. In the winter months when western disturbances passes across north India, minimum temperatures may sometimes go down to the freezing point of water. From about the middle of March, temperature begins to rise fairly rapidly. May and June are the hottest months. While day temperature is higher in May the nights are warmer in June. From April the hot wind known locally as 'loo' blows and the weather is unpleasant. In May and June maximum temperature may sometimes reach 46 or 47°C. With the advance of the monsoon

into the area towards the end of June or the beginning of July day temperatures drop appreciably while the night temperatures remain high. In October the day temperatures are as in the monsoon months but the nights are cooler.

- Humidity:

The air over Delhi is dry during the greater part of the year. Humidity is high in the monsoon months. April and May are the driest months with relative humidity of about 30% in the morning and less than 20% in the afternoons.

- Cloudiness:

During the monsoon especially in July and August skies are heavily clouded and often overcast. In the rest of the year skies are clear or lightly clouded. But in the months January, February and early March skies become cloudy by western disturbances.

- Winds:

Winds are generally light during the post monsoon and winter months. They strengthen during the summer and monsoon months. Except during the monsoon months, winds are predominantly from a westerly or northwesterly direction and tend to be more northerly in the afternoon. Easterly and southeasterly winds are more common in the monsoon months.

Table - 7 Normal and Extremes of Rainfall (Long Terms 1930 to 1980 IMD Normal)

Stations	No. of Years of DATA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	HIGHEST ANNUAL RAINFALL AS % OF NORMAL & (YEARS)**	LOWEST RAINFALL	HEAVIEST RAINFALL in 24HOURS * Amount Date (mm)
Chandigarh (Willy)	20 a	65	53	30.7	5.5	18.2	67.6	220.6	208.4	103.3	14.4	8.2	11.6	696.5	163	66	171.5 1976 Aug 08
	b	0.6	1.2	1.3	0.5	1.5	2.2	10.6	10.6	3.6	1.0	0.2	0.4	20.9	(1977)	(1968)	
New Delhi (Safdj)	79 a	20.5	26.1	13.3	7.9	12.6	43.2	259.2	252.2	107.6	23.7	3.1	8.0	713.2	219	43	468.2 1978 Sep 09
	b	1.8	1.9	1.2	0.8	1.4	3.8	9.2	9.8	5.1	1.2	0.2	0.7	36.0	(1933)	(1905)	
Delhi (University Willd)	29 a	20.7	18.3	10.1	6.1	10.4	42.2	241.5	262.5	107.4	41.5	4.1	7.6	680.9	200	62	260.0 1980 Sep 16
	b	1.8	1.4	1.0	0.7	1.0	2.8	10.3	10.9	5.2	1.9	0.2	0.6	36.1	(1961)	(1974)	
New Delhi Palam	22 a	14.7	14.1	9.3	6.1	10.9	34.2	241.1	284.3	119.4	16.8	5.4	8.6	750.9	164	61	265.8 1972 Jul
	b	1.7	1.5	1.0	0.6	1.0	3.5	10.0	10.7	4.8	1.4	0.2	0.6	36.3	(1967)	(1965)	09
Jaipur (Sanganer)	21 a	8.6	11.9	14.1	2.6	11.1	90.9	212.5	296.3	104.8	23.2	6.7	1.9	792.4	159	68	190.0 1967 Aug
	b	0.9	1.3	0.8	0.3	1.4	3.4	9.1	10.7	5.1	1.0	0.3	0.5	35.1	(1944)	(1974)	26
Bikaner	33 a	13.9	16.1	7.2	3.4	3.0	25.3	159.0	152.5	56.7	13.5	1.5	2.3	469.0	197	42	177.0 1911 Sep
	b	1.1	0.7	0.5	0.5	0.3	1.5	5.5	5.3	3.0	0.3	0.2	0.3	20.3	(1944)	(1954)	28
Delhi Safdar	39 a	22.5	17.5	10.0	6.9	9.5	44.9	196.3	180.0	103.3	28.1	3.5	5.7	647.6	194	42	224.5 1942 Sep
	b	1.9	1.4	1.4	0.9	0.9	3.4	7.8	9.9	4.7	1.0	0.3	0.6	31.7	(1964)	(1963)	05
Nangloi	25 a	8.5	4.6	1.1	4.0	2.4	10.8	180.3	121.8	89.0	6.8	0.4	0.6	337.2	240	21	123.0 1984 Aug
	b	0.9	0.2	0.2	0.2	0.2	1.1	4.8	3.4	2.1	0.4	0.0	0.0	15.4	(1984)	(1993)	14
Safdarjung	12 a	10.3	11.9	5.5	3.3	2.8	34.8	113.7	125.8	74.5	7.9	0.5	0.6	437.3	204	42	123.5 1944 Sep
	b	0.7	0.8	0.7	0.3	0.3	1.4	4.1	5.2	2.6	0.3	0.0	0.1	16.1	(1944)	(1949)	04
Najafgarh	23 a	8.9	8.2	4.7	4.2	3.5	35.1	122.9	122.9	76.8	24.7	6.5	1.8	386.5	171	13	133.7 1984 Oct 01
	b	0.6	0.7	0.7	0.5	0.4	1.3	5.5	5.3	3.7	0.8	0.2	0.2	19.1	(1942)	(1958)	
Sonli	23 a	10.7	9.6	6.8	3.5	1.4	24.9	164.3	161.9	86.2	32.9	0.8	0.0	518.1	237	37	210.7 1982 Jul 17
	b	1.0	0.7	0.6	0.4	0.2	1.3	6.8	6.4	3.7	0.9	0.0	0.0	23.7	(1980)	(1971)	
Alipur	21 a	11.1	10.0	3.3	3.5	0.3	20.7	148.9	137.1	87.1	13.7	1.3	1.1	448.9	232	12	152.1 1981 Jul 17
	b	1.3	0.7	0.4	0.4	0.4	1.3	4.7	6.0	3.9	0.7	0.1	0.1	19.3	(1961)	(1129)	
Narela	19 a	13.5	14.5	10.8	4.5	7.2	33.5	182.7	185.9	111.2	14.8	1.1	1.5	581.3	196	32	154.1 1987 Sep
	b	1.2	0.9	1.1	0.5	0.8	1.8	5.8	9.2	4.0	0.5	0.1	0.2	25.3	(1961)	(1995)	15
Delhi (Metro)	a	14.5	11.3	8.5	5.5	8.2	38.5	181.8	187.4	108.1	18.5	2.8	4.3	611.8	231	44	
	b	1.2	1.3	0.8	0.5	0.8	2.1	7.4	7.5	4.0	0.8	0.1	0.4	27.0	(1933)	(1931)	

(a) Normal rainfall in mm.

(b) Average number of rainy days (i.e. days with rainfall of 2.5 mm or more)

* Based on all available data up to 1980.

** Years given in brackets.

2. GROUND WATER REGIME MONITORING

Monitoring of ground water regime is an effort to obtain information on variation in ground water levels and chemical quality through representative sampling, both in time and space. Systematic and regular monitoring of groundwater levels and quality brings out various information about the changes taking place in the groundwater regime.

2.1. Monitoring Objective and Method

Main objective is to record the response of ground water regime to the natural and artificial conditions of recharge and discharge with reference to geology, climate, physiography, land-use pattern and other hydrologic characteristics. The database generated, in forms of reports and maps, are of immense help for regional groundwater flow modeling which serves as a groundwater management tool to provide the necessary advance information to the user agencies to prepare contingency plans in case of unfavourable groundwater recharge situation. The data also has immense utility in deciding the legal issues arising out of conflicting interests of groundwater users and also form the basis for ground water development and management programme.

2.1.1. Monitoring Stations Status

Central Ground Water Board, as a part of its national programme, has established a network of observation wells in the NCT of Delhi with the objectives. Number of wells monitored during 2017-18 in NCT of Delhi varied from 93 in May 2017 to 81 in January 2018. Details of monitoring wells, with district wise breakup and types of wells (dug wells / piezometers etc) is given in Table 8 and their distribution in NCT of Delhi shown in map in figure 7.

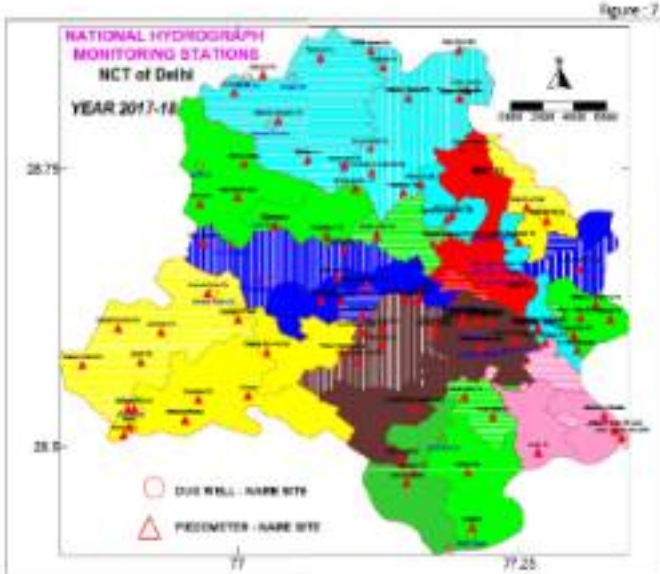
Table :8 Numbers of Stations Monitored by CGWB During 2017-18 – NCT Delhi

	May-17			Aug-17			Nov-17			Jan-18		
	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total
Central	3	1	4	3	1	4	3	1	4	3	1	4
East	3	1	4	3	1	4	3	1	4	3	1	4
New Delhi	5	10	15	4	10	14	5	10	15	5	10	15
North	5	10	15	5	10	15	5	10	15	5	10	15
North East	3	1	4	3	1	4	3	1	4	3	1	4
North West	5	4	9	5	4	9	5	4	9	5	4	9
Shahdra	3	1	4	3	1	4	3	1	4	3	1	4
South	5	4	9	5	4	9	5	4	9	5	4	9
South East	3	1	4	3	1	4	3	1	4	3	1	4
South West	7	12	19	7	12	19	7	12	19	7	12	19
West	6	5	11	6	5	11	6	5	11	6	5	11
Rural Land	5	2	7	5	2	7	5	2	7	5	2	7
TOTAL	63	30	93	57	31	88	54	27	81	56	25	81

It is observed that at present district wise distribution of monitoring network stations has become highly uneven. Over the period, mainly during last three years, numbers of monitoring stations became defunct largely due to corrosion of well assembly and at some places, destroyed / filled up due to other unavoidable urban development activities. During last two decade, at places, continuous decline in ground water level is observed. Such condition necessitate more attention and close monitoring at micro level. It is fact that establishing of new Piezometers or identifying new working dug wells in metropolitan city of Delhi is very difficult due to non-availability of space, although Central Ground Water Board is striving to increase the number of monitoring stations in NCT Delhi to have close observation in the diverse hydrogeological domain. To ensure optimum network density of monitoring station for scientific analysis of the dynamics of ground water regime, in exceedingly developing areas of NCT Delhi is most inevitable. CGWB has taken up groundwater exploration programme to drill and construct new piezometers to replace existing defunct piezometers at 10 sites

of NCT Delhi during the Annual Action Plan of year 2018-19 onward. Map showing locations of existing monitoring stations of CGWB is presented in figure 7.

Figure - 7



2.1.2. Distribution of Monitoring Stations

Central Ground Water Board has carried out extensive hydrogeological mapping and groundwater exploration in NCT of Delhi and its surrounding States. The information generated from these studies has helped to figure out the subsurface disposition and inter-relationship of the aquifers spatially and depth wise. This information has enabled to decide grouping of interrelated aquifers into one aquifer system for the purpose of monitoring.

In alluvial areas of NCT of Delhi, number of sand zones constituting individual local aquifers are grouped into major one main aquifer system and piezometers have been installed accordingly. Three distinct potential aquifer groups within the depth of 450 m below ground level, identified and grouped on basis of various hydrogeological mapping and ground water exploration, are as follows.

1. Aquifer Group I - Down to 65 m below ground level (Un-confined)
2. Aquifer Group II- Between 65 to 200 m below ground level (Confined/ Semi-Confined)
3. Aquifer Group III- Between 200 to >600 m below ground Level (Confined)

Separate piezometers are installed, tapping the two aquifer groups, the first one in the phreatic zone deep enough to accommodate long term fluctuation (i.e. up to 65 m deep) and the other one tapping

the middle parts of the aquifer groups II, lying between 65 to 200 m. The Aquifer group III is not being monitored at present.

Similarly, hard rock area of NCT Delhi is being monitored through piezometric wells, which are installed in a single borehole tapping the weathered and fractured aquifers combined. Generally, the depth of the well goes up to 80 m, but in some cases it goes up to 140 m.

Besides piezometers, numbers of dug wells, tapping phreatic aquifer zone are included in monitoring network. Over the period, numbers of dug wells are becoming defunct due to lack of their use and maintenance. Still, there are 22 dug wells integrated with monitoring network of NCT Delhi (figure 7).

3. HYDROGEOLOGY

Occurrence and movement of groundwater in subsurface aquifer system depends upon topography, geology, climate, water yielding and water bearing properties of subsoils / rocks in the zones of aeration and saturation. The upper surface of the zone of saturation is the Water Table which is measured during water level monitoring. In case of wells penetrating confined aquifers, the water level represents the pressure or Piezometric Head at that point. For effective water level monitoring, it is essential to have a complete understanding of aquifer disposition and geometry in the area before establishing monitoring network.

3.1 Physiography & Drainage

NCT of Delhi represents a mature topography with vast, gently undulatory plains dominated by Yamuna River, low lying ridges and isolated hillocks. Physiography of Delhi is dominated by the Yamuna river, the Aravalli range, and the plains in between formed by alluvium deposits of Recent age. The SSW- NNE trending Aravalli Ranges are designated as *Delhi Ridge*, occupy the south central part of Delhi and extend up to western bank of Yamuna River near Okhla in the south and Wazirabad in the north-east. Ecologically, in western part of the India, the Aravalli Ridge acts as a barrier between the Thar desert and the plains and slows down the movement of dust and wind from the desert. In NCT Delhi, the ridge area are covered with forests, acts as city's lungs and help maintain its environment. This green belt, a natural forest, has a moderate influence on temperature, besides bestowing other known benefits to the people.



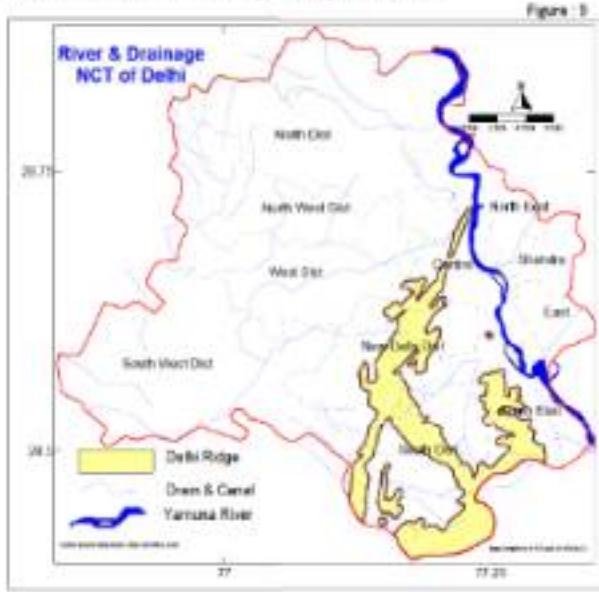
Figure : 6

The area towards east of ridge has a gentle slope of 3.5 m/km towards Yamuna. The area towards west of ridge representing Older Alluvial Plain is mostly covered by sand dunes and has a westerly slope. Yamuna River flows across Delhi in a south-southeasterly direction with vast flood plain, marked by a bluff of 3 to 4 m on either bank. Digital Elevation Model Map of Delhi is presented in fig. 6. Surface elevation varies from 332 m above mean sea level at the ridge to 82 m above mean sea level at river Yamuna. The low-lying Yamuna flood plains, with an elevation as low as 208 m amsl, provide fertile alluvial soil suitable for agriculture but are prone to recurrent floods.

The Yamuna river flowing in a southerly direction in the eastern part of the NCT of Delhi is the only perennial river in the area besides the number of micro watersheds originating from the quartzite ridge. The drainage on the East of the ridge enters river Yamuna, whereas on the West, it enters natural depressions located in Najafgarh Tehsil of South-West district. The NCT of Delhi can be

divided into seven sub basins, ultimately discharging into the Yamuna (figure 9), namely (i) The Najafgarh Drain is about 38 Km long, flows North-Easterly and joins Yamuna River at Wazirabad in North Delhi. (ii) Supplementary drain, (iii) Barapullah drain (iv) Wild life sanctuary area, (v) Drainage of Shahadra area, (vi) Bawana drain basin, (vii) Other drains directly out falling into river Yamuna on right bank. Swamp areas are common along the flood plains of Yamuna.

Figure : 9



3.2 Geomorphology

The ground water availability in NCT of Delhi indirectly relates with its distinct landforms units, which in turn represent underlying intrinsic geological features. Map showing these landforms of NCT of Delhi are presented in Fig. 10. All these landforms of NCT, Delhi can be grouped into three broad geomorphic units namely Rocky surface, Older Alluvial Plain and Flood Plain of Yamuna River.

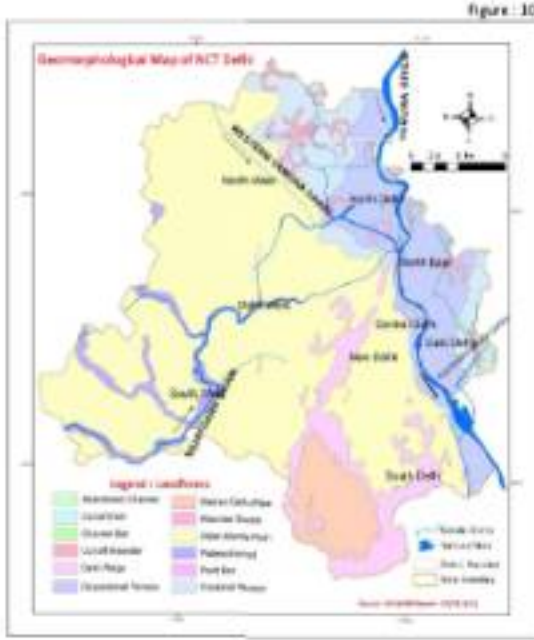
Rocky Surface : The rocky surface represents structurally controlled relict linear ridges and isolated hillocks comprising of rocks of Delhi Supergroup. This distinct landform comprising of isolated hills is most prominent in the south and south central parts, and extends from Mahipalpur to Wazirabad in the north. Towards south of Mahipalpur the ridge gets bifurcated, one arm extends towards Mandi and further south while the other arm takes a turn towards southeast and extends upto Tughlakabad-Greater Kailash-Nehru Place and Okhla. It attains a maximum elevation of 382 m amsl which gradually diminishes towards north where rocks are exposed on the western bank of Yamuna near Wazirabad.

Older Alluvial Plain: The gently undulatory terrain on either side of the rocky surface is described as Older Alluvial Plain. This surface is separated from the Yamuna Flood Plain by a bluff. Depending upon

the morphological expressions / features, this unit is further divided into different subunits namely, (i) Najafgarh Older Alluvial Plain , (ii) Delhi Older Alluvial Plain and (iii) Maidan Garhi Plain. Najafgarh Older Alluvial Plain occupying western and southwestern part of the region is partly covered by sand dunes and sandy sheets. The gently sloping surface including the covered pediment along the western flank of the ridge represents the Delhi Older Alluvial Plain. Maidan Garhi Plain is a relatively higher plain surface and forms part of Chhatarpur Basin. A narrow zone of badland has formed mostly along the western margins of structural ridges due to intense development of gullies and rills.

Flood Plain of river Yamuna: The low-lying flat surface representing the Flood Plain of river Yamuna occupying northern, northeastern and western parts of the ACT is an important geomorphic unit. North of Narela, the width of flood plain varies from 15 to 17 km. The wider Older Yamuna Flood plain indicates lateral migration of river Yamuna over large areas. This belt has good potential for ground water development. It forms the erosional terrace. The Yamuna Active Flood Plain represents the wide belt bounded on both the sides by Eastern and Western bunds and is naturally prone to annual / periodic floods being in the flood way and flood fringe zone of river Yamuna. It forms depositional terrace and is characterized by abandoned channels, cut-off meanders, meander scrolls, point bars and channel bars. Presence of number of cut- off meanders in the Yamuna Flood Plain suggests oscillatory shifting of river. The lakes near Bhalswa, Kondli and Khichripur are remnants of large meanders.

Figure : 10



3.3 Geology

The rock formations exposed in the National Capital Territory of Delhi are mainly quartzite interbedded with thin bands of micaceous schist. These Proterozoic age rocks occur along the ridge, extending from Harcharipur (Haryana) in the South to Wazirabad (Delhi) in the North. Quaternary sediments consisting alluvium deposit directly overlie the Proterozoic rocks. Systematic geological and geomorphologic studies carried out by the Geologists of Geological Survey of India[1] has revealed three Stratigraphic horizons and underlying these distinct lithostratigraphic units of NCT Delhi. The highest of these is the erosional surface forming the top of denudational hills. The second surface is Older Alluvial plain and the third is depositional Younger Alluvial plain (Yamuna). All three lithostratigraphic units corresponding them have undergone changes due to widespread and uncontrolled urban activity over the period. The geological map of Delhi after Kachroo and Bagchi (1999)[1], showing these main units is shown in figure 11 and generalized stratigraphy of NCT of Delhi is presented in table 9.

Table : 9 Generalized Stratigraphic Units of NCT Delhi (compiled after GSI Study[4])

Alluvium	Newer Alluvium	Unconsolidated, inter-bedded lenses of sand, silt gravel and clay confined to narrow flood plains of Yamuna river and Aeolian deposit of South Delhi.
	Older Alluvium	Unconsolidated thickness varies upto 300 m. interbedded, inter-lingering deposits of sand, clay and kankar, poor to moderately sorted.
Delhi Super Group	Alwar Quartzite	Well stratified, thick bedded, brown to buff colour, hard and compact, intruded locally by pegmatite and quartz veins interbedded with mica schist.

Figure : 11



3.3.1. Alluvium Deposits

In NCT Delhi region, exposures of the oldest lithostratigraphic unit, the Delhi Quartzite ridge acts as main recharge zone to subsurface aquifer system. The Quaternary deposits in the form of aeolian and alluvial deposits constitute the major repository of ground water in the area. In the East of the ridge, the thickness of unconsolidated sediments gradually increases away from the ridge, with the maximum reported thickness being 170 m. In the Southeastern, Western and Northern parts of the area, the thickness of sediments is more than 300 m except at Dhansa where the bedrock has been encountered at 197 m below land surface. In Dichaitanpur basin, the maximum thickness of sediments is 116 m. The aeolian deposits of South Delhi are mainly comprised of loam, silty loam and sandy loam. The bedrock is overlain by these deposits. Older alluvial deposits consist mostly of interbedded, lenticular and inter fingering deposits of clay, silt, and sand along with kankar. These deposits are overlain by the newer alluvium, which occurs mostly in the flood plains of river Yamuna.

3.3.2. Hard Rock Formation

Quartzite is one of the most physically durable and chemically resistant rocks found in NCT of Delhi. The suits of quartzite and associated mica schist /phyllite bands of Delhi system have undergone multiple folding and different phases of metamorphism. When the mountain ranges are worn down by weathering and erosion, less-resistant and less-durable rocks are destroyed, but the quartzite remains. This is why Delhi Quartzite is so often the rock found as linear ridges ranges and covering their flanks as a litter of scree. One of the research study on weathering of Proterozoic quartzite in the semi-arid conditions around Delhi[4], it is suggested that Quartzite being a resistant rock, dissolution of small amount of pyrites presence, by moving water produced a sulphate-bearing acidic solution and ferrous iron which reacted with aluminosilicate minerals and quartz respectively and has made the Delhi Quartzite porous and subsequent friable. The coupled weathering mechanism, from the core outward and also proceeded initially from fractures towards the inside, produced weathering rinds and subsequent physical erosion of loose sand, produced during rind development in the outermost zones, has given rise to features like tors, spheroids, gullies, cavities and small-scale caves on these quartzites. Thus, the terrain has acquired ruggedness in semi arid conditions.

In one of the studies of GSI[5] it is reported three generations of folding in the rocks of Delhi. The fold axes of first generation folds follow the trend of main ridge i.e. NNE-SSW, the second generation folds trending NE-SW are observed at Tughlaqabad - Mehrauli area, and third generation fold trending NW-SE is observed at Anand Parbat. The rocks are highly jointed and two sets of conjugate vertical to sub-vertical joints have been reported [6]. Another study of GSI[7] has inferred a number of faults trending NNE-SSW, NE-SW and WNW-ESE.

3.3.3. Subsurface Aquifer Dispositions

Central Ground Water Board had been engaged in Ground Water Exploration in National Capital Territory of Delhi since its inception in 1972 and till date more than 327 boreholes are drilled out of which 151 are Exploratory Well (EW), 176 are Observation Well (OW) / Piezometers (Pz) / Slim holes[7]. Locations of exploratory boreholes are shown in figure 12. All these boreholes were electrically logged to identify granular zones with fresh ground water and other lithological characteristics of subsurface litho units. All these studies has revealed that there is distinct variations in sub surface lithology characteristics and thickness of individual subunits of the main aquifer zone, within the Younger and Older alluvium deposits of NCT Delhi (refer fig 11) which make the aquifer geometry of Delhi complicated and complex. Younger Alluvium confined to the flood plains of Yamuna River and also along the courses of major streams, comprises of clay/silt mixed with small mica flakes, and medium to coarse-grained sand and gravel whereas Older Alluvium comprises interbedded and lenticular deposits of clay, silt and sand ranging from very fine to very coarse with occasional kankar. In general, the younger alluvium, the disposition of different sediments particularly the pervious layer constituting the unconfined aquifer is well delineated in the Yamuna flood plain area while in the

older alluvium, the disposition of different lithological units is not well defined and they are heterogeneous in nature, making it difficult to identify the deep aquifer zones which are regionally extensive, both vertically and laterally. In the Yamuna flood plain, Younger Alluvium thickness is about 40m thick and underlain with silty clay with kankar whereas the thickness of the Older Alluvium, mainly west of Delhi Ridge is highly variable and is dependent mainly on the configuration of the basement ; at Shahbad Mohammadpur near IGI airport the thickness of the older alluvium is 560 meters overlying the bed rock. Whereas in areas underlain by hard rock units, mainly South, South East, Parts of New Delhi and Central district of NCT of Delhi, the aquifers are defined by the presence of fractured zones at different depths. These fractured zones at places are locally well defined but not regionally extensive.

Figure : 12

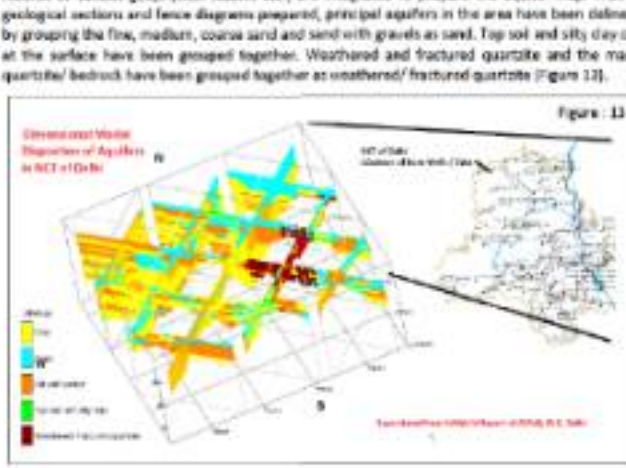


The subsurface configuration of aquifers, in entire NCT of Delhi has been deciphered on basis of available lithological and geophysical logs of exploratory wells drilled by Central Ground Water Board under the Ground Water Exploration Programme. To mark the aquifer geometry, on the basis of

these lithlog data, the different sediments i.e. clay, silt, kankar and different grades of sand, and their admixture has been categorized as pervious (silt + kankar + sand) and impervious (mostly clay with some silt + kankar). In the areas underlain by hard rock formation, upper most weathred regolith and quartzite with fractured zones at different depths and associated exca vated land constitutes unique hard rock aquifer system.

In recent report of CGWB taken up under NAQUIM, the detailed aquifer geometry on regional scale has been established in the NCT, Delhi. All available information about subsurface aquifer configuration, deciphered on basis lithological and geophysical logs of exploratory wells drilled by Central Ground Water Board under the Ground Water Exploration Programme along with interpreted records of various geophysical studies etc., are integrated to prepare the aquifer map. From the geological sections and fence diagrams prepared, principal aquifers in the area have been delineated by grouping the fine, medium, course sand and sand with gravels as sand. Top soil and silty clay or silt at the surface have been grouped together. Weathered and fractured quartzite and the massive quartzite/ bedrock have been grouped together as weathered/ fractured quartzite (Figure 13).

Figure : 13

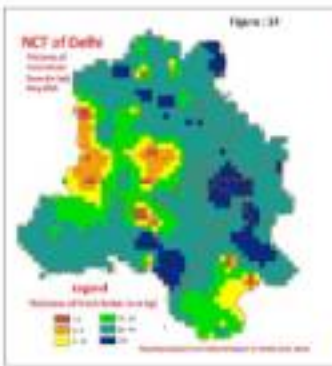


3.3.4. Fresh - Saline Ground Water Interface

Various hydrogeological and groundwater exploration studies in NCT of Delhi by CGWB has revealed that thickness of fresh water in major part of the State varies from 20 to 40 m. It is also observed that no fresh water is available in a few pockets in Narela and Alipur tehsils of North District, Saraswati Vihar tehsil of Northwest district, Punjabi Bagh and Patel Nagar tehsils of West District, Najafgarh tehsil of Southwest district and Kalkaji tehsil of Southeast District. (Figure 14).

In one of the recent study undertaken under NAQUIM projects by WAPCOS, the granular zones (the aquifers) with varied resistivity were picked up from the combined interpretations of electrical resistivity (64 inches Normal) and gamma radioactivity logs of the boreholes drilled in the area. It shows that resistivity values greater than 10 ohm-m to 50 ohm-m represents predominately sand with fresh ground water. Resistivity less than 10 ohm-m indicates predominately clay and kankar with saline water. Further lowering of resistivity values to 1 ohm-m indicates further deterioration of water quality with depth. Resistivity of the order of 50 to 500 ohm-m in hard rock (quartzite) area is represented by weathered/ fractured/ jointed quartzite which forms potential aquifer with potable water. In general, it is clear that fresh water sediments are followed by the saline water sediments in

all over NCT of delhi. The thickness of fresh water sediments is thin in major parts of NCT, Delhi. The depth to fresh – saline water interface varies from 10 m bgl to 80 m bgl. Ground water quality below fresh saline water interface is saline all through up to the bedrock. At a few locations like Dhansa, Qutabgarh and Bankner, saline ground water is present at a very shallow depth range. Panel diagram showing fresh – saline ground water interface in subsurface aquifer system of NCT of Delhi, from NAQUIM report of CGWB, is presented in figure 15.





Perusal of figure 15 shows that in the Southwest district of NCT Delhi, bedrock are encountered at many places i.e. in Dhansa, Samalkha, Kabuli lines, Jhuljhuli where fresh/saline water interface also varies greatly in entire area. All along the Najafgarh Drain and two depressions i.e Gummanhera & Pindwalan Kalan, fresh water layer is somewhat deeper i.e. up to 35 m bgl but rest of the area is having thin layer of fresh water i.e. up to the depth 25 to 28 m bgl only. In the western parts of the district, the thickness of fresh water zone is limited. At a few locations like Dhansa, the saline ground water is present at a very shallow depth and as we move towards areas in the eastern part of the district, where hard rock is present, the thickness of fresh water aquifers is more and fresh/saline water interface occurs at deeper depth i.e. generally around 80 to 90 m bgl. At Rajokri, the depth of fresh/ saline water interface has been observed to be 150 m bgl.

In West district, the depth of fresh/saline interface varies from 25 to 50 m bgl. The depth of fresh water zone varies from 30 to 45m. At places like Dichau Kalan and Kalkrola, the thickness of fresh water aquifers is more and fresh/saline interface is at deeper depths while in the areas around Janakpuri, Mundka, the saline water is present at shallow depths.

In South district, depth of fresh/ saline water interface varies from 75 to 100 m. The thickness of fresh water zone varies from 30 to 85 m. At locations like Gadaipur, Bhatti and Munirka, fresh water aquifers are followed by hard rock (Delhi quartzite). In Southeast district, at places around Madanpur Khadar, the thickness of fresh water zones is limited. Here, fresh water aquifers are followed by saline water zone and bedrock is encountered at depth of around of 300 m.

In North West district, the depth of fresh/ saline water interface varies greatly. The thickness of fresh water aquifers is limited in this district. At locations like Auchandi, Qutabgarh & Bankner, the saline water is present at shallower depths. In areas along Yamuna Flood Plain fresh/ saline water interface is at deeper depth i.e around 40 to 70 m bgl, whereas in rest of the area it is 22 to 40 m. No bedrock has been observed up to the depth of 250 m.

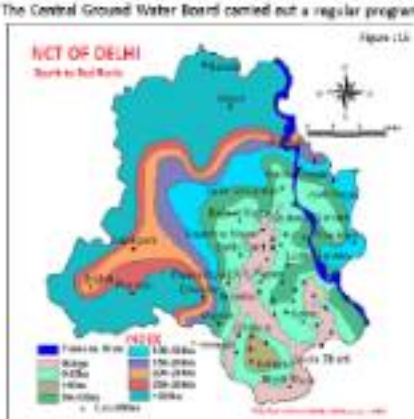
In Northeast district, thickness of fresh water aquifers is more in areas around Yamuna Flood Plain. The depth of fresh/ saline water interface in Yamuna Flood Plain ranges between 32 and 50 mbgl whereas in rest of the area, it ranges from 25 to 38 m bgl.

In New Delhi and Central Districts, fresh water sediments are followed by saline water and then by quartzites (Delhi Ridge). In East & Shahdara districts, thickness of fresh water aquifers is more at locations i.e Kalyanpuri, Kondli and Shakarpur up to 60 m bgl.

3.3.5. Basement Topography

The pre- Cambrian basement rocks are exposed in form of series of isolated hillocks with different dimension, usually termed as Ridge, trending almost in NNE- SSW direction in NCT of Delhi. Main exposures are Northern Ridge near Delhi University (0.87 Sq. Km), Central Ridge near Dhaula Kuan (8.88 Sq. Km), South Central Ridge near Vasant Kunj (6.26 Sq. Km) and Southern Ridge near Asola (82 Sq. Km). The strike of these rocks varies from north-east and south-west to north north-east and south south-west with steep dips towards east and south-east except for some local variation due to folding.

The Central Ground Water Board carried out a regular programme to drill exploratory wells in NCT Delhi and its surrounding States. So far, in NCT of Delhi alone, nearly 350 wells have been drilled in various parts of Delhi, which covers diverse terrain i.e. Yamuna flood plain , older alluvium area , Chattarpur Enclosed Basin and Delhi Quartzite terrain, for their aquifer evaluation and quality determination of ground water. Moreover, as a short term basis electrical resistivity survey was also carried out along Najafgarh Drain and , along Rajpath (India gate) as well as in different parts of south district. All these has helped to configure extension of basement rock topography, below variable thickness of alluvium, from the land surfaces of exposed ridge in all the stretches in & around NCT of Delhi. Earlier, during 2000, bed rock configuration map prepared on the basis of subsurface geological data generated from exploratory drilling and supplementary geophysical data input, indicated that the contour of the bed rock up to 200 m almost follows the Ridge alignment indicating the slope of the bed rock to be uniform. As such, taking into consideration of geological and tectonic processes undergone by basement rocks during the Pre-Cambrian and subsequent periods, the basement topography of NCT, Delhi is presumed to be highly uneven with the presence of sub-



surface ridges and valleys. A simplified basement topography map, an abridged information derived by all available explorations & survey reports, mainly by using exploratory data of NCT Delhi, reproduced from old report of CGWB is shown in figure 16. Taking into account of thickness of alluvium overburden, the area of NCT Delhi has been classified into three zones Viz, A, B, C, which is shown in the table 10.

Table 10 Thickness of Alluvium overburden over Bed rock

Zone	Depth of Bed rock or overburden in m bgl	Area of NCT Delhi
Zone A	< 30	Lal Qila, Delhi Gate, Feroj Shah Kotla, Ramlila Ground, Ajmeri Gate, Sder Bazar, Dhir pur, Timarpur, Majanu Ka Tila, Gandhi Nagar (Rail Bridge) Maharpark, Roj Mandi, Chandani Chauk- Sadar Bazar, Greater Kailash-Kalakaji, North of Connaught Place & Moti Bagh.
Zone B	30 to 100	Usmanpur, Loni border, Metro rail Depot, Mayur Vihar Phase-II (Block 80), Geeta colony, Khajuri Khas, Shakarpur Khas, Gadaipur, Jasanpur, Ayernagar,Hauz Khas, Vayusena Bal Jamia Univ. (Okhala), Aravalo Marg, Gulabi Bagh, Trilokpuri, Mayur Vihar-Ph-I, Ghaopur, Kondli (Loni Bdr).
Zone C	> 100	MidenPur Khadar, Jagat Pur, Jaitpur, WEST of Najafgarh Nala, Kirki Place , Palam Village, Shastri Nagar , CBD Shehedara, Anada Vihar, Dilsad Garden, Barwar, Nangloi ,Tikri kala.

4. GROUND WATER BEHAVIOURS DURING 2017-18

The monitoring of ground water levels has been carried out four times in a year simultaneously throughout the NCT of Delhi during following periods.

a) May - 20th to 30th (water level of pre monsoon period)
b) August - 20th to 30th (peak monsoon water level)
c) November - 1st to 10th (water levels of post monsoon period)
d) January - 1st to 10th (the recession stage of water level)

The data is analysed for each set of measurement, and report prepared which include following maps to understand the groundwater regime in NCT of Delhi.

a) Depth to water level – water level with reference to ground level.
b) Seasonal fluctuation – water level fluctuation in comparison to pre-monsoon.
c) Annual fluctuation – water level fluctuation in comparison to same month in the previous year.
d) Decadal fluctuation – water level fluctuation in the month of measurement with reference to the decadal average for the same month.
e) Ground Water Flow Net – water level with reference to mean sea level.

4.1 Depth to Water Level

An analysis for numbers of monitoring wells in the different categories of the water levels for all four monitoring periods of year 2017-18 reveals that water level depth up to 5 m varies considerably over two monitoring periods (May & other months) which shows that dynamic changes in ground water levels are conspicuously deciphered in shallow water zones. For depth range of 5 to 10 m and 10 to 20 m and more at few locations, changes in numbers of monitoring wells in August, November & January compared to May period not prominent. This may be interpreted as stressed water level conditions suppressing dynamic fluctuation in water levels. Whereas numbers of monitoring station showing water level below 40 m remain almost same in all four monitoring period, indicate stressed water conditions in deep aquifers of NCT Delhi.

Figure 17





4.1.1. May 2017

The Depth to water level recorded in NCT Delhi during May-2017 ranges from 1.13 at Deonia to 78.1 m. bgl at Gadaipur. A map showing May 2017 ground water levels in NCT of Delhi is given in Figure 19 and areas under various depth zones is presented in figure 20. Around 16% of NCT Delhi areas, in parts of North, North West & Central districts have shallow water level up to 5 m bgl. Deep water levels of 20 to 60 m observed in around 30% of NCT Delhi, in South, South East, New Delhi & South West districts. In rest of NCT Delhi, 54 % areas have water level in range of 5 to 20 m bgl.

Figure : 19

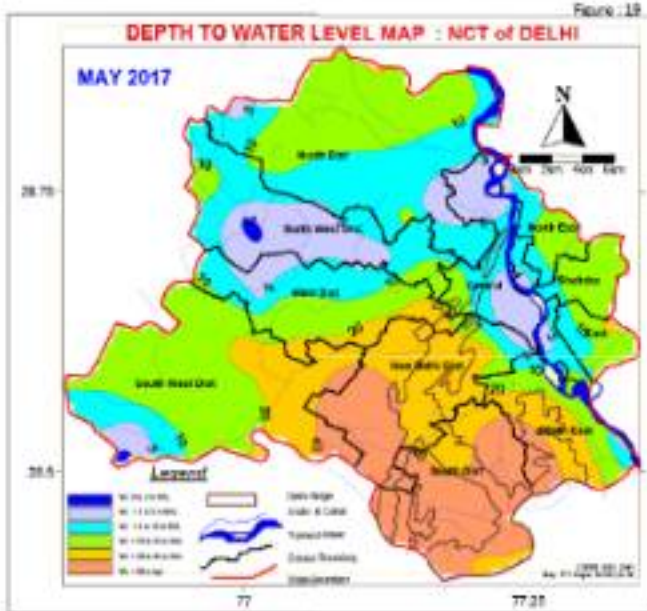
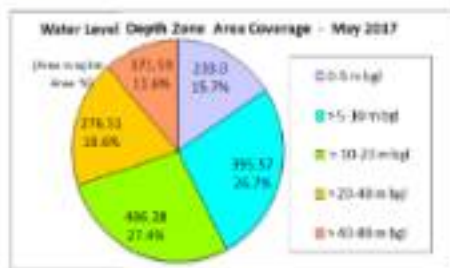


Figure : 20



4.1.2. August 2017

The Depth to water level recorded in NCT Delhi during August-2017 ranges from 0.41 at Dwarka to 64.25 m. bgl at Pusp Vihar. A map showing August 2017 ground water levels in NCT of Delhi is given in figure 21 and areas under various depth zones presented in figure 22. Around 18% of NCT Delhi areas, in parts of North, North West, Northeast, East, Central and Southwest districts have shallow water level up to 5 m bgl. Deep water levels of 20 to 60 m observed in around 30% of NCT Delhi, in South, South East, New Delhi & South West districts. In rest of NCT Delhi, 52 % areas have water level in range of 5 to 20 m bgl.

Figure : 21

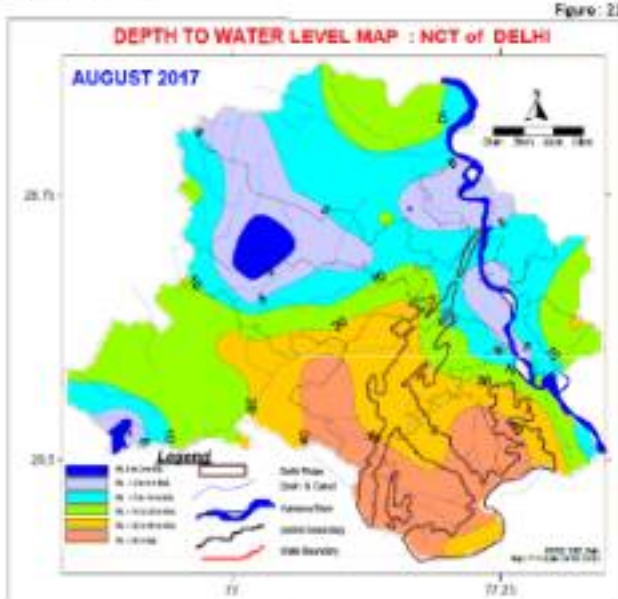
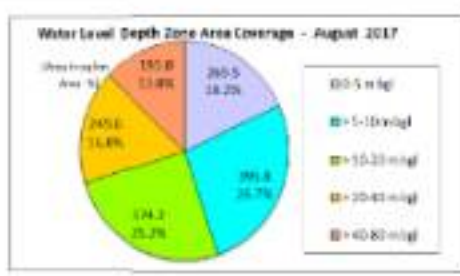


Figure : 22



4.1.1. November 2017

The Depth to water level recorded in NCT Delhi during November 2017 ranges from 0.32 at Deonla to 60.06 m. bgl at Gadaipur. A map showing November 2017 ground water levels in NCT of Delhi is given in figure 23 and areas under various depth zones presented in figure 24. Around 10% of NCT Delhi areas, in parts of North, North West, Northeast, East, Central and Southwest districts have shallow water level up to 5 m bgl. Deep water levels of 20 to 60 m observed in around 12% of NCT Delhi, in South, South East, New Delhi & South West districts. In rest of NCT Delhi, 40 % areas have water level in range of 5 to 20 m bgl.

Figure : 23

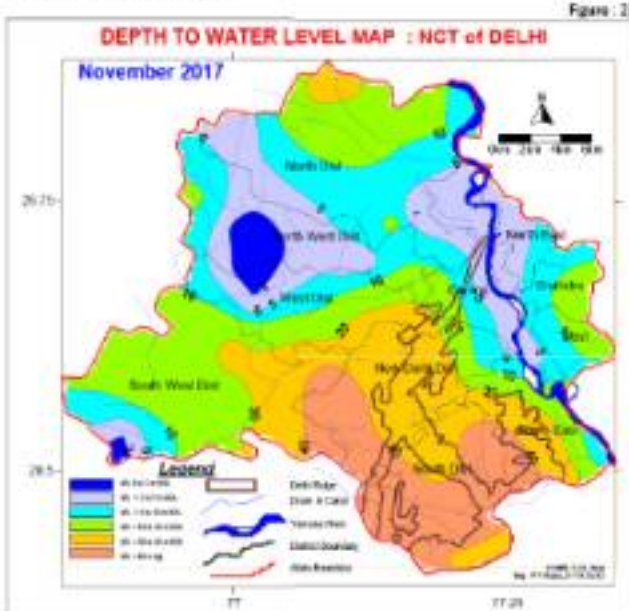


Figure : 24



4.1.4. January 2018

The Depth to water level recorded in NCT Delhi during January-2018 ranges from 0.35 at Deonla to 60.21 m. bgl at Gadaipur. A map showing January 2018 ground water levels in NCT of Delhi is given in figure 25 and areas under various depth zones presented in figure 26. Around 15% of NCT Delhi areas, in parts of North, North West and some small pockets of Central & Southwest districts have shallow water level up to 5 m bgl. Deep water levels of 20 to 60 m observed in around 30% of NCT Delhi, in South, South East, New Delhi & South West districts. In rest of NCT Delhi, 54 % areas have water level in range of 5 to 20 m bgl.

Figure : 25

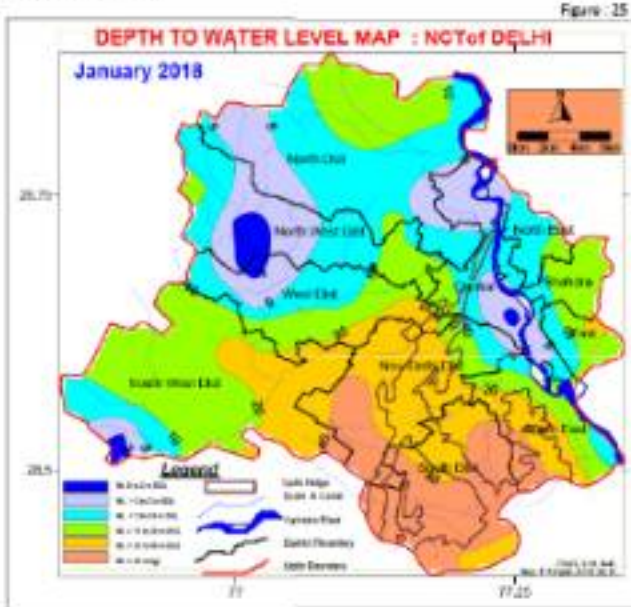


Figure : 26



4.2 Seasonal Water Level Fluctuation : 2017-18

The seasonal water level fluctuation, i.e. the changes in depth of water levels of August 17, November 17 and January 18 with respect to May 17 water level reveals the effect of subsequent utilisation of groundwater for various needs like agriculture, irrigation, domestic etc., on overall groundwater regime of the area. Number of wells showing change in groundwater levels in the region over different periods is presented in figure 27 (a,b & c) and table 11.

Figure : 27 a

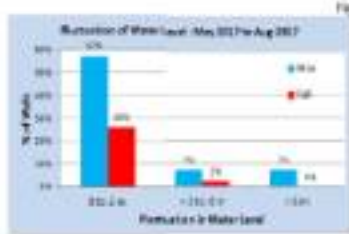


Figure : 27 b

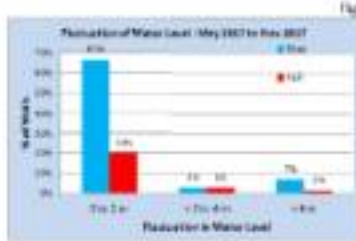


Figure : 27 c



Table 11 : Monitoring Wells Showing Seasonal Fluctuation in Water Level

Water Level Fluctuation Range	May'17 - Aug '17		May'17 - Nov'17		May'17 - Jan '18	
	Rise	Fall	Rise	Fall	Rise	Fall
0 to 2 m	49	22	20	16	44	20
> 2 to 4 m	3	2	1	2	1	2
> 4 m	2	0	1	0	4	1
Total	80	24	27	18	49	23
	84		75		72	

4.2.1. May 2017 to August 2017

A perusal of figure 27a and table 11 reveals that comparing water levels of May 17 to August 17, total 58 (71%) monitoring wells of the NCT of Delhi show a rise whereas rest shows decline. The extent of rise and decline in water levels is shown in map presented in figure 28 and also as pie chart in figure 29.

Figure : 28

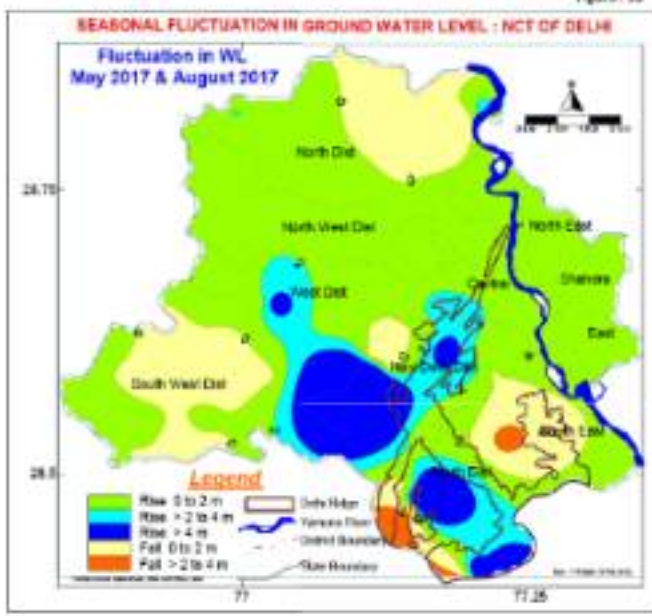
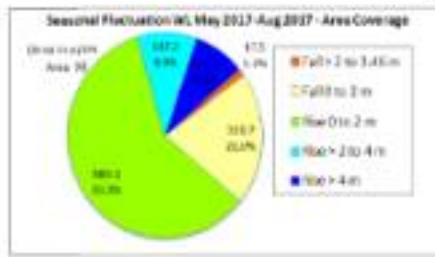


Figure : 29



4.2.2. May 2017 to November 2017 (Pre & Post Monsoon)

A perusal of figure 27(b) and table 11 reveals that comparing water levels of May 17 to November 17, total 103 (33%) monitoring wells of the NCT of Delhi show a rise whereas rest shows decline. The extent of rise and decline in water levels is shown in map presented in figure 30 and also in pie chart in figure 31.

Figure : 30

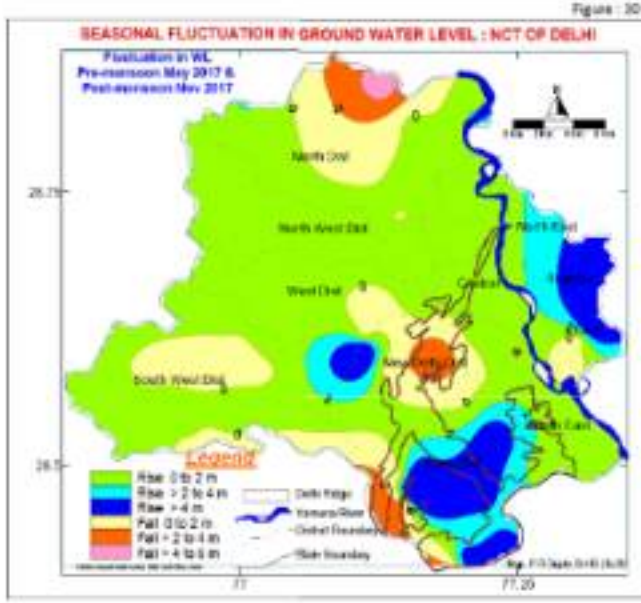
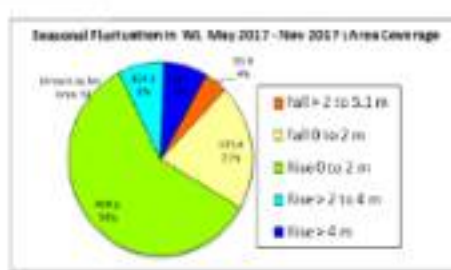


Figure : 31



4.2.3. May 2017 to January 2018

A perusal of figure 27(c) and table 11 reveals that comparing water levels of May 17 to January 18, total 78 (70%) monitoring wells of the NCT of Delhi show a rise whereas rest shows decline. The extent of rise and decline in water levels is shown in map presented in figure 32 and also in pie chart in figure 33.

Figure : 32

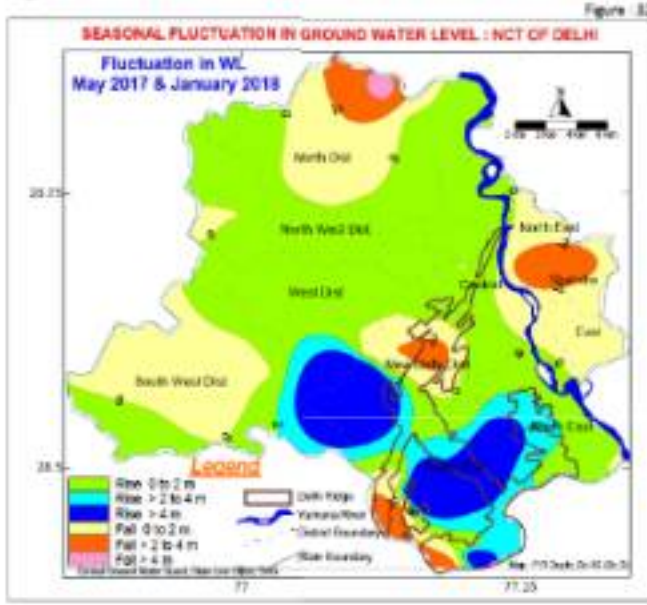
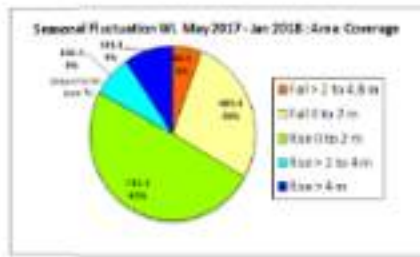
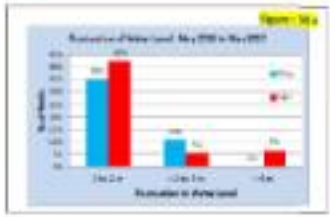


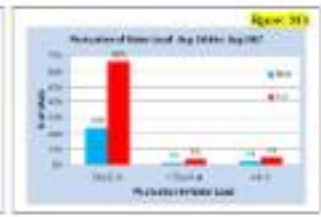
Figure : 33



4.3 Annual Water Level Fluctuation : 2017-18

Annual fluctuation in the water levels of the ground water monitoring wells during 2017-18 for different monitoring periods were compared with same period of 2016-17 and wells showing change in groundwater levels over different periods is presented in figure 14 (a,b,c & d) and table 12.





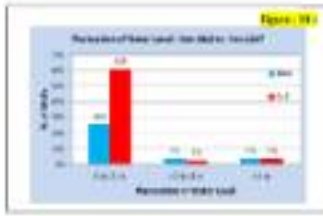




Table: 12 Monitoring Wells Showing Annual Fluctuation in Water Level

Water Level	May 16 - May 17		Aug 16 - Aug 17		Nov 16 - Nov 17		Jan 17 - Jan 18	
	Rise	Fall	Rise	Fall	Rise	Fall	Rise	Fall
0 to 2 m	32	39	71	60	71	55	32	39
2 to 4 m	10	6	1	1	1	2	1	4
> 4 m	0	6	2	4	3	3	1	2
Total	42	56	24	67	77	55	34	45
	92		91		82		71	

4.3.1. Annual Fluctuation : May 2017 & May 2018

The fluctuation of water level between May-2016 and May-2017 of NCT Delhi shows that except parts of North, North West, West and some pockets of South and South-West districts, represented by 46 % of wells show rise up to 3.8 m. Rest of major parts of NCT Delhi areas, represented by 47 % of monitoring wells, show fall in range of 0 to 2 m while rest of 7 % monitoring stations shows fall up to 4 m with respect to the previous year water level. (Figure 18). Chart showing extent of areas having rise and fall, computed from map grid, is presented in figure 20.

Figure : 35

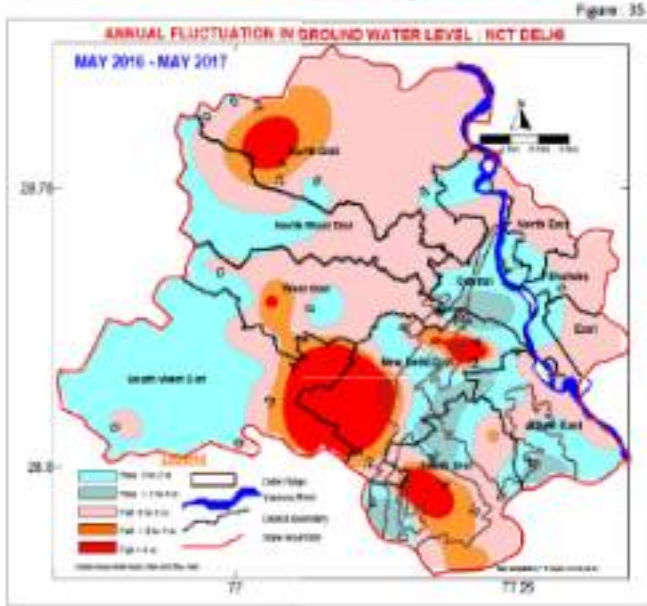
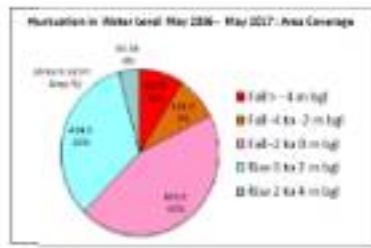


Figure : 36



4.3.2. Annual Fluctuation: August 2016 & August 2017

The variation of water level from August-2016 and August-2017 reveals that there is a rise in the range of 0 to 2m in nearly 23% of the wells, while 66 % wells shows falls in range of 0 to 2 m. Fall of more than 4 m is observed in small pocket of South district (4 % wells). Nearly 10 % areas shows rise up to 2 m while rest 74 % area has fall up to 0 to 4 m (figure 37 & chart figure 38).

Figure : 37

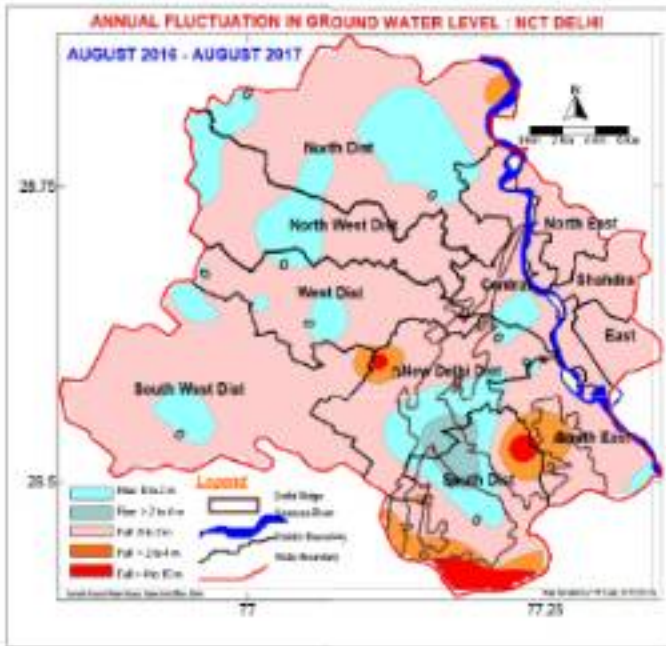


Figure : 38



4.3.3. Annual Fluctuation : November 2016 & November 2017

Comparing water level data of November 2016 to November 2017, it is revealed that 24 % wells show rise in range of 0 to 2 m whereas 4% show rise more than 2 m; max up to 10.08 m in Delhi Cantonment area.. Rest 61 % wells shows fall, mostly in range of 0 to 2 m except small pockets of New Delhi & South district shows fall more than 2 m (Figure 39). Nearly 26% area shows rise up to 2 m while 61 % area show fall in range of 0 to 2 m. Rest 2 % area has fall up to 2 to 5.26 m while 3 % area has rise up to 10.08 m (Figure 40).

Figure : 39

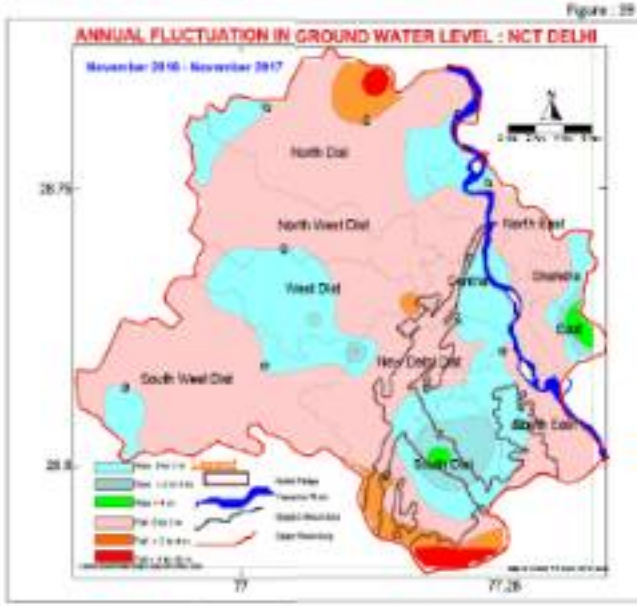
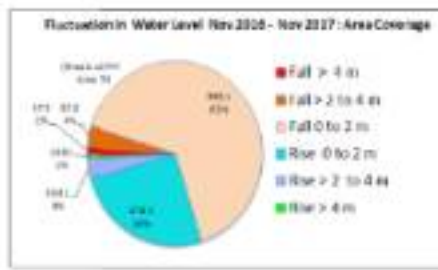


Figure : 40



4.3.4. Annual Fluctuation : January 2017 & January 2018

Comparing water level data of January 2017 to January 2018, it is revealed that 41 % wells shows rise, mostly in range of 0 to 2 m whereas small pockets in Southeast & South district has rise up to 5.6 m at Mehrali area, whereas rest 49 % wells shows fall in range of 0 to 2 m (Figure 39). Nearly 35 % area shows rise up to 2 m while rest 57 % area show fall in range of 0 to 2 m. Rest 1 % area has fall in range of 2 to 8.3 m while 4 % area has rise in range of 2 to 5.6 m (Figure 40).

Figure : 41

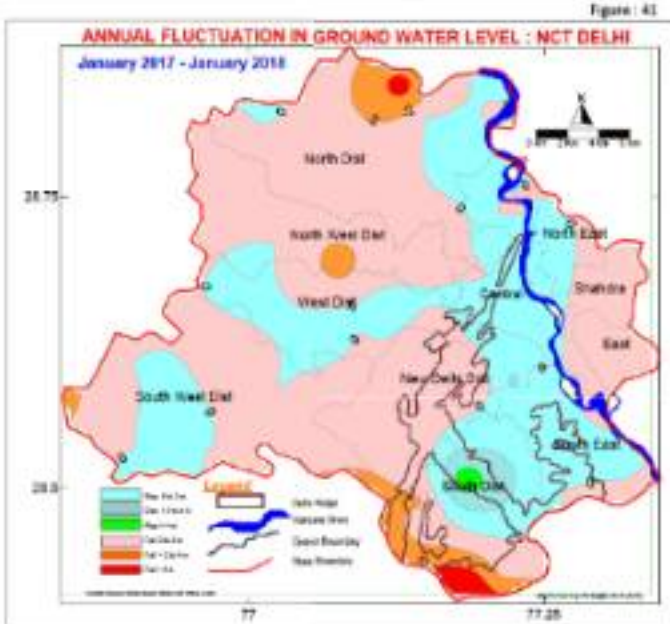
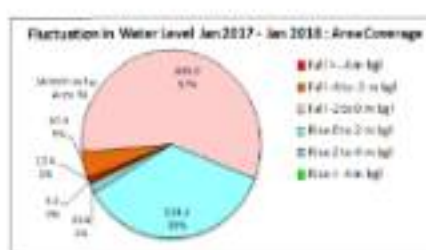
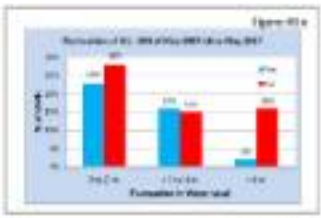


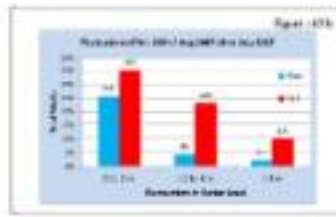
Figure : 42



4.4 Long Term Ground Water Scenario

Long-term behaviour of water levels was studied by analysing water level change of decadal mean water levels data of 2007-16 for May, August & November and 2008-17 decade for January month with corresponding water level data of 2017-18. Statistical analysis of numbers of monitoring wells and range of water levels showing decadal change is presented as charts in figure 43 (a, b, c & d) and also in table 13.







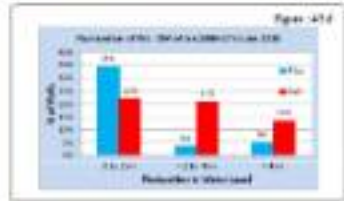


Table :13 Monitoring Wells showing Change in Water level comparing Decadal Mean

Water Level Fluctuation Range	DM of May 07-16 & May 17		DM of Aug 07-16 & Aug 17		DM of Nov 07-16 & Nov 17		DM of Jan 08-17 & Jan 18	
	Rise	Fall	Rise	Fall	Rise	Fall	Rise	Fall
0 to 2 m	23	28	23	32	25	23	28	18
> 2 to 4 m	16	15	4	21	3	18	3	17
> 4 m	2	16	2	9	5	9	4	11
Total	41	59	29	62	33	50	35	46
	100		91		83		81	

Maps showing change in water level scenario over May, August, November and January for year 2017-18 with decadal mean of May, August & November for 2007-16 and January 2008-17 respectively are presented in figure 44, 46, 48 and 50 and pie diagrams showing areas under different ranges of water level change are presented in figure 45, 47, 49 and 51 respectively for month corresponding May, August, November and January of 2017-18.

4.4.1. Decadal Fluctuation : (DM of May 2007-16 & May 2017)

Comparing water level data of May-2017 with 10 year mean water level of May (2006 to 2016), the change in water level ranges from -8.8 m to 8.0 m. Nearly 71 % of monitoring wells show increase in fall of water level of May 2017 when comparing decadal mean of May water level of 2006-15, whereas rest 29 % wells show increase in rise of water levels. This increase in rise mainly confined to east parts of Southwest & West districts, central part of New Delhi and South districts; entire northeast of NCR Delhi covering parts of North East, Shahdra and East district and northern parts of North district. (Figure 44). Nearly 28 % areas shows increase in fall up to 2 m, 21% up to 4 m and rest 22 % up to 8.0 m. Similarly increase in rise up 2 m is recorded in 23 % areas and 5 % areas shows rise in range to 2 to 4 m. Chart showing extent of areas having change in rise and fall of water level, computed from map grid, is presented in figure 45.

Figure : 44

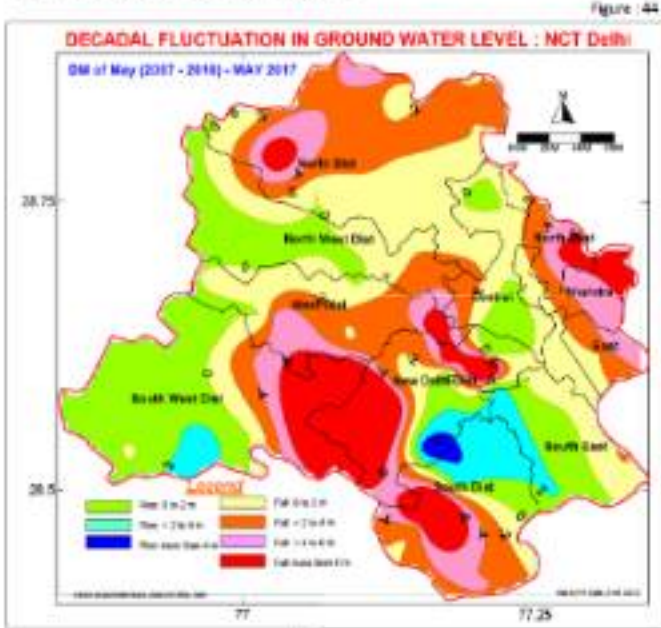
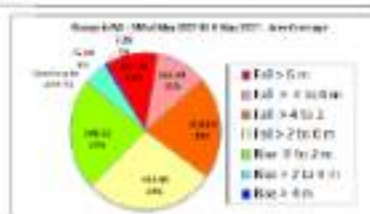


Figure : 45



4.4.2. Decadal Fluctuation (DM of August 2007-16 & August 2017)

Comparing water level data of August-2017 with 10 year mean water level of August (2007 to 2016), the change in water ranges from – 7.8 m to 10.6 m. Nearly 31 % of monitoring wells show increase in rise of water level of August 2017, comparing decadal mean of August water level of 2007-16, whereas rest 69 % monitoring wells show increase in fall of water level. This rise mainly confined to central parts of NCT Delhi, covering parts of Northwest, West, Southwest and New Delhi district; south parts of South district; patches of North, North East, Shahdra and East districts (Figure 46). Nearly 33 % areas shows increase in rise up to 2 m, 4% from 2 to 10.6 m. Similarly increase in fall up 2 m is recorded in 45 % areas, 22% upto 4 m and rest 6% from 4 to 7.8 m. Chart showing extent of areas having change in rise and fall, computed from map grid, is presented in figure 47.

Figure : 46

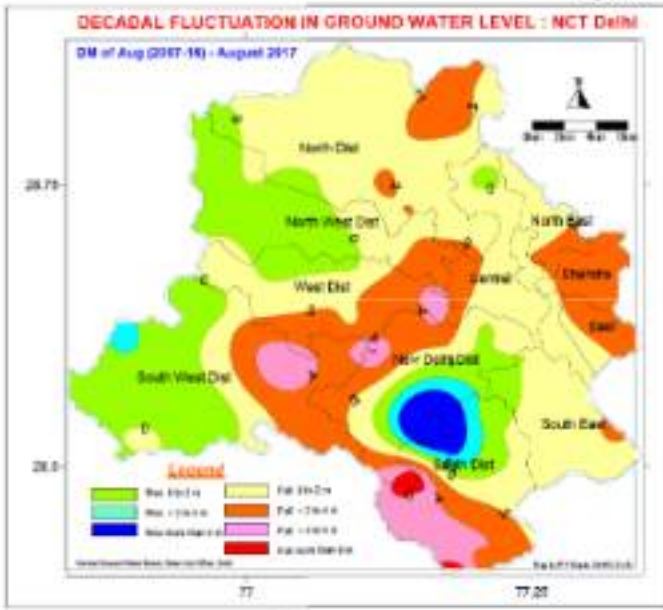
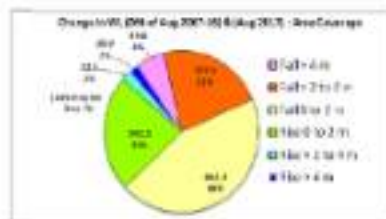


Figure : 47



4.4.3. Decadal Fluctuation: DM of Nov 2007-16 & Nov 2017

Comparing water level data of November-2017 with 10 year mean water level of November (2007 to 2016), the change in water level ranges from -7.6 m to 9.2 m. Nearly 31% of monitoring wells show increase in rise of water level of November 2017, comparing decadal mean of November water level of 2007-16, whereas rest 69 % monitoring wells show increase in fall of water level. This rise mainly confined to two parts of NCT Delhi; i.e. in western part of Southwest, West and Northwest districts and in Southeast, South and New Delhi district of NCT Delhi (Figure 48). Nearly 37 % areas shows increase in fall up to 2 m, 23% up to 4 m and rest 9 % up to 7.6 m. Similarly increase in rise up 2 m is recorded in 25 % areas and 6 % areas shows rise in range to 2 to 9.2 m. Chart showing extent of areas having change in rise and fall, computed from map grid, is presented in figure 49.

Figure : 48

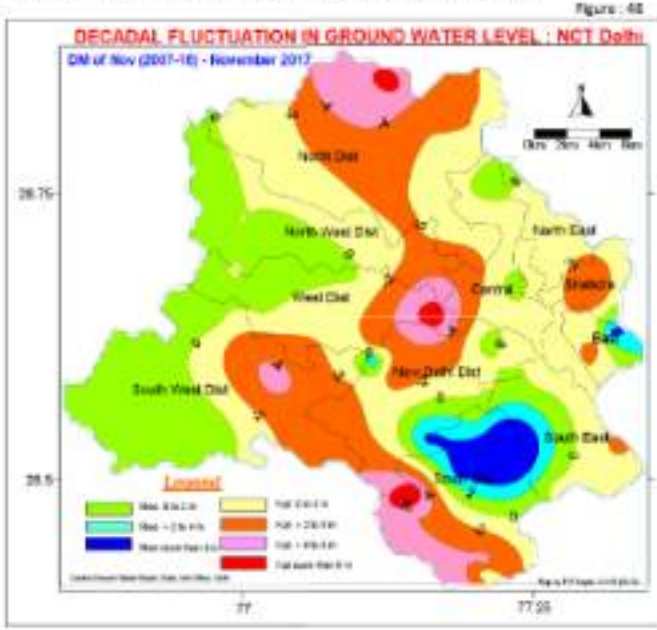
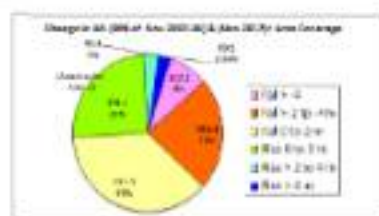


Figure : 49



4.4.4. Decadal Fluctuation: DM of January 2008-17 & January 2018

Comparing water level data of January-2018 with 10 year mean water level of January(2008 to 2017), the change in water level ranges from – 7.8 m to 9.01 m. Nearly 44 % of monitoring wells show increase in rise whereas rest 56 % monitoring wells shows increase in fall. This rise mainly confined to western half of NCT Delhi covering parts of Southwest, West, Northwest and North districts. Similarly parts of Southeast, South, New Delhi and Central districts also shows rise. (figure 50). Nearly 31 % areas shows increase in fall up to 2 m, 29% up to 4 m and rest 18 % up to 7.9 m. Similarly increase in rise up 2 m is recorded in 22 % areas and 6 % areas shows rise in range to 2 to 9.01 m. Chart showing extent of areas having change in rise and fall, computed from map grid, is presented in figure 51.

Figure : 50

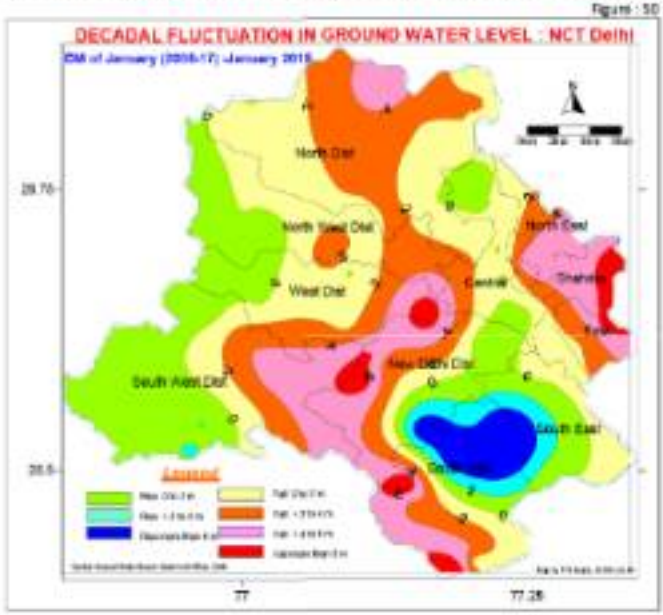
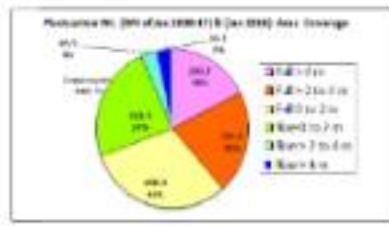


Figure : 51



4.5 Water Table Scenario

Water table contour map of May 2017 is presented in figure 52. The perusal of the map shows that the water table elevation ranges from 154 m amsl at Pusp Vihar in Hauz Khas Tehsil to 255 m amsl at Bakhi Nagar in Saket tehsil in south part of NCT Delhi. Aravalli Ridge areas is main recharge zones for NCT Delhi. In these areas water table ranges from 210 to 230 m amsl. Closely spaced contours on the eastern side of the ridge indicate steep gradient and high rate of flow of ground water, while widely spaced contours on the western side of the ridge indicate gentle gradient. Two trough of lowest water table observed indicate high development of groundwater, one is around Pusp Vihar in Mukhtu tehsil and another is in Dwarka area of Dwarka tehsil. In rest part of NCT Delhi, water table counter follows general topography of the areas. Yamuna river flood zone shows water table in range of 185 to 198 m amsl. Major parts of Yamuna flood zone in NCT of Delhi, on either banks, water table configuration indicate influent nature of river Yamuna while in small section passing through South East district it shows effluent nature on right bank, in Southeast part of NCT Delhi whereas left bank area, in adjoin Uttar Pradesh it shows influent nature.

Figure : 52



5. HYDROGEOCHEMISTRY

The water that falls as rain and snow infiltrates into the subsurface soil and rock. Some water remains in the shallow soil layer whereas large portion infiltrate deeper and becomes part of groundwater system. The chemical characteristics of groundwater are mainly based on the surface and subsurface environment, such as the chemical composition of rain, composition of infiltrating surface water, properties of soil and rock in which the groundwater moves. It varies as per duration of contact time and contact surface between groundwater and geological material along its flow path, rate of geochemical (oxidation/reduction ion exchange, dissolution, evaporation, precipitation) process and microbiological process.

Hydrochemistry is an interdisciplinary science that deals with all these aspects responsible for the chemical composition of the groundwater and as such, it is helpful in knowing about residence time, flow path and aquifer characteristics, as the chemical reactions are time and space dependent. The classical use of chemical characteristics in hydrochemistry is to provide information about the regional distribution of water qualities. At the same time, hydrochemistry has a potential use for tracing the origin and history of water. The hydrochemistry can also be of immense help in yielding information about the environment through which water has circulated.

5.1 Hydrogeochemistry of NCT Delhi

The diverse physiographic, topographic and geologic conditions have given rise to diversified groundwater situations and groundwater quality of NCT of Delhi and it varies with depth and space. It is mainly influenced by local geology and inherent salinity, and uneven development of groundwater.

In alluvial formations, in general, the quality of ground water deteriorates with depth, which is variable in different areas. The fresh ground water aquifers mainly exist up to a depth of 25 to 35 m in North West, West and parts of South west districts and in minor patches in North and Central districts. In South, Southwest & Southwest district, especially in Najafgarh Jheel area the fresh water occurs up to a depth of 30 to 45 m. A localised area located just north of Kamala Nehru Ridge (part of Delhi ridge falling in Central District) covering area of Dhirpur, Wazirabad and Jagatpur are characterized by shallow depth of fresh water aquifers that is in the range of 12 to 28m, regardless of proximity to River Yamuna. In the flood plains of Yamuna, in general, fresh water aquifers exist down to depth of 30-45m and especially in Palla it reaches to the depth of 60 to 75m below which brackish and saline water exists. The ground water is fresh at all depths in the areas around the ridge falling in Central, New Delhi, South and eastern part (Ridge Area) of South-West districts and also in Chattarpur basin. In the areas west of the ridge, in general, the thickness of fresh water aquifers decreases towards North-West, the thickness of fresh water zone is limited in most parts of west and southwest districts.

5.2 Groundwater Quality Monitoring

Monitoring of groundwater quality is an effort to obtain information on chemical quality through representative sampling in different parts of NCT Delhi. Groundwater is commonly tapped from phreatic aquifers through representative dug well / bore wells or hand pump located nearest to the monitoring station. A total number of 62 water samples were collected from NCT of Delhi, as part of groundwater quality monitoring work, during May 2017. List of locations and result of chemical analysis for its basic parameters such as pH, EC, TDS, CO3, HCO3, Cl, NO3, SO4, F, Ca, Mg, TH, is presented in annexure IV. Map showing locations of water sample locations is presented in figure 53.

Figure : 53



The overall results of hydro chemical analysis are attached in Annexure IV whereas distribution of major groundwater quality parameters in NCT of Delhi are described as under.

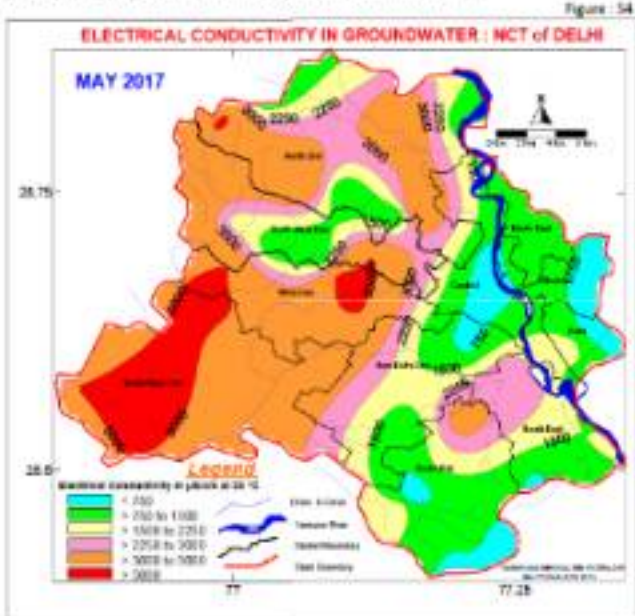
5.2.1. Electrical Conductance

Electrical conductivity represents total number of cations and anions present in groundwater, indicating ionic mobility of different ions, total dissolved solids and saline nature of water. Electrical Conductivity (EC)[7] is a measures of salinity of the groundwater in terms of saltiness, calculated as Micro Siemen / cm at 25°C. Similar expression is Total Dissolved Solid (TDS), a measure of total dissolved salt contents in mg / liter of groundwater. Different substances dissolve in groundwater giving it taste and odour. In fact, human beings have developed senses, which are able to evaluate

the potability of water. In general water having EC < 1500 uS/cm, is considered as fresh water, EC 1500 – 15000 uS/cm is considered as brackish water and EC > 15000 uS/cm is considered as saline water.

Map showing distribution of electrical conductance in groundwater of NCT Delhi is presented in figure 54. Most of eastern part of NCT Delhi, in areas around Yamuna in district of Central, North East, East, Shahdara, South East & South has EC within permissible range, upto to 2250 µS/cm at 25°C. The area of Najafgarh, Singhola, Bakhra and some portions of south Delhi are showing exceptionally high EC Values, even in shallower depth. It is also observed that deeper aquifer water have greater EC value than the shallow aquifer, value increases with increase in depth. The major part of the area underlain by Delhi quartzite ridge have EC values in range of 400 µs/cm to 2000 µs/cm.

Figure : 54



It is observed that nearly 41 % areas of New Delhi falling in North, North West, West and South West districts show EC more than 3000 µS/cm at 25°C whereas rest 59 % area has EC in range from 0 to 3000 µS/cm at 25°C. Nearly 6 % (85 sqkm) areas of North East, South East, Central & South district has EC of 0 to 750 µS/cm at 25°C (Figure 55).



5.2.2. Chloride

Chloride is present in all natural waters being highly soluble and moves freely through soil and rock. In groundwater Chloride content is mostly below 250 mg/l except in cases where aland salinity is prevalent. BIS have recommended a desirable limit of 250mg/l of chloride in drinking water; this concentration limit can be extended to 1000 mg/l of chloride in cases where no alternative source of water with desired concentration is available. The map showing distribution of Chloride in NCT Delhi is presented in Figure 56.

Figure : 56



It is observed major part of NCT Delhi, is areas having EC with in permissible limits, up to 2250 to 3000 µS/cm, has chloride also within permissible limit of 250 mg/l. In areas having high EC more than 3000 µS/cm, chloride value is more than 1000 mg /l to high up to 3000 mg /l (figure 56).

5.2.3. Nitrate

Nitrate is a naturally occurring compound that is formed in the soil when nitrogen and oxygen combine. The primary source of all nitrates is atmospheric nitrogen gas. This is converted into organic nitrogen by some plants by a process called nitrogen fixation. Dissolved nitrogen in the form of nitrate is the most common contaminant of groundwater. Nitrate in groundwater generally originates from non point sources such as leaching of chemical fertilizers and animal manure, groundwater pollution from septic and sewage discharges etc. It is difficult to identify the natural and man-made sources of nitrogen contamination of ground water. Some chemical and microbiological processes

such as nitrification and denitrification also influence the nitrate concentration in ground water. As per the BIS standard for drinking water the maximum desirable limit of nitrate concentration in groundwater is 45 mg/l. Though nitrate is considered relatively non-toxic, a high nitrate concentration in drinking water is an environmental health concern arising from increased risks of methaemoglobinemia particularly to infants.

Figure : 57



The map (figure 57) shows NHS having nitrates in ground water of Delhi, as point source of pollution, within permissible and beyond permissible limit of 45 mg / ltr.

5.2.4. Fluoride

Fluorine is a fairly common element but it does not occur in the elemental state in nature because of its high reactivity. Fluorine is the most electronegative and reactive of all elements that occur naturally within many type of rocks. Most of the fluoride found in groundwater is naturally occurring from the breakdown of rocks and soils or weathering and deposition of atmospheric particles. Most of the fluorides are sparingly soluble and are present in groundwater in small amount. The map showing distribution of Fluoride in NCT Delhi is presented in figure 58.

It is well known that small amount of fluoride (>1.0 mg/l) have proven to be beneficial in reducing tooth decay. Community water supplies commonly are treated with sodium fluoride or fluorosilicates to maintain fluoride level ranging from 0.8 to 1.2 mg/l to reduce the incidents of dental carries. However, high concentrations (>1.5mg/l) have resulted in staining of tooth enamel while at still

higher levels of fluoride (> 3.0 mg/l) further critical problems such as stiffness of bones. BIS has recommended an upper desirable limit of 1.0 mg/l of fluoride concentration in drinking water, which can be extended to 1.5 mg/l in case no alternative source of drinking water is available. Water having fluoride concentration more than 1.5mg/l is not suitable for drinking purposes.

Figure : 56



The map (figure 56) shows NHS locations having fluoride in ground water of Delhi, within permissible limits & beyond permissible limit of 1.5 mg / liter.

ANNEXURE : I A LIST OF CENSUS TOWNS – NCT OF DELHI

[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

ANNEXURE : I B LIST OF VILLAGES – NCT OF DELHI





ANNEXURE : II RAINFALL DATA & PROBABILITY ANALYSIS

Rainfall, Departure and Cumulative Departure & Occurrence of Drought - NCT of Delhi

Year	Rainfall (mm)	Departure	Cumulative Departure	Type of Drought
1984	579.2	-0.34	0.14	Mild
1985	773.4	0.33	0.02	
1986	646.4	-0.19	-0.02	Normal
1987	454.2	-0.51	-0.07	Normal
1988	1035.2	0.79	-0.14	
1989	463.6	-0.55	-0.68	Severe
1990	884.1	0.39	-0.45	
1991	614.7	0.08	-0.17	Mild
1992	581.8	-0.04	-0.62	Mild
1993	861.4	0.29	0.12	
1994	784.6	0.17	0.15	
1995	827.8	0.24	0.08	
1996	778.8	0.46	0.54	
1997	627.4	0.08	0.46	Mild
1998	803.1	0.27	0.73	
1999	644.1	0.33	0.33	Mild
2000	808.8	0.21	0.75	
2001	646.4	-0.04	0.72	Mild
2002	459.3	-0.31	0.40	Normal
2003	825.9	0.38	0.79	
2004	591.5	-0.21	0.58	Mild
2005	664.4	-0.10	0.48	Mild
2006	618.7	-0.08	0.40	Mild
2007	689.8	-0.02	0.38	Mild
2008	863.8	0.27	0.66	
2009	805.6	0.21	0.44	Mild
2010	871.9	0.40	0.87	
2011	765.8	0.23	0.65	Mild
2012	598.4	-0.16	0.49	Mild
2013	788.8	0.06	0.75	
2014	648.4	-0.04	0.41	Normal
2015	847.8	0.28	0.72	Mild
2016	806.1	0.02	0.20	Mild
2017	644.7	-0.09	0.00	Mild

Rank	Probability in %	Arrange in decreasing order
1	3.03	1035.2
2	5.09	934.6
3	8.08	861.9
4	11.08	825.9
5	14.07	861.4
6	17.07	853.3
7	20.06	852.8
8	23.05	827.6
9	26.05	808.0
10	29.04	803.6
11	32.04	784.6
12	35.03	771.6
13	38.03	708.9
14	41.02	661.8
15	44.01	656.1
16	47.01	646.2
17	50.00	641.6
18	52.99	618.7
19	55.99	617.4
20	58.98	614.7
21	61.98	603.3
22	64.97	595.6
23	67.96	588.0
24	70.96	579.2
25	73.95	559.4
26	76.95	547.5
27	79.84	541.2
28	82.93	531.7
29	85.93	531.5
30	88.92	499.5
31	91.92	485.4
32	94.91	440.4
33	97.90	408.2
34	100.90	303.6

ANNEXURE : IIA WATER LEVEL MONITORING DATA : (2017-18)

List of NHS / Monitoring Wells monitored during 2017-18 : NCT of Delhi

List of NMS / Monitoring Wells monitored during 2017-18 : NCT of Delhi

ANNEXURE : IIB - DECADAL MEAN WATER LEVEL DATA

List of NHS / Monitoring Wells monitored during 2017-18 and Decadal Mean

	Decadal Mean Water Level in mbgl			
SITE_NAME	DMW2007_3(Mar	DMW2007_4(Aug	DMW2007_4(Nov	DMW2008_1(Jan
Asola Pz	50.84	48.46	47.54	48.18
Aychandi Pz	3.41	3.66	3.8	2.62
Bakoli :- Shallow Pz	9.71	10.45	9.28	9.14
Bakoli :- Deep Pz	9.39	10.66	9.56	9.29
Balbir Nagar	19.94	19.39	17.44	20.75
Balwan Lake	2.17	3.56	1.46	1.59
Bankner Pz			17.13	
Begumpur Dw	4.48	3.12	3.04	3.27
Bemnala Pz	6.06	5.68		
Bemnala Dw New	6.57			
BHNR Nanak Pz	16.91			
Bhatti Pz	47.17	44.07	44.29	43.8
Bibi ka mandir	10.99	7.44		8
Burarai-Pz		3.12	3.03	3.54
Burari Augar Pz	3.96			
Chd Shahdara Pz		8.77	9.08	
Chowla	15.16	13.84	13.87	14.05
Chilla Regulator	8.44	8.11	7.87	7.96
Chillasarai Pz	6.9	6.95		
CVO Depot Cant (Dp)	30.78	29.93	29.98	30.41
Daryapur Khurd			5.96	4.92
Daulatpur Pz	17.24	16.14	16.29	17.09
Delhi College of Engineering		5.26	5	5.31
Deoraia Pz	2.51	1.46	1.63	1.71
Dwarka Sec-16 (Tpl)	16.66	16.77	17.38	17
Garhi pur Pz	55.62	54.74	54.67	55.53
Ghazipur Crossing Pz	16.91	17.96	17.07	16.85
Gokalpuri II Pz	7.78			
Gokalpuri W Pz	7.64			
Haiderpur Pz	10.09	9.98	9.76	9.7
Harnoli Dw	4.62	3.79	3.68	3.46
Hauz Khas Pz	35.3	35.24	35.06	34.97
Hiran Kudna Dw	2.99	2.08	2.32	2.72
Humayun Tomb	6.68	6.05	6.01	6.16
India gate	6.97	5.77	6.08	
ISBT (Kashmiri Gate) Dw	3.1	3.76	2.57	2.74
Issapur Khera Pz	10.99	10.94	10.24	
Jagatpur Pz-1	2.69	1.77	2.07	2.13
Jagatpur Pz-2	2.33	1.87	1.58	1.71
Jafrpur Khadar RD-2000	4.86	3.98	4.44	4.99
Jafrpur Khadar RD-9000	5.77	4.69		5.84
Jamal i Kamali	39.98	37.98	38.03	38.06
Janakpuri Pz	11.33	10.88	10.69	11.07
Jaunapur DW	52.91	52.58	52.7	53.22
Jaunti Dw	12.91	12.56	12.3	12.95
Jharoda Kalan Pz	15.46	14.9	14.7	14.95
Jhuzi Khali	30.1	30.23	31.09	30.13
Jui Jhul Dw	2.61	1.29	2.25	2.32
JNU Pz-15 Upstream	14.91	12.77	13.24	13.61

List of RMS / Monitoring Wells monitored during 2015-16 and Decadal Mean

(NU Pz-1 (D) Desertstream	38.79	37.75	37.25	37.1
Kabuli Line Pz	25.68	26.09	25.93	26.23
Kanchanvihar (pz)	2.39		1.24	1.48
Kingsway Camp Police Ground Pz	6.22	5.78	5.93	6.53
Kitchener road	18.61	17.09		
Lodhi Garden (D)	9.48	8.86	8.64	8.44
Lodhi Garden (SH)	9.4	8.98	8.43	8.4
Lodhi Garden Dw	12.4	12.71	11.9	11.51
Madan pur Khadar	4.68	3.68	4.03	4.63
Mahabir Nagar	25.62		25.64	25.53
Malaria Ka Tila Dw	6.67	7.06		8
Mayapuri Dubai		2.56	2.94	3.23
Mandela Kharal Pz	13.88	14.21	12.85	13.57
Mangolpuri Pz		3.29		3.82
Mayapuri Pz	14.15	14.59	14.3	14.01
Mayur Vihar B Block	6.43		6.55	6.55
Nagali Nasirpur Pz		2.12	2.82	3.03
Najafgarh Town	18.87	19.31	18.89	18.75
Nehru Park Dw	21.07			
Nizampur	8.62	7.51	7.36	7.75
Nizamuddin Bridge 1	4.5	3.38	3.47	
Nizamuddin Bridge 2	4.35	3.13	3.23	
Okhala Pz	16.82	16.33	15	16.14
Palam Signal Camp		14.99	14.55	
Palla Temple	6.85	6.01	6.25	6.42
Palla Zero RD	8.18	8.32	7.79	7.95
Peera Garhi Dw	7.14	8.43	8.52	8.69
Peera Garhi Pz	5.63	8.02	4.75	4.98
PUSA (MB)	19.23	19.4	19.39	19.68
PUSA (WSC)	18.4	18.35	19.08	
PUSA Inchapuri Sale	21.68	21.88		
Punjabi Bagh Pz	63.92	64.04	64.49	63.71
Rajghat Pz				1.55
Rani Kheda	3.28	2.35	2.44	2.94
Rasela	2.8	3.58	2.74	2.24
Rohini Sec-20	5.02	4.75	4.38	4.62
Rohini Sector - 13	6.12	5.55	5.46	5.43
Safdarjung tomb	18.47	15.29	15.05	14.61
Sainik Vihar Pz	2.29	1.94	1.72	
Shahdara Line Pz	19.07	19.25		19.14
Shiram Shakti Bhawan 1	14.71	13.61	13.48	
Shiram Shakti Bhawan 2				13.75
Shiram Shakti Bhawan 3	15.26	14.75	14.49	
Shivanjur Bangi	14.78	13.35	12.6	12.95
Shivanjur Dwelling	12.55	12.3	11.88	11.95
Singhola Pz	13.66	13.63	13.62	13.16
Sultanpur RMS	51.37	51.25	51.62	52.19
Sundar Nursery Pz	7.99	7.49	7.3	7.1
Tagore Garden Pz	9.76	9.25		9.53
Tiggipur Deep Pz	7.75	8.03	7.65	7.67

List of NMS / Monitoring Wells monitored during 2015-16 and Decadal Mean

Tajpur Shallow Pz	7.45	7.18	7.09	6.81
Tikri Kalan Pz	8.44	7.75		
Tilangpur Kotla Dw	6.44	5.62		
Udaipur pz	4.39	3.6		3.39
Wazirpur Pz	12.93	12.73	13.07	12.56

ANNEXURE : IV LIST GROUNDWATER SAMPLES & CHEMICAL ANALYSIS : MAY 2017

Sr No.	Location	ec	CO_3	HCO_3	Cl^-	SO_4	NO_3^-	F^-	PO_4	Ca^{++}	Mg^{++}	Na	K	SiO_2	TH as $CaCO_3$
1	Akshardham temple	1831	0	232	351	300	4.4	0.05	<0.10	105	59	227	7	19	505
2	Asola	658	0	244	71	90	18	0.32	<0.10	61	20	81	3.8	38	233
3	Auchandi	5826	0	695	333	1898	5.68	1.30	<0.10	88	139	1200	11	15	790
4	Bakoli	4665	0	341	1031	830	0.2	0.8	<0.10	213	191	589	10	22	1317
5	Balbir nagar	316	0	195	20	35	5.0	0.10	<0.10	55	13	22	1.4	26	182
6	Bakswa lake	6385	0	390	1595	672	3.81	0.82	<0.10	240	165	1091	20	22	1381
7	Bapraula	4750	0	659	990	416	75	2.06	<0.10	93	150	725	10	23	849
8	Barwala	7345	0	195	1262	722	110	0.56	<0.10	769	306	421	7.8	22	3183
9	BBMB Narela	1925	0	341	281	292	30	0.85	<0.10	120	78	174	8.6	22	620
10	Bhatti mines	910	0	451	68	30	13	0.30	<0.10	101	32	87	1.2	30	384
11	Birla mandir	751	0	232	84	85	4.1	0.44	<0.10	74	22	50	4.9	18	275
12	Buvari	1781	0	317	203	200	112	0.05	<0.10	145	34	155	11	15	505
13	Chilla regulator	886	0	342	139	19	1.1	0.13	<0.10	73	39	54	7.2	20	344
14	Chilla saroda	2110	0	378	295	501	0.2	0.29	<0.10	73	54	384	11	19	624
15	Gadaipur	118	0	500	66	16	59	0.44	<0.10	57	29	139	3.8	35	263
16	Gazipur crossing	185	0	89	6.9	40	2.8	0.05	<0.10	28	7.4	0	0.8	5.8	91
17	Haiderpur	430	0	232	14	40	0.69	0.98	<0.10	53	26	7.33	3.09	16	240
18	Harevli	2770	0	427	435	452	42	0.82	<0.10	100	129	335	10	20	741
19	Hauz khas	3790	0	293	615	760	298	0.44	<0.10	253	147	592	2.5	29	1313
20	Hiranbustie	30500	0	317	10564	2288	90	1.41	<0.10	860	1604	4310	25	22	8250
21	Humayun tomb	2730	0	756	316	272	74	1.25	<0.10	45	42	390	221	19	285
22	I.S.B.T	245	0	73	14	46	1.9	0.05	<0.10	28	9.8	8.6	2.5	5.9	111
23	India gate	980	0	195	139	86	121	0.52	2.15	65	30	98	18	16	285
24	Jaspur khera	7591	0	537	1023	260	498	1.15	<0.10	156	285	960	59	20	1561
25	Jagatpur-2	1305	0	305	140	268	1.9	0.05	<0.10	85	44	168	4.6	14	384

Sr No.	Location	ec	CO_3	HCO_3	Cl^-	SO_4	NO_3^-	F^-	PO_4	Ca^{++}	Mg^{++}	Na	K	SiO_2	TH as $CaCO_3$
26	Jahpur RD 2600	1532	0	390	213	130	19	0.52	<0.10	88	46	160	16	14	410
27	Jahpur RD list	1505	0	402	206	144	2.61	0.48	<0.10	100	39	165	7.9	23	410
28	Jamali kamali	1716	0	647	167	180	32	3.36	<0.10	61	37	300	7.6	29	303
29	Jaunapur	1824	0	537	281	94	28	0.73	<0.10	78	50	254	8.3	31	398
30	Jautni	4480	0	879	449	660	415	1.10	<0.10	40	79	270	1678	15	420
31	Jharoda kalan	5484	0	403	1858	240	58	1.15	0.116	234	189	733	15	26	1364
32	JNU Campus	721	0	342	86	56	16	0.53	<0.10	61	37	61	1.4	32	313
33	JNU South	776	0	366	86	72	16	0.56	<0.10	77	32	60	1.4	32	123
34	Kanjhawala	1868	0	909	77	100	15	23	<0.10	12	4.98	440	3.5	12	51
35	Katkupur	477	0	305	14	0	1.4	0.54	<0.10	36	24	39	2.03	15	190
36	Madanpur khadar	1548	0	464	213	150	85	0.46	<0.10	109	56	181	10	18	505
37	Mahatri Vansthali	1117	0	280	196	60	6.78	0.68	<0.10	78	25	130	2.4	23	296
38	Majnu ka tilla	890	0	110	49	42	6.3	0.24	<0.10	32	15	10	3.3	7.1	142
39	Majwalshan	3785	0	927	886	825	62	16	<0.10	56	32	903	23	14	270
40	Mangolpuri	613	0	281	42	46	0.88	0.05	<0.10	53	27	44	1.7	15	243
41	Mayur vihar ph-I	1446	0	427	246	45	58	0.38	<0.10	109	37	163	13	18	424
42	Mubarakpur Okhas	810	0	305	49	62	4.62	7.80	<0.10	48	15	90	4.24	15	230
43	Najafgarh	4680	0	427	1298	102	85	1.30	<0.10	184	203	475	29	22	1290
44	Nehru park	641	0	85	91	120	0.61	0.30	<0.10	37	17	75	3.4	6.23	161
45	Nizamuddin bridge 1	1478	0	403	223	140	26	0.17	<0.10	109	34	174	17	18	414
46	Nizamuddin bridge 2	1814	0	342	407	60	7.9	0.03	<0.10	137	39	194	4.5	15	505
47	Ojwah	2468	0	671	428	90	55	1.25	<0.10	61	51	423	10	21	367
48	Palla (zero Rd)	1853	0	353	237	318	2.85	0.05	<0.10	92	61	219	6.85	19	480
49	Peera garhi	5300	0	415	1299	466	7.0	1.59	<0.10	142	195	587	17	4	1374
50	PUSA (NRL)	1972	0	439	393	78	34	0.78	<0.10	110	69	210	1.4	25	661

Sr No	Location	ec	CO_3	HCO_3	Cl^-	SO_4	NO_3^-	F^-	PO_4	Ca^{++}	Mg^{++}	Na	K	SiO_2	TH as $CaCO_3$
51	PUSA (WTC)	1910	0	293	491	42	25	0.56	<0.10	143	37	225	2.6	28	530
52	Pusha vihar	2465	0	344	425	52	460	0.88	<0.10	272	54	160	3.5	30	901
53	Ranta	9800	0	525	2808	442	36	1.36	<0.10	128	175	1760	10	22	1043
54	Rohini sec-28	674	0	220	84	72	5.24	2.15	<0.10	32	27	41	6.7	13	214
55	Sainik vihar	15040	0	305	4724	872	35	0.90	<0.10	433	365	2400	26	22	2583
56	Sathori	967	0	476	60	0	22	0.75	<0.10	20	56	135	2.1	29	200
57	Sunder nursery	2125	0	561	281	195	126	1.01	<0.10	82	55	337	5	28	428
58	Surhinta	8442	0	427	1546	2550	83	2.75	<0.10	357	377	1300	24	20	2442
59	Tagore garden	12100	0	354	470	5730	28	0.52	<0.10	327	437	1988	12	23	2618
60	Tigalpur	923	0	293	88	102	0.2	0.70	<0.10	96	17	82	4.43	22	310
61	Usmanpur	1128	0	390	120	118	3.1	0.05	<0.10	113	44	56	31	18	465
62	Wazirabad	1412	0	451	190	142	1.4	0.05	<0.10	93	51	152	13	17	445

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Annexure – V
Seismic Study

SMEC India
Member of the Surbana Jurong Group

Preparation of Detailed Project Report Including Pre-Construction Activities for Construction of a Road Tunnel For NH-148AE with its Approach and Connection to NH-248BB and Existing Delhi Internal Roads in the State of Delhi

GEOLOGICAL & GEOTECHNICAL INTERPRETIVE REPORT

June 2022



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1 INTRODUCTION

The project consist of construction of a road tunnel for NH-148AE with its approach and connection to NH-248BB in the NCT, Delhi. The proposed project road is a green field alignment and takes off from proposed interchange at Shivmurti and terminates at Nelson Mandela Marg. The proposed length of the project is 9.0km, out of which tunnel length is 4.2km and rest of the stretch is an open /surface highway. The proposed tunnel is located between Rajokari and Vasant Kunj area of Delhi with its North-West portal in the vicinity of National Highway 48 at Shivmurti and the another portal (North) is proposed at Nelson Mandela Marg. The purpose of the tunnel is to connect NH-148AE with NH-248BB to avoid traffic congestion in Rangpuri and Mahipalpur area.

2 OBJECTIVE AND SCOPE

This report describes interpretations of the observations and data obtained during the Geological surface mapping of the tunnel alignment and data obtained from geotechnical investigations. Surface geological mapping has been carried out in the ridge area along the tunnel alignment with a length of 1.5km and width of 200m. Mapping has been carried out using local measurements and systematic measurements with scanline survey at various available outcrops. Site investigation comprising exploratory drilling and field and laboratory tests have been proposed to determine the engineering properties rock and soil.

The primary work carried out included:

- Geological Mapping in the vicinity of the tunnel alignment
- Collection of Discontinuity Data (local measurements and scanlines)
- Borehole Drilling and Core Sampling
- Borehole Testing including
  - Standard Penetration Test (SPT)
  - Permeability Testing
  - Pressure-meter Testing
- Laboratory Testing (Soil)
  - Index properties (including Atterberg's limit and PSD)
  - Shear Strength test (both drained and undrained)
  - Young's Modulus Test
  - Consolidation Test
  - Permeability Test
- Laboratory Testing (Rock)
  - Unconfined Compressive Strength
  - Tensile Strength

- Triaxial Test
- Young's Modulus Test
- Abrasivity test

3 REGIONAL GEOLOGY

3.1 GEOMORPHOLOGY

Delhi area mainly represents a mature topography with vast flat to undulating plains, low linear ridges and isolated hillocks. The flat portions forming part of the Indo-Gangetic plains are occupied by quaternary sediments, while the ridge comprises hard rocks. The strikingly conspicuous NNE-SSW trending Aravalli-Delhi Ridge occur in the south-eastern part where it enters the state from Haryana extending over a strike length of about 30km and width of 15km upto Wazirabad. Thereafter, it peters out as scattered isolated hillocks jutting out of alluvial plains.

The general level of plains varies between 198m and 220m above m.s.l., with the ridge rising 40-45m above the adjacent alluvial tract. On the eastern side of the ridge, moderately undulating topography has a gradient of about 3.5m/km towards Yamuna River while on the western side generally flat terrain is dotted with isolated hillocks, sand dunes and has a general slope towards west.

Yamuna River is the major natural drainage in the area, which follows a straight to slightly sinuous course in this reach. It enters Delhi along its north-eastern boundary and flows southward upto Okhla from where it takes an easterly turn and flows south-easterly to leave the state near village Madanpur Khadar/Kalindi Kunj in the south. The river has an average gradient of 1:6000 from north to south. Besides Yamuna, Najafgarh and Mungeshpur nala, part of Sahibi Basin drains the south and south-western part of the area. Minor nalas originating from the eastern flank of the Delhi Ridge drain into Yamuna River whereas those from the western slopes of the ridge drain into a depression called Najafgarh *jhil*. The overflow from the *jhil* drains out through Najafgarh drain, which flows northeasterly before joining Yamuna River near Wajirabad. The ridge acts as the watershed divide for the eastern and western alluvial plains. A few natural paleo-channel scars have been manually canalised which drain out into Yamuna River.

3.2 REGIONAL GEOLOGY

The area is predominantly occupied by Quaternary sediments of Late Pleistocene to Holocene age with NNE-SSW trending linear ridges and mounds which standout as predominant feature in the midst of flattish landscape. NE to NNE trending Aravalli Range extends northwards up to Delhi and forms a rocky table land; designated as Delhi Ridge in the area. The tunnel location is situated in the Delhi Ridge of the Aravalli range in National Capital Territory of Delhi. The ridge occupies the south central part of Delhi extends up to western bank of Yamuna River. In the south central part, near mahipalpur the Ridge gets bifurcated, one arm extending towards Mandi and further south, while the other arm takes a turn towards southeast up to Tughlakabad-Greater Kailash-Nehru Place.

The rock formations exposed in the Delhi area are mainly quartzites of the Delhi Supergroup that are interbedded with thin micaceous schist bands. Srivastava et al. (1980) grouped these rocks of Delhi area as the Alwar formation of Delhi Super group while, Kachroo, and Bagchi (1999) have classified these rocks as part of the Barkhol formation of the Ajabgarh Group of the Delhi Supergroup (**Figure 1**). These rocks are intruded by pegmatites and quartz veins which can be seen in southern and central parts of Delhi and also as isolated outcrops. The generalized sequence of Delhi Supergroup is given in the **Table 1**.

The rock formation exposed in the project area are quartzites belongs to Barkol formation of Ajabgarh group of Delhi supergroup having thin interbeds of micaceous schist.

Table 1: Generalised Stratigraphic Succession of Delhi Supergroup

Group	Formation	Lithology
Ajabgarh Group	Aravli Formation	Quartzite interlayered with staurolite-garnet schist, slate, etc.
	Barkhol Formation	Quartzite with interlayered carbonaceous phyllite
	Thana-Ghazi formation	Carbonaceous phyllite Marble
	Soniaka Formation	Brecciated quartzite and ferruginous quartzite
	Kushalgarh Formation	Impure marble
Alwar Group	Pratapgarh formation	Massive quartzite with minor schist and marble
	Kankarwahi formation	Schist (sericite, biotite, garnet, and andalusite bearing) with quartzites and conglomerate.
	Rajgarh formation	Quartzite, marble, gritty quartzite, conglomerate and pebbly quartzite.

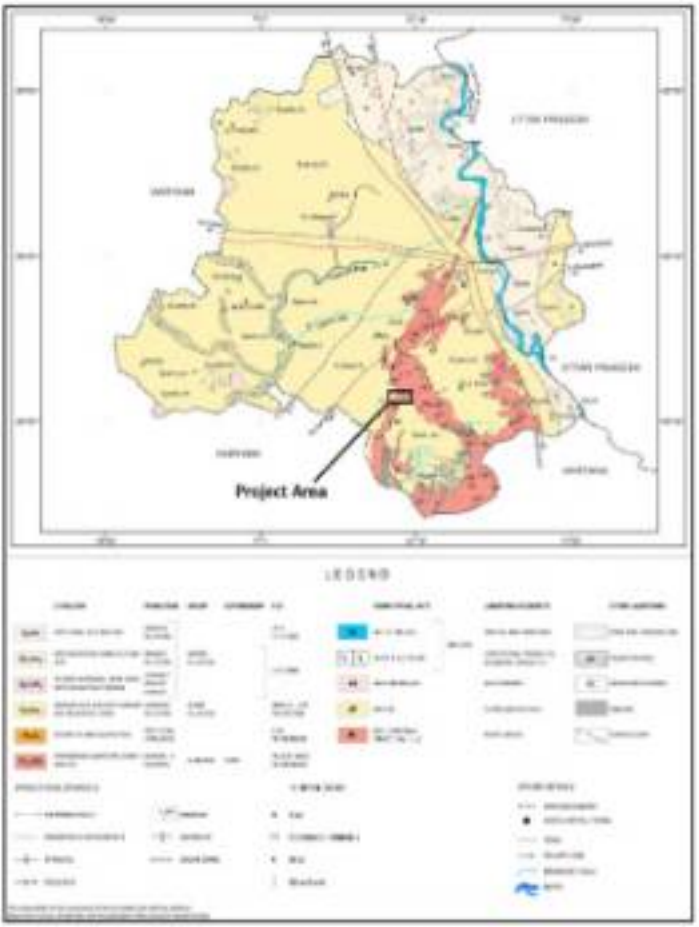


Figure 1: Geological Map of NCT, Delhi (GSI)

The quartzite with mica schist and garnet-staurolite schist exposed in the NCT area has been classified under the Bhankhol Formation, Ajabgarh Group of Delhi Supergroup (Kachroo and Bagchi, 1999). Project area falls under Ajabgarh Group of Delhi Supergroup.

The generalized stratigraphy of NCT Delhi is given in (**Table 1**).

Table 2: Generalised Stratigraphy of NCT, Delhi

Age	Geological Unit		Lithology
Holocene	Newer Alluvium	Channel Alluvium	Grey very fine to medium micaceous sand, silt-clay
		Terrace Alluvium	Grey to buff, very fine to fine and medium micaceous sand, silt-clay with kankar at places
	Aeolian Sediments		Brown very fine sand
Middle to Upper Pleistocene	Older Alluvium		Brown silt-clay with or without kankar, very fine micaceous sand, kankar beds
----------Disconformity----------			
	Post Delhi intrusive		Pegmatite and Quartz veins
Proterozoic	Delhi Supergroup	Ajabgarh Group	Quartzite inter-layered with minor schist bands

3.3 MAJOR STRUCTURES IN THE AREA

The Delhi region occupies an area between latitude 28°24' to 28°53' N and longitude 76°50' to 77°20' E. The terrain of Delhi is flat in general except for a low NNE-SSW trending ridge which is considered an extension of the Aravalli hill ranges of Rajasthan. The seismicity in this region may be associated with the Delhi-Hardwar Ridge which constitutes an important tectonic block between 28°-30° N and 76°-79° E with a NE-SW trend. It coincides with the extension of the Aravalli Mountain belt beneath the alluvial plains of the Ganga basin to the northeast of Delhi towards the Himalayan Mountains.

This region is encompassed by several dominant features such as the Himalayan Main Boundary Thrust (MBT) and Main Central Thrust (MCT), the Delhi-Hardwar ridge, the Delhi-Lahora ridge, the Aravalli-Delhi fold, the Sohna fault, the Mathura Fault, the Rajasthan Great Boundary Fault and the Moradabad fault in addition to several other minor lineaments. Major structural features present around Delhi region is given in the Figure 2.

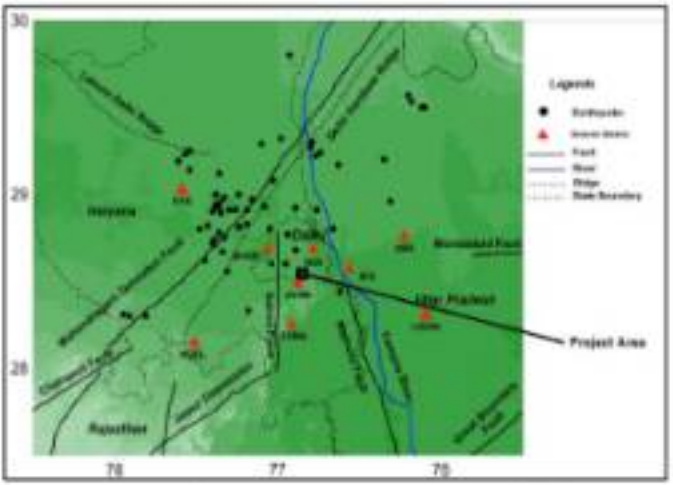


Figure 2: Major Structural Features present around Delhi Region.

3.4 SOHNA FAULT

Among all the structural features, Sohna fault is of great importance due to near vicinity of tunnel area and seismic activity recorded in past years along the fault which contributes maximum PGA values in the Delhi NCR region. Sohna fault zone runs in N-S direction from Sohna to the west of Delhi, has been mapped by the Geological Survey of India. The Sohna fault is associated with geothermal activity witnessed by presence of a hot spring along the fault at Sohna. The fault zone is identified as the seismogenic source for the NCR region having the capability of producing an earthquake of magnitude M≥ 6.0 and is also active since it has been shocked by many earthquakes from past to date.

The geo-seismological studies carried by GSI in Delhi have revealed maximum concentration of epicentres along the Sohna fault. The earthquake of 15th July 1720 has been described by Oldham as a dreadful earthquake in which walls of the fortress and many houses in Delhi were destroyed. It was followed by 4 to 5 aftershocks per day for 40 days and occasional shocks for 4 to 5 months. The likely magnitude for this earthquake, based on macro-seismic data has been assigned by IMD as 6.5. Since 1720 the region has experienced about 68 earthquakes out of which 28 are below magnitude 3. There is only one earthquake in the region with magnitude 6.3. The Delhi/Gurgaon earthquake of 1960 has been considered to be related with it. Studies suggests that the Sonepat-Delhi-Sohna dislocation is responsible for frequent earthquakes in and around Delhi city.

The tunnel is located at aerial distance of around 13-15km from sohna fault. The project area may experience devastating intensities in case of moderate to the major earthquake in the vicinity due to proximity of sohna fault.

3.5 SEISMICITY

Delhi and its surrounding region is known to be seismically active through ages. Small to medium earthquakes are frequently recorded and even possibility of large earthquakes on the area may not be ruled out. The major noted earthquakes were; Mathura earthquake, a violent shock of MMI = IX is reported to have been felt near Mathura on 01.08.1803. A major earthquake took place near Bulandshahar on 10.10.1956. This event was felt over a large area with death and destruction. An earthquake known as Delhi/Gurgaon earthquake of intensity VII occurred on 27.08.1960 near Sohna about 60 Km SE of Delhi. This event inflicted damage to property and about 30 persons were injured. An event of magnitude 4.0 was recorded on 28.07.1994. This was reported to have caused damage to the minarets of Jama Masjid. On 28.02.2001 and 28.04.2001, Delhi experienced two small earthquakes of magnitude 4 and 3.8 respectively, of local origin. Far distance Himalayan earthquakes namely Kangra (04.04.1905) and Uttarkashi (19.10.1991) reportedly shook Delhi to the extent of intensities VI and V respectively. The Chamoli earthquake of 29th March, 1999 was also felt in Delhi with damage to some well-constructed buildings in central and eastern part. The felt intensity of the Chamoli earthquake was VI at Delhi. The Kutch (Bhuj) earthquake (26th January 2001) with devastating effects, was also felt in Delhi.

It is observed from the above discussion that Delhi gets affected by events originating locally as well as those from the Himalayan region. Delhi is expected to be widely affected by Himalayan earthquakes. Thus, the control region around Delhi is inhomogeneous as far as its seismotectonics is concerned. The seismic zoning map of India, IS1893-2002, marks a fairly large region including Delhi to be in zone IV, specifying thereby the peak ground acceleration (PGA) for this region to be 0.24g.

The terrain of Delhi is flat in general except for the NNE-SSW trending ridge. This is one of the prominent features of Delhi and considered as an extension of the Aravalli hill, which is buried under the Yamuna alluvium in the northern parts of Delhi. This region is seismically active and shows sporadic activity aligned in NNE-SSW direction, nearly perpendicular to the Himalayan arc. Proximity of Himalayan region makes Delhi susceptible to the earthquakes from Himalayan seismic sources also. The nearest point from the Main Boundary Thrust (MBT) to Delhi is around 180 km. A large number of fractures and faults are noticed in the Himalayas. This zone is well known for its severe seismic activity. In comparison with this, the Delhi region is seismically less active.

Delhi area is to be active on micro seismic level and in addition to major and moderate events, a series of micro seismic events have been recorded in Delhi and adjoining Sonepat-Gurgaon section. The geoseismological studies carried by GSI in Delhi have revealed maximum concentration of epicentres in N-S trending Sonepat-Sohna fault; west of Delhi, and at the tri junction of Delhi-Haridwar Ridge, Delhi-Lahore ridge and axis of Delhi folding. The fault has concentration of epicentres and hot springs. The Delhi/Gurgaon earthquake of 1960 has been considered to be related with it. Studies suggests that the Sonepat-Delhi-Sohna dislocation is responsible for frequent earthquakes in and around Delhi city.

Delhi and its environs have been placed in the Zone-IV of the Seismic Zone map of India (**Figure 3**) characterised by possible occurrence commonly of magnitude 5-6 and occasionally of 6-7 (IS: 1893-2002). Very occasionally, the shocks of M 7.5-8.0 could occur in this zone along the basement fault. Major earthquakes of magnitude more than 5, recorded in the vicinity of project area is given in **Table 3**.

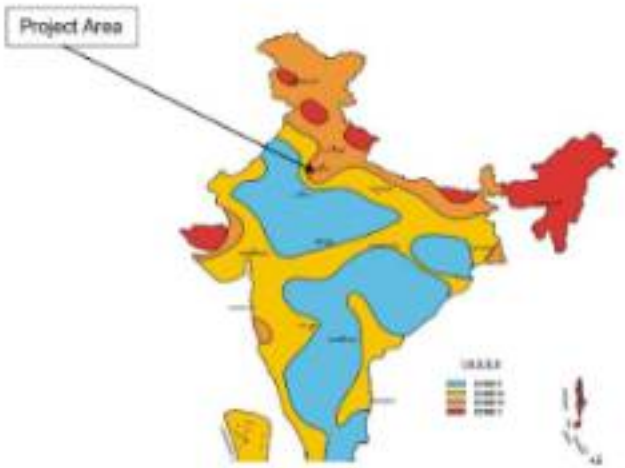


Figure 3: Seismic Zonation Map of India

Seismic hazard micro-zonation mapping of the NCT, Delhi has been carried out by IISI. As per the Seismic hazard micro-zonation map of Delhi (**Figure 4**) the project area falls in the low hazard where the tunnel is passing through the ridge and in high hazard where the tunnel is passing through the alluvium/soil, due to basin effect.



Figure 4: Seismic Hazard Micro-zonation map of NCT, Delhi

Table 3: Major Earthquakes of more than 5 Magnitude in the vicinity of Project Area (USGS Website).

Date	Location	Depth	Magnitude	Mag. Type
11/8/2017	55km NW of Pipalkoti, India	10	5.1	mb
2/8/2017	58km NW of Pipalkoti, India	16.05	5.1	mwb
12/1/2016	17km NNE of Dharchula, India	11.98	5.2	mb
5/5/2012	Haryana - Delhi region, India	10	5.1	mb
2/8/2012	Uttaranchal, India	8.2	5.1	mb
4/4/2011	Nepal-India border region	28.1	5.3	mwb
7/8/2010	Nepal-India border region	32.8	5	mwc
8/22/2010	Nepal-India border region	18.3	5.2	mb
8/28/2010	Himachal Pradesh, India	19.8	5	mb
8/21/2009	Uttaranchal, India	32.8	5	mb
9/4/2008	western Xizang-India border region	10	5	mwc
7/22/2007	Uttaranchal, India	19	5.1	mb
8/8/2006	Nepal-India border region	17.6	5	mb
11/14/2005	Uttaranchal, India	44	5.1	mwc
4/6/1999	Uttaranchal, India	10	5.1	mb
8/30/1999	Uttaranchal, India	10	5.3	mb
9/26/1999	Uttaranchal, India	10	5.4	mb
9/25/1999	Uttaranchal, India	15	6.8	mwb
1/3/1997	Nepal-India border region	33	5.8	mwc
10/19/1991	Uttaranchal, India	10.3	6.6	mwb
9/21/1990	Uttaranchal, India	33	5.1	mb
7/16/1986	Himachal Pradesh, India	33	5.5	mw
8/23/1984	Uttaranchal-Uttar Pradesh border region, ...	33	5.1	mb
3/19/1984	Nepal-India border region	21.4	5	mb
7/29/1980	Nepal	15	6.5	ms
11/22/1979	Uttaranchal, India	33	5	mb
8/20/1979	western Xizang-India border region	33	5.9	ms
9/22/1977	Nepal	33	5	mb
3/5/1976	Punjab-Himachal Pradesh border region, ...	37	5	mb
11/15/1988	Nepal-India border region	20	5.7	mw
8/15/1966	Uttar Pradesh, India	27	5.8	mw
8/27/1966	Nepal-India border region	25	6.3	mw
8/27/1966	Nepal-India border region	25	5.7	mw
8/27/1966	Nepal-India border region	25.9	6	mw
9/26/1964	Nepal-India border region	25	5.9	mw
12/25/1958	Uttaranchal, India	15	6.1	mw

8/4/1945	western Xizang-India border region	15	6.4	mw
8/15/1916	Nepal-India border region	20	7	mw
10/14/1911	western Xizang-India border region	20	6.8	mw

4 GEOLOGY OF THE PROJECT AREA

The tunnel is located in the Quartzites of the Delhi Supergroup that are interbedded with thin micaceous Schist Bands. The area belongs to the Delhi Ridge, which is the extension of the NE-NNE trending Aravali Range. The Delhi ridge is divided into five fragmented zones namely, Northern Ridge, Central Ridge, South Central Ridge, Southern Ridge and Nanakpura South Central Ridge. The tunnel is located in the south central Ridge also called Mehrauli Ridge.

The tunnel area is represented by two distinct landforms i.e. Structural Hills or Rocky surface and Upland Surface. The central part of the tunnel is characterised by rocky surface represents quartzites of Delhi Supergroup. Upland surface comprising Older Alluvium is present in the north-western part of the tunnel. It comprises mainly of polycyclic sequence of sand, silt, clay and kankar. Area lying to the eastern part of the tunnel forms Inland Chhatarpur Basin of Older Alluvium. Chhatarpur Basin comprises of sand and in-situ light yellowish-brown sandy soil derived from the soft parts of weathered quartzite. On the margins quartzite show boulder outcrops with intervening areas covered with residual coarse reddish soil leached from quartzite. The rocky ridge is traversed through the illegal mining pits of depth 8-12m throughout the alignment. Litho-stratigraphic succession of project area is given in the Table 4.

Table 4: Litho-Stratigraphic Succession of the Project Area

Age	Geological Unit		Lithology
Middle to Upper Pleistocene	Older Alluvium		Brown silt-clay with or without kankar, very fine micaceous sand, kankar beds
----------Disconformity----------			
	Post Delhi Intrusive		Pegmatite and Quartz veins
Proterozoic	Delhi Supergroup	Alwargarh Group	Quartzite inter-layered with minor schist bands

The geological mapping has been carried out covering the ridge along the alignment, within scattered illegal mining pits on the ridge. The results of the geological mapping are presented in Drawing 1611-GEO-001 and shown in Figure 5.



Figure 5: Excerpt from the Tunnel area Geological Map.

4.1 LITHOLOGY DESCRIPTION

The lithology within the tunnel section is dominated by light grey to purple quartzites intercalated with minor schist bands and pegmatite veins in the central part and alluvium, characterized by polycyclic sequence of sand, silt, clay and kankar present along western and eastern alignment of the tunnel.

4.1.1 OVERBURDEN

4.1.1.1 ALLUVIUM/SOIL

Older Alluvium is the major Quaternary unit present along the tunnel alignment. It is present in the north western and eastern part of the tunnel, on both sides of the quartzitic ridge.

Older Alluvium (Photo-1) comprises polycyclic, non-rhythmic sequence of sand and silt-clay with or without kankar is present in the initial part of the tunnel. The surface sediments are generally brown in colour and silty-clay in nature. Kankar occurs in the form of nodules and amoeboid shape pieces embedded in silt-clay or very fine sand at different levels.

The eastern part of the tunnel lies in the Inland Chhatarpur basin. The Alluvium is made up of the basin fill material. The depression of the Chhatarpur basin itself is bounded on all sides by Delhi Ridge. This basin surface is slightly undulating and is dotted with the remnants of the surrounding ridge in form of isolated linear detached outcrops of quartzite rising above the surrounding alluvial sediments. The Alluvium present in Chhatarpur basin composed of sand, weathered material and in-situ light yellowish- brown sandy soil derived from the soft parts of the weathered quartzite.



Photo-1: Alluvium/Soil present along the Tunnel Alignment

4.1.2 ROCK TYPES

4.1.2.1 QUARTZITE

The fresh quartzite is massive to jointed light grey to purple coloured with intercalation of quartz-mica schist and muscovite- schist. Quartzite exposed in the tunnel area is hard, compact, massive medium to very coarse grained and strong to very strong. It is bedded, jointed and fractured. The rock is found well exposed in the quarry pits. The rock outcrops are bouldery (**Photo-2**) in nature due to weathering along the profusely developed joints which are rectangular in distribution. Weathering along these joints leads to spheroidal weathering. Leaching of ferruginous material impart a reddish brown colour to the outcrop (**Photo-3**). The intact rock can be classified as generally fresh (**Photo-4**) to rarely discoloured and decomposed, the latter are typically confined to volumes adjacent to discontinuities. Small outcrops of vesicular quartzite (**Photo-5**) are observed in the project area. The vesicles in the quartzites are not superficial and can be traced from surface upto the limits of the beds. Mostly these vesicles are empty. Color banding has also been observed in quartzite (**Photo-6**).



Photo-2: Exposure of Bouldery Outcrop of Quartzites.



Photo-3: Typical Exposure of the Light Grey to Purple Quartzite in the Tunnel Area.



Photo-4: Exposure of the Medium to Coarse Grained Light Grey to Purple Quartzite in the Tunnel Area.



5(a)



5(b)

Photo-5: Examples of Vesicles observed in the Quartzite. 5(a) Vesicles observed on quarry pit in DS-1 Area. 5(b) Vesicles observed in Boulders Outcrops.



Photo-6: Colour Banding observed in the Quartzite.

4.1.2.2 SCHIST

Muscovite-schist and quartz-mica schist are present as thin bands within quartzite. The thickness of schist bands varies from 10-40cm and spacing of these schist bands found between 3-10m. Generally, the frequency of schist bands varies between 10-13 bands per 100m length of the exposure. In general, schist bands are weak to moderately strong and moderately to highly weathered at surface (Photo-7). Weathering is observed to extend quite deep to about 10-15m in some of the exposed bands. Many of the bands are sheared as these have acted as localized planes during tectonic deformations within the interbedded hard quartzites. The sheared schist (Photo-8) are typically associated with higher degrees of weathering and are considerably weaker than non-deformed bands/zone. Schist bands are rarely discernible at the natural ground surface due to their susceptibility for weathering, but, observed in the mining pits. The muscovite schist bands show puckering (Photo-9) and the contact with quartzite is very sharp. The sheared schist bands are characterised by presence of micaceous sand in the vicinity. These schist bands can hardly be traced beyond 20m.



Photo-7: Example of Highly Weathered and Fractured Quartz-Schist Band (20-25cm thick)



Photo-8: Sheared Muscovite Schist Band (15-20cm thick)



9(a)



9(b)

Photo-9: Example of Exposed Schist bands. 9(a) Puckering of the Foliation in Muscovite Schist, 9(b) 15-20cm thick Weathered Muscovite Schist band.

4.1.2.3 **PEGMATITE VEIN**

The quartzites are intruded by a number of pegmatite veins (Photo-10). These are generally intruded along the weak planes, viz. bedding and joint planes of the rocks. All major pegmatite bands in area are covered under the mine dump due to past mining activity. The pegmatites are composed of quartz, mica and feldspar.



Photo-10: Pegmatite Vein (1.2-1.5m thick)

4.1.3 WEATHERING

In general, the depth of weathering from natural ground surface is about 3-4m, but, the iron staining has extended to tens of meters deep in the bedrock, especially along major discontinuities. Leaching of ferruginous material impart a reddish brown colour to the outcrop. Highly weathered rock has been observed in the upper 3-4m depth from natural ground surface (**Photo-11**). Rockmass in these reaches is profusely jointed due to near surface nature, weathering along these joints leads to spheroidal weathering (**Photo-12**) and forms bouldery outcrops. Below 3-4m depth quartzite is generally fresh to slightly weathering at this level is typically limited to discontinuity surfaces in the form of iron staining. Weathering has entered into the matrix of quartzite to a depth of about 1cm to 5cm (**Photo-13a**) and occasionally to about 20-30cm (**Photo-13b**). Local pockets of highly to completely weathered rock, often associated with persistant fracture sets and individual beds are present in the quartzite as shown in (**Photo-14**). A 2-3m (**Photo-14a**) deep local pocket of weathering has been encounter at chainage 1+650m on tunnel alignment and another 3-4m deep (**Photo-14b**) weathering zone has been found near chainage 1+750m, about 50-70m away from the tunnel alignment. Weathering zones of thickness 5-10cm (**Photo-15**) has been encountered frequently along the major discontinuities (Bedding) filled with decomposed and disintegrated rock with a gravelly, sandy to clayey characteristic.



11(a)

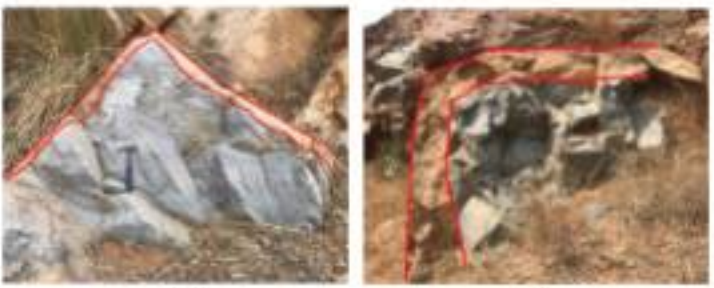


11(b)

Photo-11: Examples of Weathering 3-4m deep from Natural Ground Surface. 11(a) Depth of Weathering 3-4m from Ground Surface in DS-2 Area. 11(b) Depth of Weathering 2-3m from Ground Surface in DS-3 Area



Photo-12: Examples of Spheroidal Weathering along the profusely developed joints



13(a) 13(b)

Photo-13: Examples of Quartzite showing penetration of Weathering into the Matrix along the Surface Exposure. 13(a) Weathering along Discontinuity Surface 1-5cm. 13(b) Weathering along Discontinuity Surface 20-30cm



14(a)



14(b)

Photo-14: Examples of Deep Weathering Pocket in Quartzite exposed in the Mining Pits. 14(a) Deep Weathering at Ch. 14500m on the Tunnel Alignment. 14(b) Deep Weathering at Ch. 14600m, about 80-100m away from Tunnel Alignment.



15(a)



15(b)

Photo-15: Examples of Weathering along Major Discontinuities. 15(a) Weathering along Major Discontinuities in DS-1 Area. 15(b) Weathering along Major Discontinuities in DS-2 Area.

5 HYDROGEOLOGICAL CONDITIONS

The tunnel is passing through the soil/alluvium and quartzitic rocks belong to Delhi ridge. A number of boreholes (40m deep) have been drilled along the tunnel alignment in the soil and in the rock. It has been observed that no groundwater has been encountered in the boreholes. Joints and other discontinuities of the rock are almost closed according to the investigations and as observed from the surface outcrop. This would indicate dry conditions will be expected during excavation of the tunnel. However, presence of perched water table cannot be ruled out. Minor inflow may be expected in the rocky reaches during monsoon season.

6 FIELD AND LABORATORY TESTS

6.1 LABORATORY TESTS

Laboratory tests were performed to determine the engineering properties of soil and rock samples collected from the boreholes.

6.1.1 SOIL/ALLUVIUM

Laboratory tests were performed on selected soil samples recovered from drilled boreholes as per relevant Indian Standards. All the soil samples were identified and classified as per IS: 1498.

6.1.1.1 GRAIN SIZE DISTRIBUTION ANALYSIS

Particle size distribution or grain size analysis is carried out to classify the soil as per IS: 2720 (Part IV). Borehole soil samples are oven dried and pulverized. The sample is sieved through standard sieves such as 20mm, 10mm, 4.75mm, 2.0mm, 1.0mm, 600µ, 300µ, 150µ and 75µ. Classification of soil has been done as per IS: 1498. Soil size more than 4.75mm is classified as Gravel, particle size more than 75µ and less than 4.75mm is classified as Sand and particle size less than 75µ is classified as Silt & Clay. A summary of test results is presented in **Table 5**.

Table 5: Summary of grain Size distribution Analysis

S. No.	Borehole No.	Test Depth (m)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)
1	BH-1	5.0	5	30	45	22
2		8.0	2	39	42	17
3		16.0	1	28	50	21
4		24.0	4	34	47	15
5	BH-2	5.0	2	34	53	21
6		12.0	3	36	49	12
7		16.0	5	38	45	12
8		27.0	4	18	55	23
9	BH-3	1.50	5	23	50	22
10		8.0	2	25	46	24
11		16.0	3	23	49	25
12		24.0	2	24	54	20
13	BH-4	5.0	8	37	42	13
14		8.0	3	30	49	18
15		15.0	4	45	41	12

S. No.	Borehole No.	Test Depth (m)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)
16		36.0	5	31	50	14
17	BH-5	2.5	4	37	51	18
18		6.0	3	38	53	19
19		13.0	8	33	45	14
20		36.0	5	18	55	24
21	BH-6	3.0	0	40	46	14
22		13.0	0	18	54	27
23		21.0	0	34	54	33
24		33.0	13	10	58	30
25	BH-7	4.5	1	34	45	17
26		12.0	1	40	44	15
27		24.0	5	30	44	30
28		30.0	3	18	59	30
29	BH-8	3.0	2	35	45	18
30		9.0	1	15	67	20
31		21.0	3	17	48	32
32		33.0	2	18	58	22
33	BH-24	6.0	45	7	35	13
34		18.0	0	15	65	21
35	BH-25	18.0	10	11	59	20
36		24.0	3	10	67	20
37		33.0	0	8	75	18
38		40.0	0	11	76	13
39	BH-26	6.0	0	14	71	16
40		18.0	0	23	66	11
41		24.0	0	11	76	13
42		33.0	15	17	45	17
43		40.0	1	15	64	20
44	BH-27	18.0	0	8	80	14
45		24.0	28	8	44	24
No. of Test Results			32			
Maximum Value (%)			45	40	80	30
Minimum Value (%)			0	8	35	13

S. No.	Borehole No.	Total Depth (m)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)
Mean			8	22	54	16

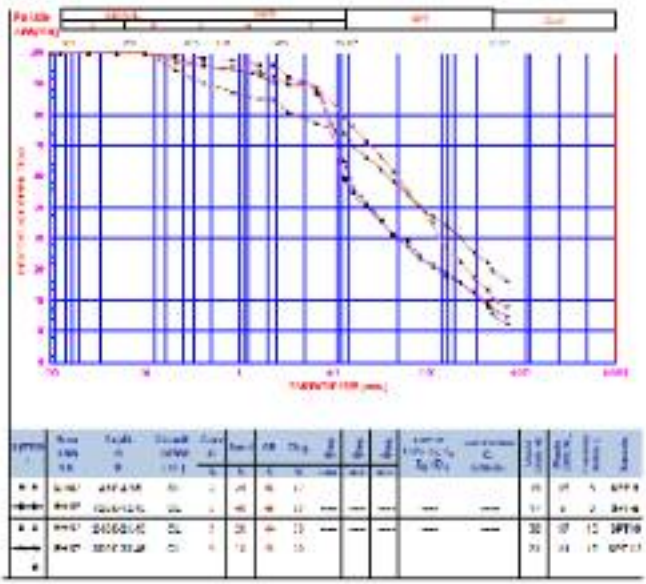


Figure 6: Grain size distribution of soil in BH-7 at different depths

Based on the test results the soil has been classified as sandy clayey silt.

6.1.1.2 INDEX PROPERTIES

Index properties like bulk and dry density, specific gravity and natural moisture content have been determined in laboratory as per IS: 2720. The results of the tests are summarised in the **Table 6**.

6.1.1.2.1 BULK AND DRY DENSITY

Bulk density is calculated from undisturbed samples by determining the weight of soil and the relevant volume IS: 2720 (Part II). A summary of test results is presented in **Table 6**.

6.1.1.2.2 SPECIFIC GRAVITY

This test is performed by density bottle method. Specific gravity of soil is calculated as per IS: 2720 (Part III). A summary of test results is presented in **Table 6**.

6.1.1.2.3 NATURAL MOISTURE CONTENT

This is obtained by simple oven drying procedure, on the SPT disturbed samples as well as undisturbed samples in accordance to IS: 2720 (Part II). A summary of test results is presented in Table 8.

Table 8: Summary of Index properties

S. No.	Borehole No.	Test Depth (m)	Bulk Density (gm/cc)	Dry Density (gm/cc)	Specific Gravity	Natural Moisture Content (%)
1	BH-1	8.0	1.83	1.60	2.69	13.38
2	BH-2	16.0	1.83	1.60	2.70	15.53
3	BH-3	8.0	1.80	1.57	2.67	15.14
4	BH-4	8.0	1.90	1.67	2.66	14.20
5	BH-5	2.5	1.76	1.55	2.69	13.66
6	BH-24	8.0	2.20	1.95	-	13.10
7		16.0	1.76	1.55	-	14.55
8	BH-25	16.0	1.94	1.65	-	15.59
9		24.0	2.0	1.69	-	16.27
10		32.0	1.83	1.69	-	8.53
11		40.0	1.81	1.45	-	15.02
12	BH-26	8.0	1.64	1.42	-	11.56
13		16.0	1.73	1.54	-	12.45
14		24.0	1.48	1.37	-	8.13
15		32.0	1.87	1.58	-	15.43
16		40.0	1.86	1.50	-	15.93
17	BH-27	16.0	2.04	1.78	-	15.66
18		24.0	2.11	1.91	-	10.42
No. of Test Results			18			
Maximum Value			2.20	1.95	2.70	15.93
Minimum Value			1.81	1.45	2.66	8.53
Mean			1.93	1.61	2.68	14.43

The data for bulk density, dry density, specific gravity and moisture content appears realistic, and indicates normal variation for the investigated values. Tests have been carried out on the samples from boreholes BH-1 to BH-5 and BH-24 to BH-27 at depth varies between 2.5 to 40m. Test on the sample from BH-5 has been done on the sample taken from shallow depth, therefore the test values can be discarded from BH-5 and mean of the test values from BH-1 to BH-4 and BH-24 to BH-27 for bulk density, dry density, specific gravity and moisture content i.e. 1.83, 1.61, 2.68 and 14.43 respectively is recommended for design.

6.1.1.3 ATTERBERG'S LIMIT

Liquid limit is the minimum water content at which soil changes from plastic state to liquid state. The purpose of these tests is to evaluate the liquid limit of soil samples and to assess the plasticity characteristics of the finer portion of the soil. Casagrande apparatus is used for Liquid limit test. The test is performed in accordance to IS: 2720 (Part V). Plastic limit is the minimum water content at which soil changes from semi-solid state to plastic state. Plastic limit of the soil is found according to the procedure mentioned in IS: 2720 (Part V). A summary of test results is presented in **Table 7**.

Table 7: Summary of Atterberg's Limit

S. No.	Borehole No.	Test Depth (m)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Free Swell Index (%)
1	BH-1	3.0	21	12	9	15
2		6.0	19	11	8	15
3		16.0	28	17	11	22
4		24.0	28	18	10	20
5	BH-2	3.0	20	10	10	15
6		12.0	16	8	8	10
7		18.0	24	12	12	21
8		27.0	27	14	13	23
9	BH-3	1.5.0	20	10	10	14
10		6.0	22	12	10	19
11		18.0	27	14	13	21
12		24.0	20	11	9	15
13	BH-4	3.0	19	9	10	15
14		6.0	21	10	11	17
15		15.0	17	8	9	10
16		36.0	24	12	12	20
17	BH-5	3.5	20	11	9	15
18		6.0	22	12	10	16
19		15.0	16	9	7	10
20		36.0	24	13	11	18
21	BH-6	3.0	20	10	10	14
22		15.0	22	11	11	17
23		21.0	24	12	12	19
24		33.0	27	14	13	22
25	BH-7	4.5	19	10	9	9.09
26		12.0	17	9	8	10
27		24.0	50	17	15	18.18
28		30.0	21	11	10	16.66
29	BH-8	3.0	18	9	9	9.09
30		9.0	19	8	11	10
31		21.0	33	18	15	20

32		33.0	33	12	11	18.18
33	BH-24	6.0	25	20	5	-
34		16.0	25	21	4	-
35	BH-25	18.0	31	19	12	-
36		24.0	33	21	12	-
37		33.0	27	18	9	-
38		40.0	28	17	11	-
39	BH-26	8.0	29	17	8	-
40		16.0	25	19	8	-
41		24.0	15	15	10	-
42		32.0	28	18	10	-
43		40.0	28	18	12	-
44	BH-27	16.0	27	15	12	-
45		24.0	31	21	11	-
No. of Test Results			45			
Maximum Value (%)			33	21	19	32
Minimum Value (%)			15	9	4	9.09

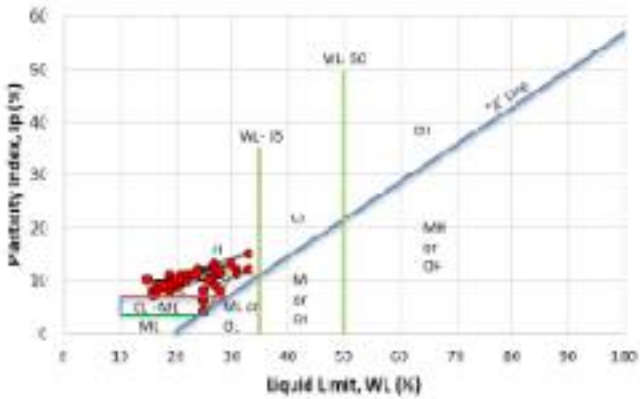


Figure 7: Liquid limit and Plasticity Index values for Soil

Sieve analysis and Atterberg's Limit tests were carried out and its test results are presented in table above. For interpretation, the Atterberg's Limits i.e. Liquid Limit (LL), Plastic Limit (PL), Plasticity Index (PI = (LL - PL) values are reported in Figure 7. Based on grain size distribution and Atterberg's Limit test of soil samples collected from drilled boreholes, the soil in the project area can be classified as Clay with low plasticity.

6.1.1.4 SHEAR PARAMETERS

6.1.1.4.1 DIRECT SHEAR TEST

This test is conducted to obtain the shear strength parameters of cohesive soil. Tests have been conducted on representative undisturbed soil samples collected from the different boreholes along the tunnel alignment. This test was conducted as per IS: 2720 (Part XIII). A summary of test results is presented in Table 8.

Table 8: Summary of Shear Strength parameters

S. No.	BH no.	Depth (m)	No. of Test Results	Shear Strength Parameters	
				C (kg/cm2)	ϕ (°)
1	BH-24	8.0	13	0.8	27
2		16.0		0.7	28
3	BH-25	16.0		0.8	30
4		24.0		0.45	29
5		32.0		0.48	28
6		40.0		0.28	31
7	BH-26	8.0		0.38	30
8		16.0		0.2	31
9		24.0		0.21	31
10		32.0		0.21	30
11		40.0		0.38	29
12	BH-27	16.0		0.25	30
13		24.0		0.38	29

To evaluate shear strength parameters in direct shear test, thirteen samples have been tested. The computed shear strength parameters, i.e., the cohesion (c) and angle of internal friction (Ø) are given in the table above. The average value of cohesion i.e. 0.39 and angle of internal friction i.e. 30° is recommended for design.

6.1.1.4.2 TRIAXIAL COMPRESSION TEST

This test is conducted to obtain the shear strength parameters of cohesive soil. Tests have been conducted on representative undisturbed soil samples collected from the different boreholes along the tunnel alignment. This test was conducted as per IS: 2720 (Part XI). A summary of test results is presented in **Table 9**.

Table 9: Summary of Shear Strength parameters

S. No.	BH no.	Depth (m)	No. of Test Results	Shear Strength Parameters	
				C (kg/cm2)	ϕ (°)
1	BH-1	8	16	0.337	9.347
2	BH-2	16		0.876	10.876
3	BH-3	8		0.325	8.434
4	BH-4	8		0.293	9.509
5	BH-5	2.5		0.267	8.463
6	BH-24	8.0		0.80	17
7		16.0		0.85	18
8	BH-25	16.0		0.85	19
9		24.0		0.75	19
10		32.0		0.42	18
11		40.0		0.45	19
12	BH-26	8.0		0.50	16
13		16.0		0.40	17
14		24.0		0.80	18
15		32.0		0.55	17
16		40.0		0.78	14
17	BH-27	16.0		0.58	18
18		24.0		0.80	14

6.1.1.5 CONSOLIDATION TEST

This test was conducted as per IS: 2720 (Part XV). A summary of test results is presented in **Table 10**.

Table 10: Summary of Consolidation Test results

S. No.	BH no.	Depth (m)	No. of Test Results	Vertical Consolidation	
				Compression Index (Cc)	Pre-consolidation Pressure (Pc) (Kg/Cm2)
1	BH-1	8	5	0.218	0.665
2	BH-2	18		0.248	0.875
3	BH-3	8		0.272	0.705
4	BH-4	8		0.192	0.695
5	BH-5	18		0.270	0.765

6.1.1.6 YOUNG'S MODULUS

The modulus of elasticity has been estimated based on the literature correlation mentioned in Bowles, 1996. For sandy clayey silt the young's modulus has been calculate using relation:

E=800(N+6) in MPa

Table 11: values of Young's Modulus from correlation

S. No.	Depth (m)	BH-7	BH-8
		E (MPa)	E (MPa)
1	1.5	5.4	-
2	3.0	5.1	7.5
3	4.5	9.3	-
4	6.0	12.8	10.8
5	9.0	22.8	14.4
6	12.0	12.3	18.2
7	15.0	21.3	20.4
8	18.0	22.2	24.8
9	21.0	28.7	28.7
10	24.0	25.2	27.8
11	27.0	24.8	28.5
12	30.0	29.4	31.8
13	33.0	29.4	28.4
14	36.0	34.8	-
15	40.0	36	-

The above data is derived through the correlation from Bowles, 1996. Average of all the values is 20.8MPa, while the mean of the data (ignoring the data above 18m depth and below 33m depth i.e. at tunnel depth) is 25.7MPa. Hence, 25.7MPa is recommended for design.

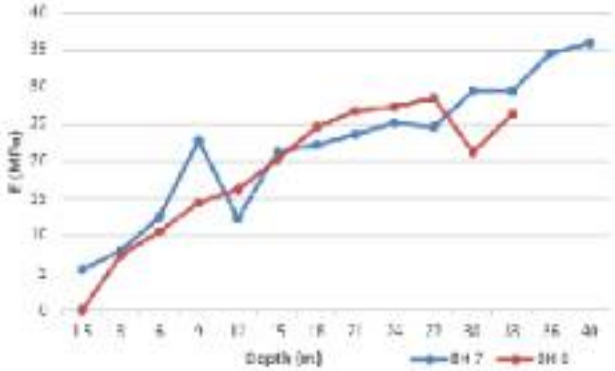


Figure 8: Variation of Young's Modulus with respect to depth in BH-7 and BH-8

Figure 8 shows the variation of young's modulus values obtained from correlation with depth in BH-7 and BH-8.

6.1.1.7 POISON'S RATIO

In the absence of field and lab test data, the following literature from Bowles, 1996 shall be used to report poisson's ratio for different soils as given in Table 12.

Table 12: Range of poisson's ratio values for different types of soils

Type of Soil	ν
Clay, Saturated	0.4 - 0.5
Clay, Unsaturated	0.1 - 0.3
Sandy clay	0.2 - 0.3
Silt	0.3 - 0.35
Sand, gravelly sand commonly Used	0.1 - 1
Rock	0.1 - 0.4 (depends on composition or type of rock)
Loess	0.1 - 0.3
Ice	0.36
Concrete	0.15
Steel	0.33

Soil in the project area is classified as clayey silt soil, so, from Table 12, Poisson's ratio of soil is considered as 0.3-0.35.

6.1.1.8 DISCUSSION ON LABORATORY TEST RESULTS IN SOIL

The results of the performed triaxial Compression Tests, index properties, consistency limits, grain size analysis, deformability test, consolidation tests provide a basis for the initial evaluation of the design parameters for soil.

Based on the grain size analysis, the soil in the project area has been classified as sandy clayey silt with maximum percentage of silt size particles i.e. ~50%. Liquid limit of the soil is <35%, indicates low plasticity.

Shear strength parameters i.e. cohesion (c) and angle of friction obtained from the direct shear test are 0.35 and 30 respectively.

The value of modulus of elasticity at tunnel depth is 25.7MPa obtained from the correlation mentioned in Bowles, 1996.

In general, the soil along the tunnel alignment can be classified as stiff to hard sandy clayey silt with low plasticity.

6.1.1.9 SUGGESTED GEOTECHNICAL DESIGN PARAMETERS FOR SOIL

The following values are recommended on the basis of investigated soil samples from the proposed locations.

Table 13: Suggested design parameters for soil at Tunnel depth

Depth (m)	Bulk Density	Dry Density	Shear Strength Parameters		E (MPa)	ν
			C (kg/cm2)	ϕ (°)		
20-30	1.85	1.61	0.35	30	25.7	0.3

6.1.2 BEDROCK

Bedrock of quartzite is exposed in the project area. Laboratory tests on rock core samples have been performed to evaluate the engineering properties of rock.

6.1.2.1 INDEX PROPERTIES

6.1.2.1.1 DENSITY

Unit weight of intact rock core sample was calculated by determining the weight of rock and its relevant volume. The summary of test results is presented in the Table 14.

6.1.2.1.2 SPECIFIC GRAVITY

Specific gravity of the rock core samples was determined on selected samples as per the relevant methods described in IS: 2386 (Part III). The summary of test results is presented in the **Table 14**.

6.1.2.1.3 WATER ABSORPTION

Water absorption or water content of the rock core samples were determined on selected samples as per the relevant methods described in IS: 13030. The summary of test results is presented in the **Table 14**.

6.1.2.1.4 POROSITY

Porosity of the rock samples were determined on selected samples as per the relevant methods described in IS: 13030. The summary of test results is presented in the **Table 14**.

Table 14: Summary of test results of index properties

S. No.	Borehole No.	Sample ID	Test Depth (m)	Rock Type	Bulk Density (g/cc)	Water absorption (%)	Porosity (%)	Specific Gravity
1	BH-13	4	9.00-10.50	Quartzite	2.60	0.13	0.05	2.66
2	BH-14	6A	19.50-21.00		2.65	0.18	0.49	2.67
3	BH-15	S16	20.50-22.50		2.65	0.09	0.14	2.65
No. of Test Results					3			
Maximum Value					2.65	0.13	0.05	2.66
Minimum Value					2.60	0.09	0.14	2.65
Mean					2.626	0.08	0.89	2.67

6.1.2.2 UNCONFINED COMPRESSIVE STRENGTH

Unconfined Compressive Strength (UCS) of intact rock core samples is calculated from laboratory testing. Unconfined Compressive Strength (UCS) of bedrock core samples were determined as per methods described in IS: 9143. The UCS test results of bedrock core samples are presented in the **Table 15**.

Table 15: Summary of UCS test results of rock samples

S. No.	Borehole No.	Sample ID	Test Depth (m)	Rock Type	UCS (MPa)
1	BH-13	4	9.00-10.50	Quartzite	26.40
2	BH-14	6A	19.50-21.00		120.49
3	BH-15	11B	30.50-33.50		134.53
4	BH-23	42A	33.00-33.17		66.13
5	BH-24	30	28.50-28.76		31.36
6	BH-25	24	30.00-30.46		11.18

UCS for the aforementioned samples in ascending order are 11.18, 26.40, 31.36, 66.13, 120.49 and 134.53 MPa. Ignoring the highest and the lowest values, rest of the data ranges from 26.40 to 120.49MPa, with an average of 73.9MPa. Hence, 73.9MPa is recommended as representative UCS value for quartzite. However as the tunnel is to be designed for TBM, therefore the maximum value should be used for design purpose.

6.1.2.5 TENSILE STRENGTH

Tensile strength of the rock samples obtained from the different boreholes has been determined using Brazilian test method. The test results are summarised in the Table 16 below.

Table 16: Summary of tensile strength test results

S. No.	Borehole No.	Sample ID	Test Depth (m)	Rock Type	Tensile Strength (MPa) (Brazilian Test)
1	BH-13	4	9.00-10.50	Quartzite	7.2
2	BH-14	6A	19.50-21.00		12.5
3	BH-15	11B	30.50-33.50		17.2
4	BH-23	42A	33.00-33.17		15.3
5	BH-24	30	28.50-28.76		12.5
6	BH-25	24	30.00-30.46		7.4

The tensile strength of the samples is 7.2, 12.5, 15.3, 15.9 and 17.2 MPa. The data (ranging from 7.2 to 17.2MPa) appears realistic, and indicates normal variation. Hence, mean 12.2MPa of the tested values is recommended for design.

6.1.2.4 TRIAXIAL SHEAR STRENGTH

Shear strength parameters of bedrock core samples were determined as per methods described in IS: 13047.

Table 17: Summary of shear strength parameters of rock samples

S. No.	Borehole No.	Sample ID	Test Depth (m)	Rock Type	Shear Strength Parameters	
					C (MPa)	ϕ (°)
1	BH-13	-	21.50-24.00	Quartzite	12.87	55
2	BH-14	-	27.00-27.50		10.37	57
3	BH-15	-	25.00-25.50		14.50	54
4	BH-23	55.84	27.00-30.75		1.41	58
5	BH-24	50.53	33.50-36.75		8.07	49
6	BH-25	24,12,11	30.00-33.17		1.42	53

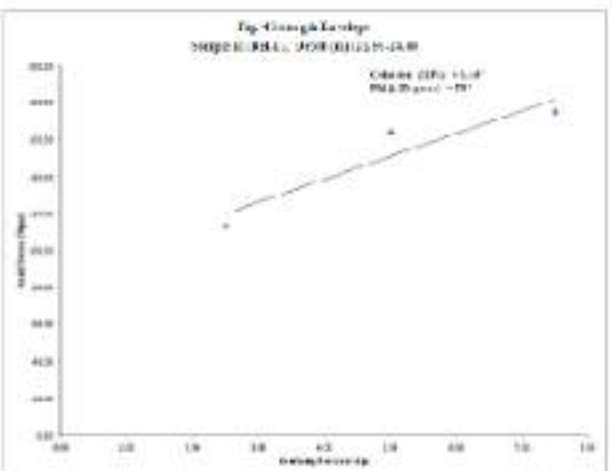


Figure 9: Shear strength envelope for Triaxial Shear Strength

To evaluate shear strength parameters in triaxial compression, six samples have been tested for the confining pressure ranging from 2.5 to 7.5MPa. The computed shear strength parameters, i.e., the cohesion (c) and angle of internal friction (Ø), are 1.41, 1.42, 8.07, 10.37, 11.67 and 14.50MPa and 49, 53, 54, 56, 57 and 58° respectively. The average value of cohesion (ignoring the two lowest values) 11.4 is recommended for design. The angle of internal friction (ranging from 49 to 58MPa) appears realistic, and indicates normal variation. Hence, 54.3MPa is recommended for design.

6.1.2.5 MODULUS OF ELASTICITY

Modulus of elasticity of bedrock core samples were determined as per methods described in IS: 9221.

Table 18: Summary of elastic modulus test results of rock samples

S. No.	Borehole No.	Sample ID	Test Depth (m)	Rock Type	Modulus of Elasticity (GPa)
1	BH-13	4	9.00-10.50	Quartzite	40.97
2	BH-14	8A	19.50-21.00		39.28
3	BH-15	81B	30.50-33.50		67.01
4	BH-15	41A	33.00-33.17		62.33
5	BH-24	30	35.50-35.76		40.10
6	BH-25	24	30.00-30.48		27.27

The above mentioned samples are tested for deformability characteristics. The values of E in ascending order are 27.27, 40.10, 40.97, 39.28, 62.33 and 67.01GPa. Average of all the values is (ignoring one highest and one lowest value) is 50.6GPa is recommended for design.

6.1.2.6 POISSON'S RATIO

Poisson's ratio of bedrock core samples were determined as per methods described in IS: 9221.

Table 19: Summary of poison's ratio of rock samples

S. No.	Borehole No.	Sample ID	Test Depth (m)	Rock Type	Poisson's Ratio, ν
1	BH-33	4	9.00-10.50	Quartzite	0.10
2	BH-34	8A	19.50-21.00		0.13
3	BH-33	81B	20.50-22.50		0.11
4	BH-23	42A	22.00-22.17		0.16
5	BH-24	50	25.50-25.76		0.13
6	BH-25	24	30.00-30.48		0.10

Fig 1: MODULUS OF ELASTICITY & POISSON'S RATIO OF ROCK
Sample Id: BH-23, Core No: Q5, Depth(m): 23.00-23.17

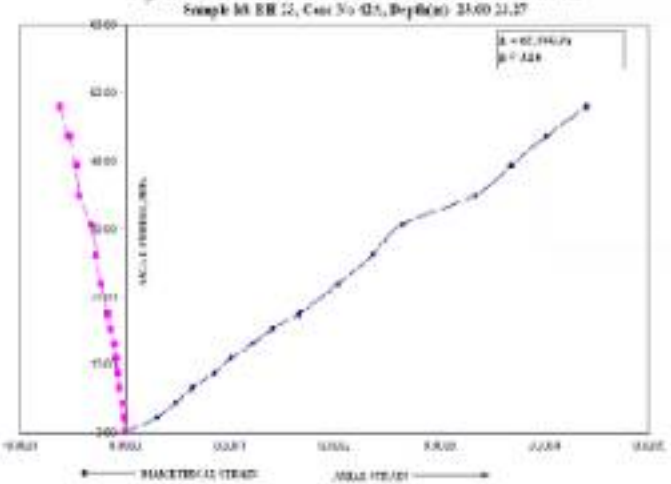


Figure 10: Elasticity modulus and Poisson's ratio graph for quartzite

On arranging the values of μ in ascending order, the values are: 0.10, 0.11, 0.13, 0.16 and 0.19. Averaging all the values, 0.14 is recommended for adoption. Graph for poisson's ratio for rock sample from BH-23 is shown in the **Figure 10**.

6.1.2.7 CERCHAR ABRASIVITY INDEX

The CERCHAR abrasivity test allows to determine CERCHAR Abrasivity Index (CAI) for the rock's abrasivity, which can be used to evaluate the wear of excavation equipment in tunneling. Standard Test Method used for Laboratory Determination of Abrasiveness of Rock Using the CERCHAR is described in ASTM D7625.

Table 20: Summary of CAI test results

S. No.	Borehole No.	Sample ID	Test Depth (m)	Rock Type	Cercher Abrasivity Index (N)
1	BH-13	4	9.00-10.50	Quartzite	5.15
2	BH-14	6A	10.50-11.00		4.04
3	BH-15	B1B	20.50-22.50		4.93

Based on the Chechar Abrasivity Index (CAI) this rock is considered very abrasive to highly abrasive.

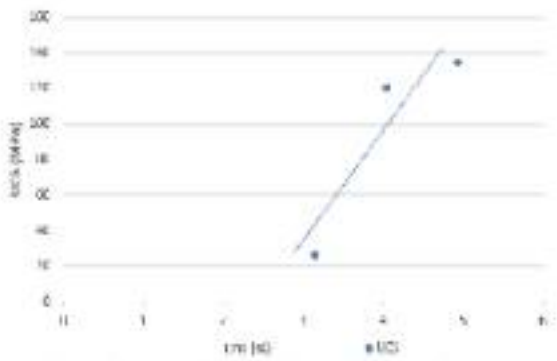


Figure 11: variation of CAI with respect to UCS

6.1.2.8 SUGGESTED DESIGN PARAMETERS FOR ROCK

Suggested design parameters for rock are presented below in the Table 21.

Table 21: Suggested design parameters for rock at Tunnel depth

Bulk Density (g/cc)	UCS (MPa)	Tensile Strength (MPa)	Shear Strength Parameters		Poisson's Ratio	E (MPa)	CAI
			C (kg/cm2)	ϕ (°)			
2.63	134.9	17.2	11.4	34.9	0.14	30.6	4.93

Note: As the tunnel will be designed for TBM, therefore maximum values of UCS, tensile strength and CAI is recommended for design.

6.1.2.9 DISCUSSION OF LABORATORY RESULTS

The results of the performed Unlaxial Compression Tests, Point Load tests, Triaxial Shear Tests and Brazilian Tests provide a basis for the initial evaluation of the intact rock parameters for quartzite.

Index properties viz. bulk density, water absorption, specific gravity of rock samples from different locations along the tunnel alignment indicate the rocks to be of good quality.

The unlaxial compressive strength for the rock along the alignment range from nearly 11 MPa to over 134 MPa, the general rock type along the tunnel alignment can be classified as moderately strong to very strong rock.

The obtained values of modulus of elasticity vary from 27.27 GPa to 67.01 GPa. The lowest value is obtained in sample 24 from BH-28 (Quartzite) and the highest value is obtained in sample 818 from BH-15 (Quartzite).

The poison's ratio obtained from the tested specimens varies from 0.10 to 0.19 which falls within typical values for the rock type investigated.

The intact friction angles from Tri-axial tests ranged from 48° to 52° with intact cohesion ranging from 1.41 MPa to 14.3 MPa which compare well to the strength values obtained from the UCS tests.

Based on the value of 4.93 of Cerchar Abrasivity Index (CAI), this rock is considered very abrasive to highly abrasive.

6.2 FIELD TESTS

Field tests comprising Standard Penetration test, Permeability test and Pressure-meter test have been proposed to establish geotechnical parameters of soil and rock.

6.2.1 SPT N VALUES

Standard Penetration Tests were conducted in the bore holes at intervals of 3.0m using a split spoon sampler by geotechnical investigation agency as per IS 2131. The used split spoon sampler was of a standard design having an outer diameter of 50.8 mm and inner diameter of 35 mm, driving with a standard hammer weighing 63.5kg, falling freely through 75cm advances the sampler. A record of the number of blows required to penetrate every 15cm to a maximum depth of 45cm was made. The first 15cm of drive is a seating drive and is neglected. The total blows required for second & third 15cm of penetration is counted and termed as Standard Penetration Resistance "N". On completion of test, the disturbed samples were collected from split spoon sampler for soil classification purpose.

Based on the results of the subsurface explorations, the subsoil profile at study area can be divided into three strata. The soil primarily comprised of fine sand, silt and clay particles. The top layer consists of greyish very stiff sandy clayey silt with low plasticity with a total thickness approximately varied from 3 m to 7.5 m. Immediately below this layer, a layer of yellowish hard sandy clayey silt with low plasticity is extended to a depth varied from 7.5 m to 14 m. The bottom layer consists of low plastic brownish hard sandy clayey silt to the depth of 34-40 m. Ground water table has not been encountered in the boreholes in soil. The N-values obtained in the boreholes ranges from 12-41 between 0-10m depth, 48-76 between 10-20m depth, 69-90 between 20-30m depth and 90-113 between 30-40m depth. Corrected SPT N values for BH-1 to BH-6 is given in **Figure 12** and **Figure 13**.

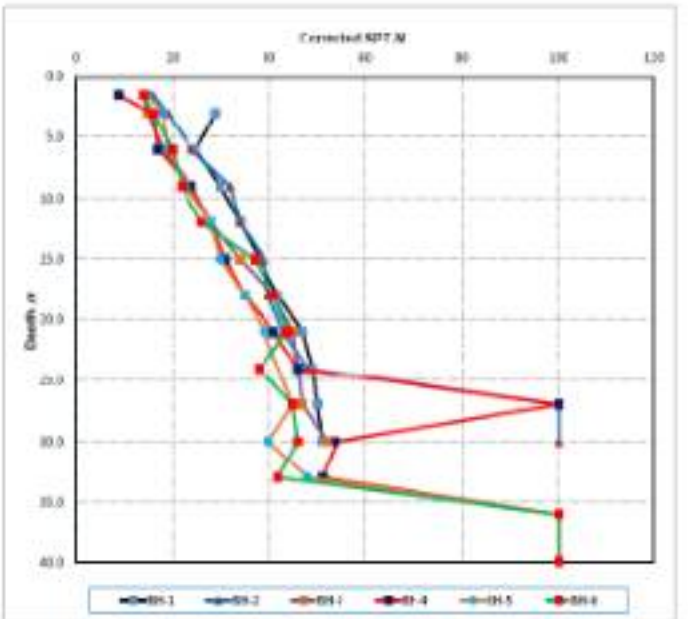


Figure 12: Depth Vs Corrected SPT, N values for BH-1 to BH-6

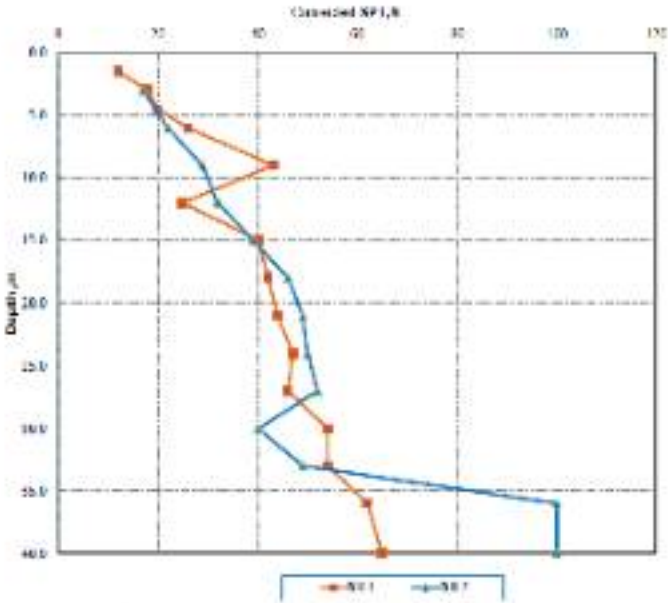


Figure 13: Depth Vs Corrected SPT, N values for BH-7 and BH-8

6.2.2 PERMEABILITY TEST IN SOIL

Permeability tests have been conducted in soil in selected borehole. Permeability in the soil has been determined using Constant Head and Falling Head Method as per IS: 5529 (Part I).

Table 22: Summary of Permeability test results in Soil

S. No.	Borehole	Depth (m)	Permeability (m/sec)
1	BH-1	12	0.0182
2	BH-5	20	0.0048
3	BH-6	20	0.0181
4	BH-8	22.5	0.0159
5	BH-24	10	0.0099
		20	0.0099
6	BH-25	10	0.0219
		20	0.0155
		30	0.0155
		40	0.0140
		50	0.0123
Mean			0.0148

6.2.3 PERMEABILITY TEST IN BEDROCK

Permeability tests have been conducted in bedrock in selected boreholes. Permeability in the bedrock has been determined using water pressure test as per IS: 5529 (Part II).

Table 23: Summary of Permeability test results in Bedrock

S. No.	Borehole	Depth (m)	Permeability (Lu)
1	BH-13	24	4.82
		30	5.72
		40	4.29
2	BH-14	24	5.60
		30	5.21
		40	4.37
3	BH-15	10	2.41
		24	5.70
		30	4.81
		40	3.83
4	BH-24	22.5	3.37
		40	3.03
Mean			4.27

7 GROUND CHARACTERIZATION

7.1 GROUND TYPE

During the geological field mapping, three Ground Types were identified. The geological conditions throughout the tunnel alignment are dominated by three distinct ground type i.e. hard rock represented by quartzite, highly to completely weathered rock mass/transition zone and alluvium represented by soil. The different ground types along the tunnel alignment are given in the geological section appended as Annexure-I.

As the tunnel alignment is passing through different type of material. Based on the type of material three major ground types have been assessed for the tunnel.

- GT-1: Massive, jointed, fresh rock mass;
- GT-2: Highly to completely weathered rock mass/Transition zone;
- GT-3: Alluvium/Soil

Table 24: Ground Type-1

Ground Type - GT1	Fresh Quartzite						
Description:	These are thickly bedded, jointed, dry and fresh to slightly weathered rockmass. Large to very large block size, spacing of discontinuities is more than 1m.						
Discontinuities:	Properties	Foliation	Remarks	Joint Sets:	Properties	J1	J2
Foliation/Bedding / Dip/Dip Dir 42/112	Orientation:	foliation/Bedding			Dip/Dip Dir:	88/020	46/108
	Spacing:	20-600 cm			Spacing:	10-60 cm	40-100 cm
	Persistence:	10-15 m			Persistence:	7-10 m	5-7m
	Condition:	Dry			Condition:	Dry	Dry
	Opening:	Tight to open			Opening:	Tight	Tight
	Filling:	Ferruginous material			Filling:	None	None
Parameters:		Intact Rock		Suggested Design Parameters			
		Min	Max				
Density, γ	[g/cc]	2.60	2.65	2.65			
UCS, σ	[MPa]	28.40	154.8	154.8			
Poisson, ν	-	0.10	0.19	0.14			
Tension, σt	[MPa]	7.4	17.2	17.2			
Cohesion, c	[MPa]	1.41	14.5	11.4			
Friction Angle, ϕ	[°]	48	58	54.5			
Young's Modulus, E	[Gpa]	27.27	67.01	50.6			
Permeability	Lu	2.03	5.72	4.2			
Abrasivity	-	3.15	4.93	4.93			
GSI	-	60	80	70			
Ground water:	Dry						

Photo:



Photo-16: GT-2 Hard rock (Fresh to slightly weathered Quartzite)

Note: As the tunnel will be designed for TBM, therefore maximum values of UCS, tensile strength and CAI is recommended for design.

Table 25: Ground Type-2

Ground Type – GT2	Highly to Completely weathered quartzite/Transition Zone						
Description:	These are shiny bedded, highly jointed, highly to completely weathered and dry rockmass. Small to very small block size, spacing of discontinuities is 10-60cm.						
Discontinuities:	Properties:	Foliation	Remarks	Joint Sets:	Properties:	II	III
Foliation/Bedding : Dip/DipDir 42/112	Anisotropy:	foliation/bedding			Dip/dip Dir:	85/010	46/295
	Spacing:	10-60 cm			Spacing:	10-40 cm	40-60 cm
	Persistence:	10-15 m			Persistence:	7-10 m	5-7m
	Condition:	Dry			Condition:	Dry	Dry
	Opening:	open			Opening:	Open	Open
	Filling:	Soil			Filling:	Soil	Soil
Parameters:		Intact Rock					
		Min	Max	Average			
Density, γ	[g/cc]	2.0	2.4	2.2			
UCS, σ	[MPa]	11	11	11			
Poisson, ν	-	0.19	0.19	0.19			
Cohesion, c	[MPa]	1.41	1.41	1.41			
Friction Angle, ϕ	[°]	20	30	25			
GSI	-	20	40	30			
Ground water:	Dry						

Photo:



Photo-17: GT-2 Highly to completely weathered rock mass

Table 20: Ground Type-3

Ground Type – GT3	Alluvium/Soil	
Description:	Yellowish-brown clayey silty soil with Kankar	
Soil Parameters:		Suggested Design Parameters
Density, ρ	[g/cc]	1.89
Cohesion, c	[KPa]	55.3
Friction Angle, ϕ	[°]	30
Young's Modulus, E	[Gpa]	0.0257
Poisson, ν	-	0.33
Permeability, kf	[m/s]	0.0148
Ground water:	Dry	

Photo:



Photo-18: GT-3 Alluvium/Soil

7.2 GEOMECHANICAL CLASSIFICATION

Hoek and Brown introduced the Geological Strength Index (GSI), both for hard and weak rock masses. The assessment of GSI values are made based on observations made during core drilling, core photographs, joint conditions, core recovery, RQD, Weathering grade, ground water condition, UCS etc. along with engineering judgement. The assessment of GSI values of GT-1 and GT-2 based on the literature correlation suggested in Figure 14.

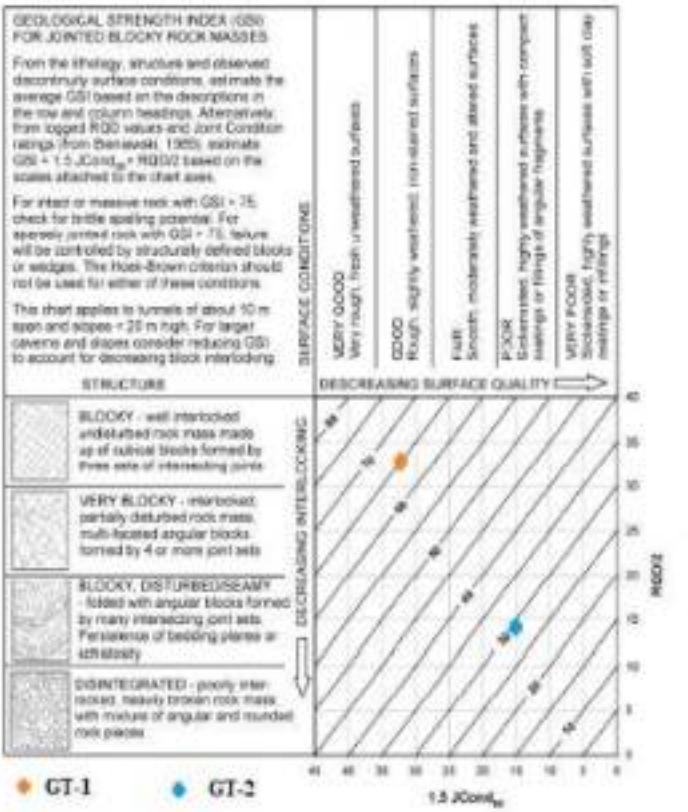


Figure 14: Representative values of GSI for Ground Types

B PARAMETERS FOR NELSON MANDELA JUNCTION MODIFICATION

To modify the junction of Nelson Mandela marg with Mehrauli-Mahipalpur road, a flyover has been proposed adjacent to the existing flyover. Proposed DC-08 underground METRO line runs parallel to the flyover. Geotechnical investigation carried out for proposed METRO line shall be used for designing of flyover. Total 7 no of holes have been drilled for investigation, out of which, data from 5 no of boreholes viz. BH-23, BH-24, BH-25, BH-26 and BH-30 shall be used to design the structure. The details of boreholes and test results are attached as Annexure-II.



Figure 15: Location of Boreholes for Flyover

9 ENGINEERING GEOLOGICAL ASSESSMENT

The geological conditions throughout the tunnel alignment are dominated by two distinct ground type i.e. hard rock represented by quartzite and alluvium represented by soil. Hard rock is present in the middle portion (Ridge area) and alluvium is present on either side of the ridge. The rocky ridge is characterised by presence of quartzite intercalated with mica schist bands and alluvium is comprised of polycyclic sequence of sand, silt and clay with kankar. Both the portal of tunnel are situated in the soil.

The middle portion of the tunnel is well exposed with light gray to purple, medium to very coarse grained hard and compact quartzite. The rock mass is widely to moderately jointed, and in general, is massive. The rock mass is strong to very strong and believe to have high compressive strengths exceeding 100 MPa. Three major sets of joints predominates in the rock mass making the rock mass blocky and interlocked. Likewise, GSI values are also expected to be more than 70, but, would be poorer where weathered zones and shear seams/zones traverse the rock mass. Quartzites are generally considered to be good media for tunnelling.

The tunnel alignment runs across the strike of the rocks; which is also geologically favourable. Rocks have an un-even distribution of weathering. Weathering of the intact rock is typically constrained to within 5 to 30 cm of the discontinuity surface. The rock mass is moderately to highly weathered in the upper 1-3 meters. In zones with closely spaced bedding or zones dominated by secondary joints, the weathering penetrates deeper into the rockmass, often forming pockets controlled by the major discontinuities.

The bedrock is moderately jointed and the joints are occasionally filled with soil or clay material. Mica schist bands of thickness 15-40cm have been found along the tunnel alignment. These schist bands are weathered and occasionally sheared. The presence of shear zones associated with schist bands and joints filled with soil makes it susceptible for failure. The intersection of these weak features may lead to planar and wedge failures.

No spring or subsurface water has observed along the tunnel alignment, however presence of perched water table cannot be ruled out. The transition zone between rock and soil has been explored by means of drilling, rock mass is highly to completely weathered and no ground water has been encountered during drilling.

The tunnel is generally shallow with ground cover ranging between 10-39m. Since the stress magnitude at shallow depth is low, the risk of distressing of the rockmass around the tunnel is large. This implies that gravitational sliding of wedges and blocks are the most probable stability problem. It is expected that very low cover zones (<10m) may encounter along the tunnel alignment, especially in the mining pits. Lateral ground cover between two tunnels varies between 20-25m which seems adequate.

9.1 GROUND SETTLEMENT

Ground settlement along the tunnel alignment is expected in the reaches where the tunnel is passing through the alluvium/soil. The soils at the site generally classified as clayey silt as encountered in the boreholes. The N-values encountered in standard penetration test at tunnel depth ranges from 83-90. But, as the tunnel is situated at shallow depth has a maximum cover of 20m, excavation at shallow depth can lead to settlement around the tunnel and further subsidence at the surface. Mixed ground conditions near the transition zone of soil and rock can lead to varying surface settlements over tunnel. The settlements can be due to loss of ground at the face. As both the portals of the tunnel are situated in the soil, therefore settlement may occur near the portal areas due to low cover.

9.2 IMPACT OF WEATHERING ON TUNNEL

The rock mass in the upper few meter depth is moderately to highly weathered with patches of completely weathered rock. In zones with closely spaced bedding or zones dominated by secondary joints associated with larger structures the weathering penetrates deeper into the rockmass, often forming pockets controlled by the major discontinuities.

Pockets of highly to completely weathered bedrock noted at some places on the tunnel alignment. However, these are not very deep at the tunnel alignment, but, presence of deeper pockets cannot be ruled out. These pockets of weathering, may resulted into the chimney development/collapse along the tunnel in the low cover reaches.

The weathering depth along individual structures is expected to reach the tunnel alignment. Especially in schist bands and or fracture zones which may resulted into the failure as they form planes of weakness in the rock mass.

The transition zone of rock and soil interface is characterized by presence of highly to completely weathered rocks results is the potential for mixed ground conditions which include flowing or ravelling ground in conjunction with rock that is fresh and strong and difficult to excavate. Such conditions are expected in the transition zone due to uneven penetration of weathering into the rock mass. Weathered rock is a ravelling material, and the vibrations resulting from the machine movement and blasting while excavation may accentuated the ravelling. Weathered crystalline rocks retain the structure of the fresh rock. The residual crystalline structure can result in the weathered rock having a significantly higher permeability than an alluvial soil of similar clay and silt content. Such materials are also prone to piping, leading to channelled flow. These conditions can lead to instability in excavations of tunnel due to presence of ground water. However, as the groundwater conditions are dry, therefore chances of ravelling ground conditions are very less. But the presence of perched water table cannot be ruled out.

10 CONCLUSIONS AND RECOMMENDATIONS

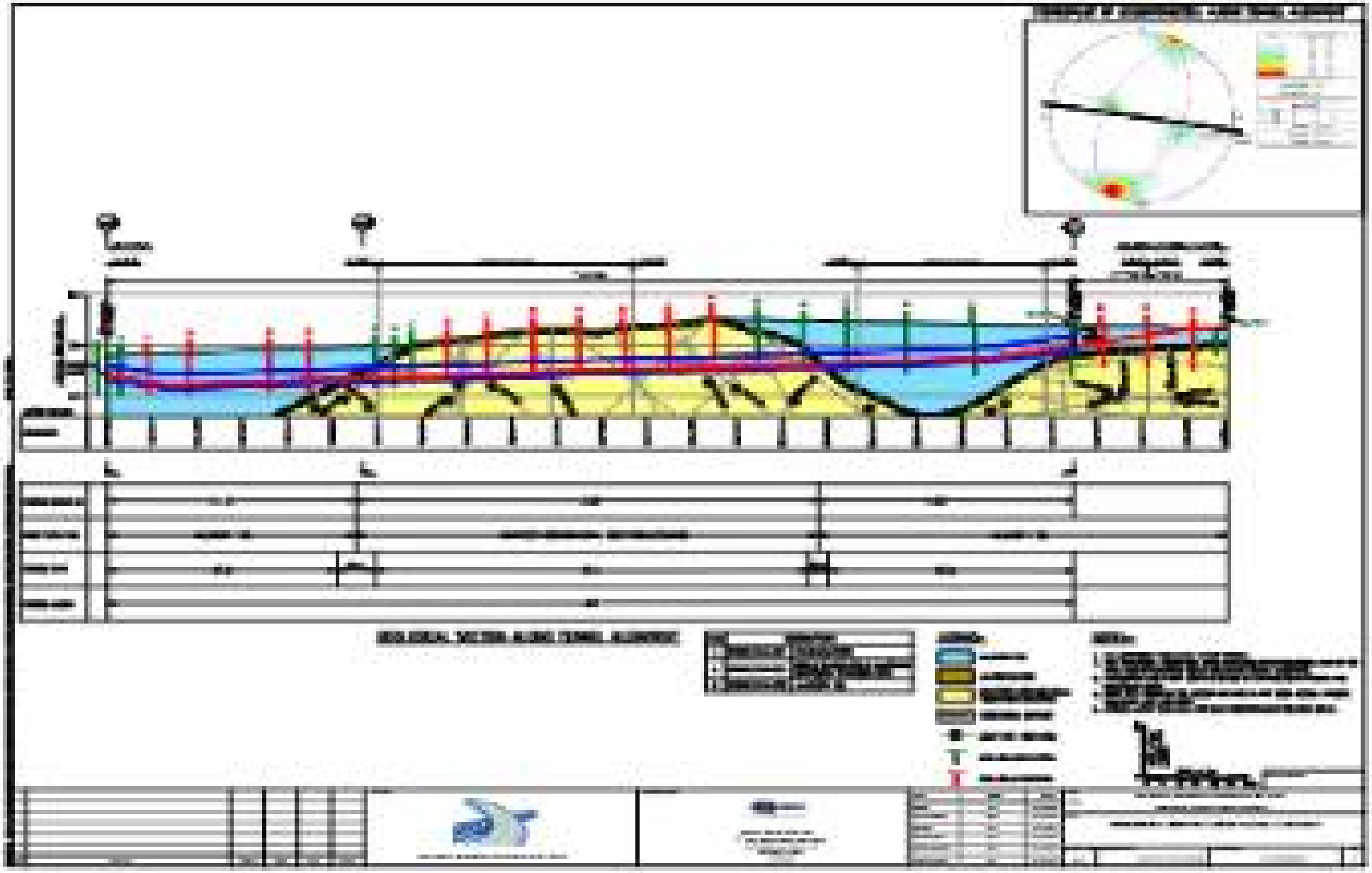
Only two main geological units are present in the tunnel area viz. the quartzites with subordinate bands of schist and the alluvium/soil. The bedrock at the grade of the tunnel is available mainly in the ridge portion.

The rock is massive, hard, thickly bedded and sparsely jointed. Depending upon the frequency of joints, their orientation, extent of weathering of rock and the ground water conditions, the tunnel may need supports which have to be provided concurrently with excavation. The portion of tunnel passing through the ridge is characterised by presence of mining pits along the tunnel alignment which may results in the low cover on the tunnel crown. The depth of these mining pits varies between 9-12m. As the tunnel grade has been proposed 25-30m below the ground surface, hence the tunnel may experience instability issues due to low cover reaches along the mining pits. Groundwater conditions are expected to be dry throughout the tunnel.

Rest of the tunnel alignment has to be constructed through alluvium on account of the bedrock occuring at deeper levels than the grade of the tunnel. Since the initial 1100m of the tunnel is situated under a residential area and last 1100m is passing through the agriculture land with a maximum soil cover of thickness 20m, it is of crucial importance. Tunnel in these reaches has to be excavated in the soil, therefore squeezing and flowing ground conditions may encounter, consequently possible collapses inside the tunnel may results in the sink hole on the ground surface.

Since liquefaction usually occurs in loose granular soils (such as fine sands) below groundwater table as a consequence of increased pore-water pressure during earthquakes (and the corresponding reduction in effective stress); the potential for liquefaction at the site is low. But as the tunnel is situated in the proximity of active Sohna fault and various other seismogenic sources like Himalaya, the soil liquefaction studies may be carried out to know the liquefaction potential of the soils present in the tunnel area.

Annexure I – Geological Section along the Alignment



Annexure II – Results of Geotechnical Investigation Carried out for Flyover at Junction Nelsan Mandela Marg and Mehrauli-Mahipalpur Road

APPENDIX-BH-23

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Atterberg Test	9
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Chemical Test Results	16
Physical Properties of Rock	17
Corebox Photographs	18 to 21

Soil Profile (BH-12)

Location : –
UTM Coordinates : [illegible]

Surface Elevation : [illegible]
Ground Water Depth : [illegible]
Termination Depth : [illegible]

Boring Method : Shell & Auger
Casing Depth : [illegible]
Boring Date : [illegible]
Boring Finish : [illegible]

Depth, m		Sample No.	SPT		Soil Symbol	SOIL DESCRIPTION	Depth of Strata, m	Grain Size Analysis				Atterberg Limits			Density and Moisture				Unconfined Compressive Strength, kPa	Direct Shear Test				Consolidation Test	
From	To		Blow Count, N	Corrected Value, N'				Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Dry Density, γ_d (kN/m³)	Moist Density, γ_t (kN/m³)	Saturated Density, γ_{sat} (kN/m³)	Moisture Content, w (%)		Cohesion, c (kPa)	Angle of Friction, ϕ (°)	Coefficient of Volume Change, m_v (m²/kN)	Coefficient of Consolidation, c_v (m²/yr)	Initial Void Ratio, e_0
[illegible]	[illegible]	[illegible]				Fill	[illegible]																		
[illegible]	[illegible]	[illegible]	8	8		SM/Fine to very stiff brown silty/clay silt • medium (dark) (CL, 1.5 m) 3.0 m • stiff, 1.0 cm to 3.0 m • fine plastic (CL), 3.0 m x 0 m • with traces of gravels, 2.0 cm to 4.0 cm • medium (dark) (CL, 4.5 m) 6.0 m • very stiff, 1.0 m to 6.0 m																			
[illegible]	[illegible]	[illegible]	22	22				0	8	62	30	34.0	16.4	17.6					3.68						
[illegible]	[illegible]	[illegible]	27	27				0	10	55	35	33.0	16.0	18.0					3.87						
[illegible]	[illegible]	[illegible]					[illegible]	0	13	53	34	35.7	17.3	18.47	1.84	1.87	1.13	3.68		13.1	1, 2, 3	1.3	6.4		
[illegible]	[illegible]	[illegible]	Ref'l Bore			Refusal met on Rock. Core drilling through rock adopted. Refer to core logs for details.																			

[illegible]

Hole No.: [illegible]

Location :	--	Surface Elevation :	[illegible]
UTM Coordinates :	[illegible]	Ground Water Depth :	Not met
		Termination Depth :	[illegible]
Boring Method :	Rotary Drilling
Casing Depth :	[illegible]
Casing Date :	[illegible]
Boring Finish :	[illegible]

Depth (m)	Depth (m)	Sample No.	Run No. & Core Loss	Core Log	Symbol	ROCK DESCRIPTION	Core Recovery (%)	RQD (%)	Core Loss (%)	Fracture Index	Point Load Strength Index (MPa)	Core Log	Point Load Strength Index (MPa)	Point Load Strength Index (MPa)	Point Load Strength Index (MPa)	Point Load Strength Index (MPa)	Point Load Strength Index (MPa)	Point Load Strength Index (MPa)
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Very weak to moderately strong, grey, [illegible], fine grained to medium grained, fractured, highly to completely weathered	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	- Occasionally strong, moderately fractured, moderately weathered, [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	- very weak, (Biotite gneiss), completely weathered, [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Hole No.: [illegible]

Location:	--	Surface Elevation:	[illegible]
UTM Coordinates:	[illegible]	Ground Water Depth:	Not met
		Termination Depth:	[illegible]
Boring Method:	Rotary Drilling
Casing Depth:	[illegible] m
Casing Date:	[illegible]
Boring Finish:	[illegible]

Depth (m)	Legend	Sample No.	Run No. (Core)	Description	Graphic Log	Depth of Weathering (m)	Bore Recovery (%)	Core Quality (Compressive Strength)	Core Loss (%)	Discontinuities	Core Diameter (mm)	Natural	Fractured	Core Length (m)	Point Load Index (MPa)	Shear Strength (MPa)	Core Recovery (%)	Core Recovery (%)	Core Loss (%)	Core Loss (%)	Core Quality (RQD)	Core Quality (RQD)
[illegible]				Very weak to moderately strong, grey, [illegible] SANDSTONE, fine grained to medium grained, thinly bedded, highly to completely weathered																		
[illegible]		[illegible]	[illegible]	- very weak, [illegible] completely weathered [illegible]			0	0	0													
[illegible]		[illegible]	[illegible]	- moderately strong (intensely fractured), highly weathered, [illegible]			44	0	60						0.18	0.77	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]		[illegible]	[illegible]	- moderately strong, moderately fractured, moderately weathered [illegible]			100	67							0.33	0.83	[illegible]	[illegible]	--	[illegible]	[illegible]	[illegible]
[illegible]		[illegible]	[illegible]				81	100	40													
[illegible]		[illegible]	[illegible]				100	100														
[illegible]		[illegible]	[illegible]				100	100	20													

Core Loss (%) Core Recovery (%) Core Length (m)

Hole HGA-19-04

Location: —
UTM Coordinates: 1000000 E, 2000000 N
Surface Elevation: 100.00 m
Ground Water Depth: Not recorded
Termination Depth: 30.00 m (RL 70.00 m)
Boring Method: Rotary Drilling
Casing Depth: 6.00 m
Casing Date: 03-Jul-19
Boring Finish: 07-Jul-19

Depth (m)	Depth (m)	Sample No.	Run No. (Core)	Core Photo	Symbol	ROCK DESCRIPTION	Depth (Photo) (m)	Core Recovery (%)	Core Quality (Comments) (%)	Point Load Index (MPa)	Core Loss (%)	Core Photo (Wet)	Core Photo (Dry)	Core Photo (Wet)	Core Photo (Dry)	Point Load Index (MPa)	Point Load Index (MPa)	Point Load Index (MPa)	Point Load Index (MPa)	Point Load Index (MPa)	Point Load Index (MPa)
6.00	6.00					Moderately strong, grey to dark grey, fine to medium grained, slightly to moderately fractured, moderately to highly weathered		44	0												
16.20		HGA19	45-47																		
16.50	16.50					- Moderately strong, very fine grained, intensely fractured, highly weathered, 16.70 to 17.20 m															
17.00		HGA19	49-50					58	0	60						2.20	2.77	0.0794	0.79	107	23207
17.45	17.45																				
17.70		Core	50-60			- Moderately strong, moderately fractured, highly weathered, 17.20 to 27.00 m		92	16	57											
18.00	18.00																				
18.30		HGA19	51-53					90	33												
18.75	18.75																				
19.00		HGA19	55-57					94	37	60						2.20	2.77	0.0800	0.77	—	8100
19.70																					
20.00	20.00																				
20.70		HGA19	59-74					100	39												
21.00	21.00																				

Core Photos (Wet and Dry)

Point Load Index (MPa)

Core Photo (Wet)

Core Photo (Dry)

Point Load Index (MPa)

Point Load Index (MPa)

Point Load Index (MPa)

Point Load Index (MPa)

Point Load Index (MPa)

Point Load Index (MPa)

Hook Inclination (BH-02)

Location:	–	Surface Elevation:	39.0 mOD
uTM Coordinates:	355853.8, 3437527.9 m	Ground Water Depth:	Not met
		Termination Depth:	30.0 m (NI, 23.0 m)
		Working Method:	Rotary Drilling
		Casing Depth:	6.0 m
		Casing Date:	03-Jul-19
		Boring Finish:	07-Jul-19

Depth (m)	Depth (m OD)	Geology	Core Run (m) Core Recovery (%)	Core Strength (MPa)	Core Fracture Density (fractures/m)	Core Fracture Description	Core Fracture Angle (°)	Core Fracture Type	Core Fracture Planarity	Core Fracture Roughness	Core Fracture Infilling	Core Fracture Thickness (mm)	Core Fracture Aperture (mm)	Core Loss Zone (m)	Core Loss Length (m)	Core Loss Percentage (%)
0.00	39.00					Moderately strong grey fine/coarse grained sandstone, intensely to moderately fractured, moderately to highly weathered											
1.50	37.50		1.50 / 1.50 (100%)	40	10												
3.00	36.00		1.50 / 1.50 (100%)	40	27	- moderately strong, moderately fractured, highly weathered, 3.1-3.4m, 3.4-3.5m											
4.50	34.50		1.50 / 1.50 (100%)	70	20												
6.00	33.00		1.50 / 1.50 (100%)	64	20												
7.50	31.50		1.50 / 1.50 (100%)	60	6	- moderately strong, intensely fractured, highly weathered, 9.0-9.2m, 9.4-9.5m											
9.00	30.00		1.50 / 1.50 (100%)	54	53	- moderately strong, moderately fractured, moderately weathered, 10.5-10.8m, 10.9-11.0m											
10.50	28.50		1.50 / 1.50 (100%)	58	20												

Hole No. [illegible] (BH-01)

(C.G.S.B.C. - 1.1.1.1.1.2.2.2)
Certified Laboratories
(Soil & Rock)
Certificate No. [illegible]

Location: —
UTM Coordinates: [illegible] E, [illegible] N

Surface Elevation: [illegible]
Ground Water Depth: Not noted
Termination Depth: [illegible]

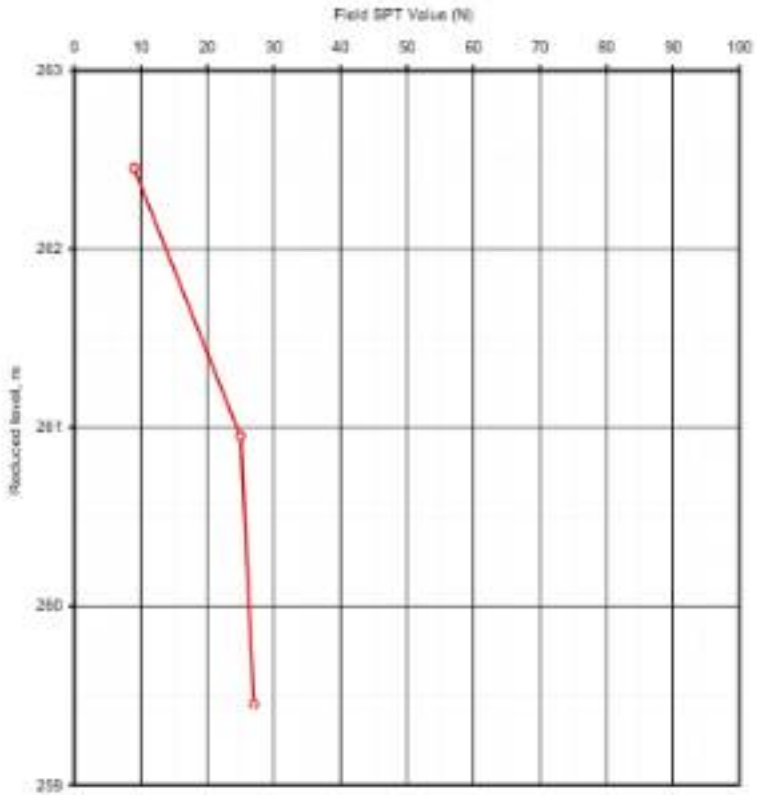
Boring Method: Rotary Drilling
Casing Depth: 6.0 m
Casing Date: [illegible]
Boring Finish: [illegible]

Depth (ft)	Depth (m)	Sample No.	Sample Type	Recovery (%)	Symbols	Soil Description	Depth (Elevation) (m)	Natural Moisture Content (%)	Dry Density (kg/m³)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Grain Size Distribution: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Undrained Shear Strength (kPa)	Remarks
[illegible]						Topsoil: dark brown, moist, [illegible]												
[illegible]	[illegible]	[illegible]				Fill: brown to dark brown, moist, [illegible]												
[illegible]		[illegible]	SPT	[illegible]		Fill: brown, moist, [illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]				Fill:

Standard Penetration Test

IS : 2131-1981, RA-2007

Borehole Details			
Symbol	Borehole Number	Reduced Level,m	Location
	BH-23	264.0	-

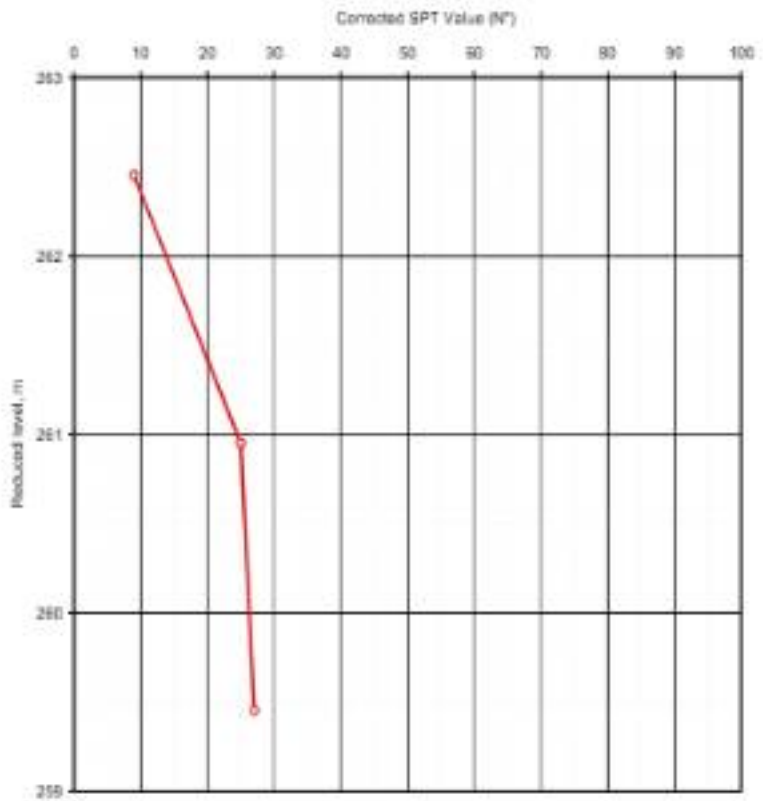


Field SPT Values vs Reduced level

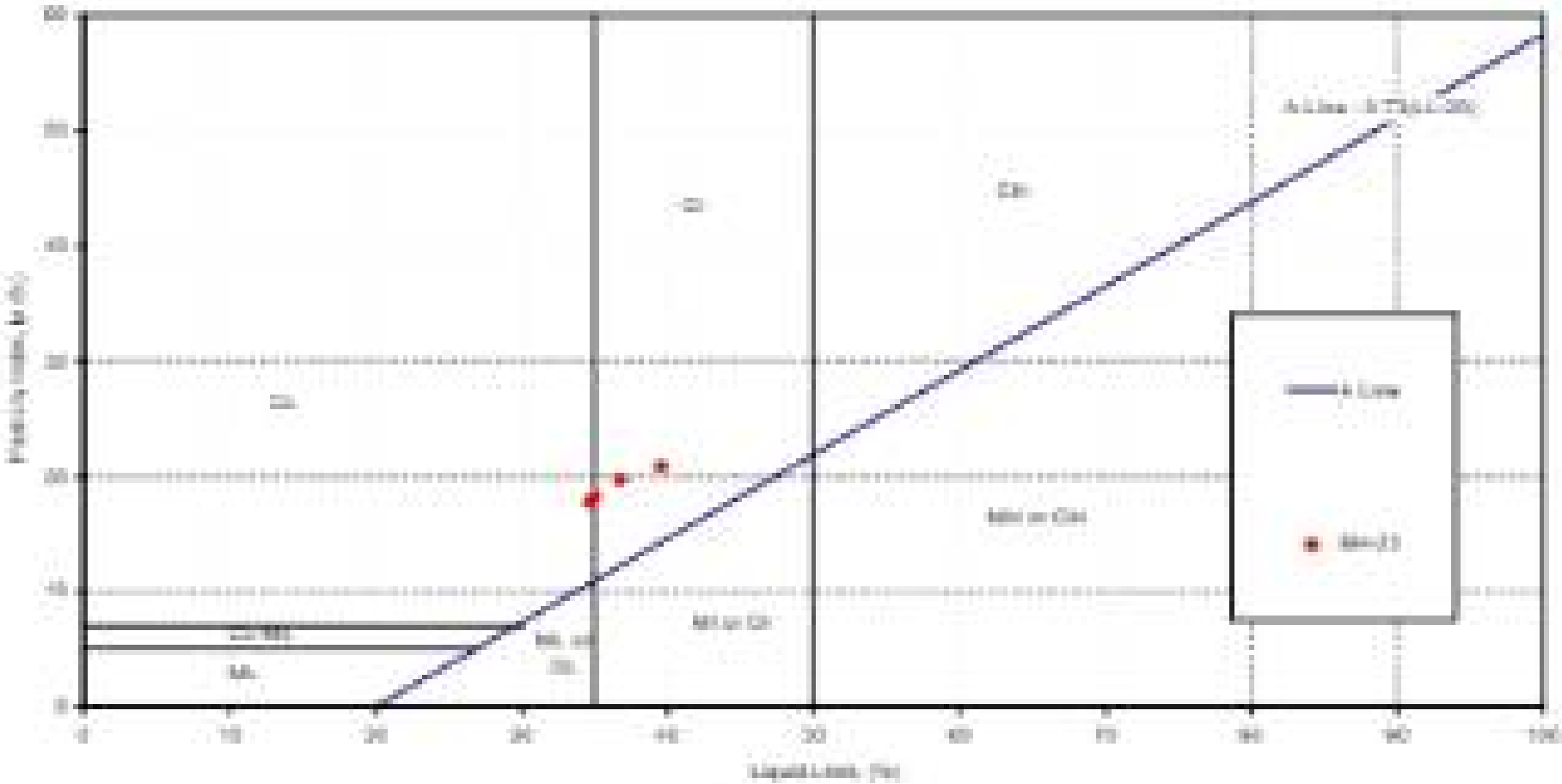
Standard Penetration Test

IS : 2131-1981, RA-2007

Borehole Details			
Symbol	Borehole Number	Reduced Level,m	Location
	BH-23	264.0	-



Corrected SPT Values vs Reduced level

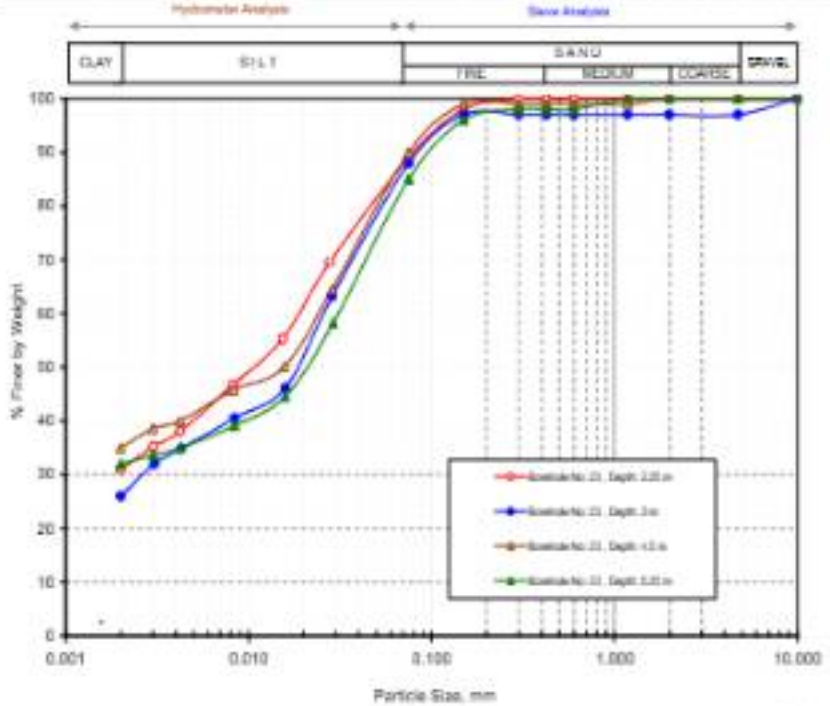


Plasticity Chart

Grain Size Analysis

IS : 2720 (Part 4) - 1985, RA-2010

Sample Details			Test Results								
Borehole Number	Sample Depth, m	Sample Description	% Gravel	% Sand	% Silt	% Clay	D_{60}	D_{30}	D_{10}	C_u	C_c
BH-23	2.25	Clayey silt (CI)	0	11	58	31	0.019	0.002			
BH-23	3.00	Clayey silt with traces of gravel (CL)	3	9	62	26	0.029	0.003			
BH-23	4.50	Clayey silt (CI)	0	10	55	35	0.025	0.002			
BH-23	5.25	Clayey silt (CI)	0	15	53	32	0.032	0.002			

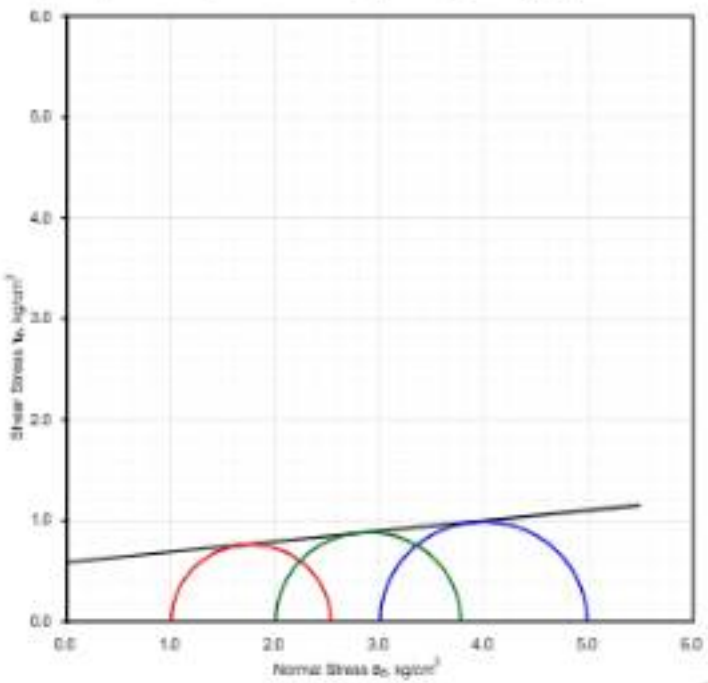


Grain Size Distribution Curve

Unconsolidated Undrained Triaxial Test

IS : 2720 (Part-11)-1993, RA-2007

Sample Details	Borehole No.: BH-23		Sample Depth: 2.25 m	
	Sample No.: UDS-1		Sample Description: Clayey silt	
	Confining Pressure, σ_3 (kg/cm^2)	1.0	2.0	3.0
	Initial diameter (cm)	3.8	3.8	3.8
	Initial Length (cm)	7.6	7.6	7.6
	Bulk Density (g/cc)	1.79	1.79	1.79
	Dry Density (g/cc)	1.61	1.60	1.61
	Moisture Content (%)	11.4	11.6	11.0
Test Results	Peak Deviator Stress, $(\sigma_1-\sigma_3)_f$ (kg/cm^2)	1.53	1.77	1.98
	Failure Strain, ε_f (%)	22.4	22.4	22.4
	Cohesion intercept, c:	**0.80**	**kg/cm^2**	
	Angle of internal Friction, ϕ:	**6.6**	**degree**	

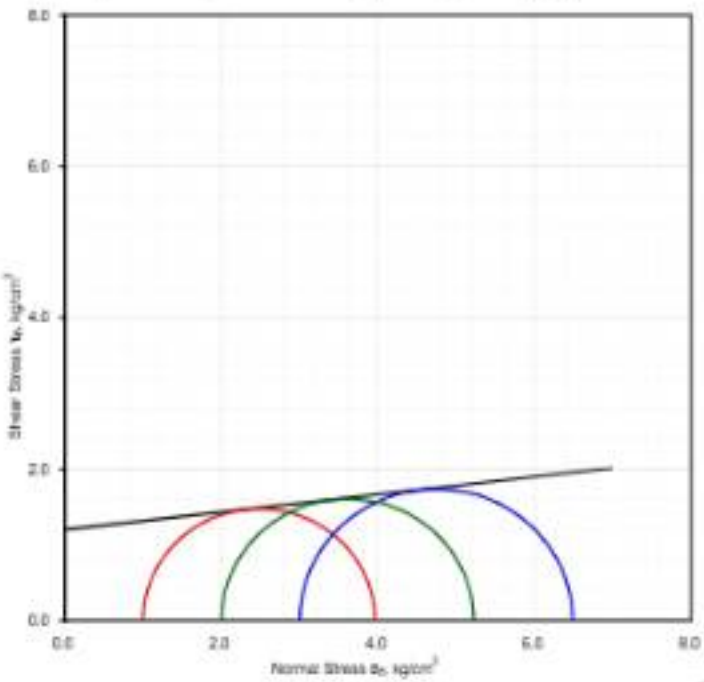


Mohr-Coulomb Failure Envelope

Unconsolidated Undrained Triaxial Test

IS : 2720 (Part-11)-1993, RA-2007

Sample Details	Borehole No.: BH-23		Sample Depth: 5.25 m	
	Sample No.: UDS-2		Sample Description: Clayey silt	
	Confining Pressure, σ_3 (kg/cm^2)	1.0	2.0	3.0
	Initial diameter (cm)	3.8	3.8	3.8
	Initial Length (cm)	7.6	7.6	7.6
	Bulk Density (g/cc)	1.82	1.82	1.82
	Dry Density (g/cc)	1.61	1.61	1.61
	Moisture Content (%)	13.2	13.1	13.3
Test Results	Peak Deviator Stress, $(\sigma_1-\sigma_3)_f$ (kg/cm^2)	2.99	3.22	3.48
	Failure Strain, ε_f (%)	22.4	22.4	22.4
	Cohesion intercept, c:	**1.20**	**kg/cm^2**	
	Angle of internal Friction, ϕ:	**6.6**	**degree**	

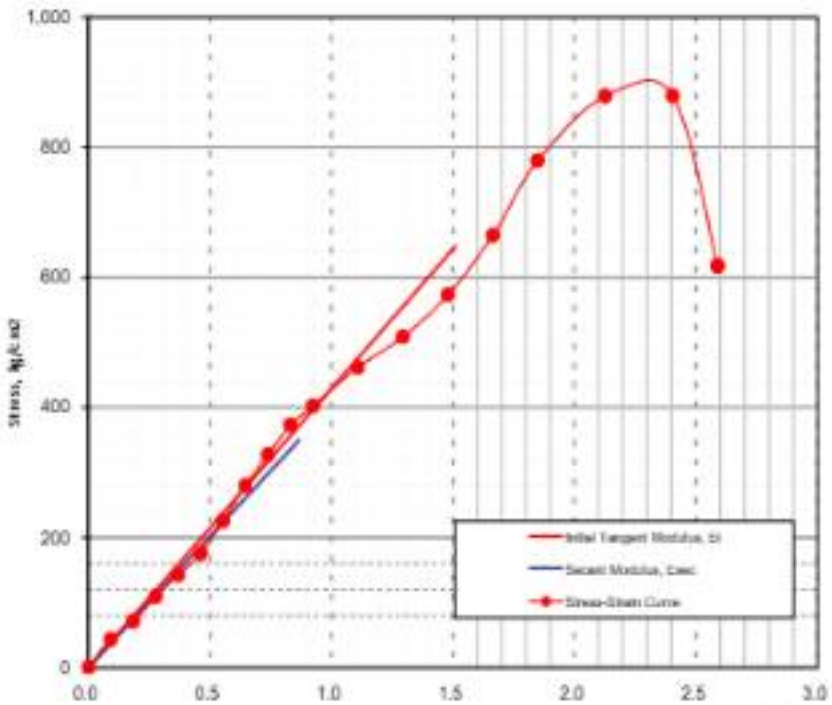


Mohr-Coulomb Failure Envelope

Uniaxial Compressive Strength

Test: (IS 9143-1979 RA-2008)

Borehole No. 23	Depth: 8.3 m	Sr. No. of Core : 10
SAMPLE DETAILS	TEST RESULTS	
Serial No. of Core.: 10	Unconfined Compressive Strength: 879 kg/sq.cm	
Rock Type: QUARTZITE		
Sample diameter (cm): 5.47	Failure Strain, ε: 2.4 %	
Sample Length (cm): 10.81	Secant Modulus, E_{sec}: 40346 kg/sq.cm	
Initial Bulk Density (g/cm^3): 2.55		
Sample Condition: Uncoated	Initial Tangent Modulus, E_i: 42857 kg/sq.cm	

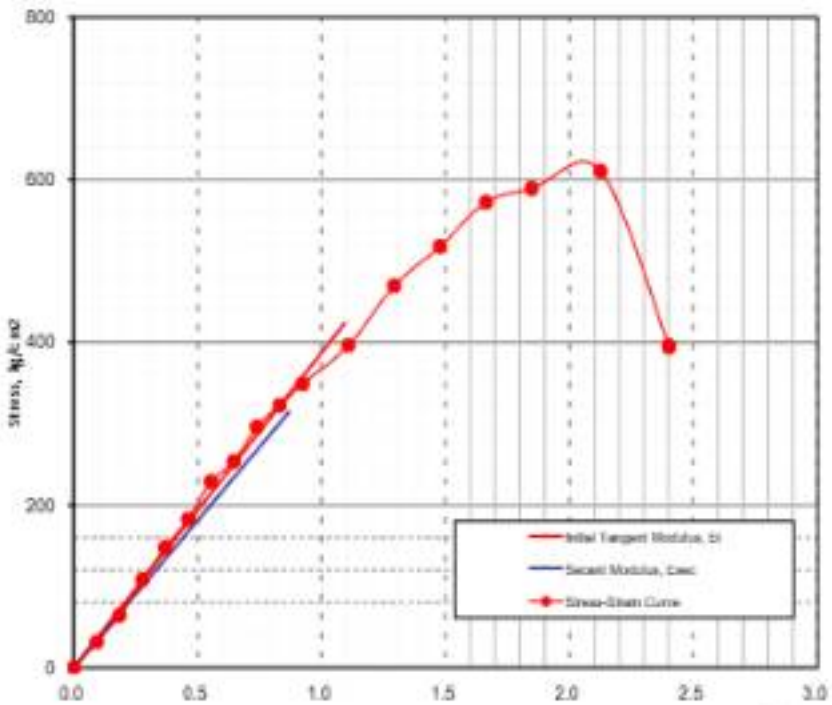


Uniaxial Compressive Strength Test on Rock Core Sample

Uniaxial Compressive Strength Test

(IS:9143-1979 RA-2006)

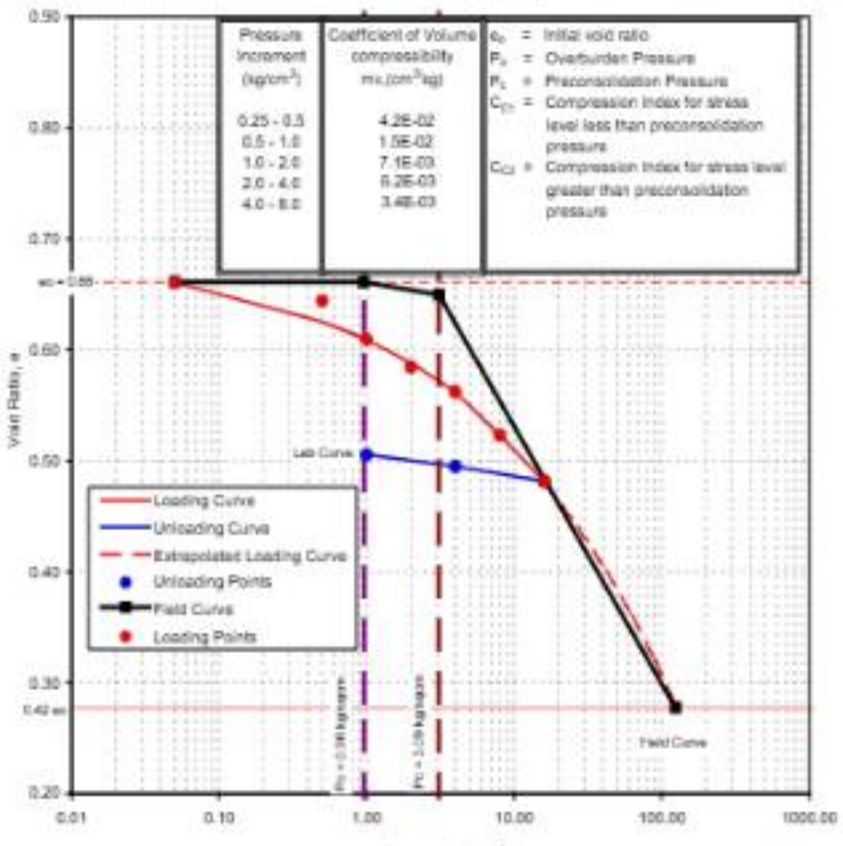
Borehole No. 23	Depth: 18.8 m	Sr. No. of Core : 71
SAMPLE DETAILS	TEST RESULTS	
Serial No. of Core : 71	Unconfined Compressive Strength: 611 kg/sq.cm	
Rock Type: QUARTZITE		
Sample diameter (cm): 5.51	Failure Strain, ε_f: 2.1 %	
Sample Length (cm): 10.83	Secant Modulus, E_{sec}: 36193 kg/sq.cm	
Initial Bulk Density (g/cm^3): 2.53		
Sample Condition: **Uncoated**	Initial Tangent Modulus, E_i: 38757 kg/sq.cm	



Uniaxial Compressive Strength Test on Rock Core Sample

Consolidation Test Results
IS : 2720 (Part-15)-1986, RA-2007
(Field Curve from Casagrande's Method)

Sample Details				Test Results	
	Borehole No. : 20	Initial moisture content : 13.2%			Preconsolidation Pressure (P_c) kg/cm^2 : 3.09
	Sample Depth, m : 6.25	Final moisture content : 15.5%			Overconsolidation Ratio (OCR): 3.2
	Sample No. : UDS-2	Initial Void Ratio before test (e_o) : 0.66			Compression Index (C_{c1}) for $p < p_c$: 0.022
	Soil Classification : Clayey silt	Final Void Ratio after test (e_f) : 0.48			Compression Index (C_{c2}) for $p > p_c$: 0.232



Void Ratio vs. Applied Pressure

TEST RESULTS

Soil-Water Extract Test Results				
Borehole No.	Depth, (m)	Sulphate Content (SO_3), %	Chloride Content (Cl), %	pH Value
BH-23	2.25	0.12	0.04	7.1

IS : 456-2000, SPECIFICATIONS

Requirements for Concrete Exposed to Sulphate Attack as per IS : 456-2000, Clauses 8.2.2.4 and 9.1.2, Table 4, Page-19

Class	Concentration of Sulphates, expressed as SO_3 In- Soil-Water Extract (Total) Percent	In Groundwater (mg/l)
1	Traces (<0.2)	Less than 300
2	0.2 to 0.5	300-1200
3	0.5 to 1.0	1200-2500
4	1.0 to 2.0	2500-5000
5	> 2.0	> 5000

Classification of Chloride Conditions in Groundwater*

Classification	Chloride Limits	
	Tropical Climate	Temperate Climate
Negligible	0-2000 ppm	Not Applicable
Moderate	2000-10,000 ppm	0-2000 ppm
High	More than 10,000 ppm	2000-20,000 ppm
Very High	Generally not applicable	Only if considerably in excess of 20,000 ppm

*Source : Institution of Civil Engineers, London (1976)

Chemical Test Results

Bor. no.	Rock Sample No.	Depth, m	(i) [illegible] (Part 2)=1987, IS(4...)=1987	(ii) [illegible] 1987 (Reaffirmed 2008)			By Calculation		(iii) [illegible] IS(P-2)2008	(iv) [illegible] IS(P-2)2008	*Rock's Grade Designation	Calcium Carbonate in Water
			Specific Gravity	Density (g/cm3)	Moisture Content, %	Water absorption, %	Void Ratio	Porosity	Point Load Index, (kg/cm2)	Unconfined Compressive Strength (kg/cm2)		
22	1	0.00-0.75	–	–	–	–	–	–	–	–	–	1.0
	2	3.25-3.50	2.77	2.63	0.11	0.56	0.060	0.076	–	876	–	–
	3	7.00-7.75	2.77	2.16	0.19	1.11	0.203	0.209	118	2037	–	–
	4	12.75-13.50	2.80	2.52	0.08	0.47	0.111	0.100	–	543	–	–
	5	14.25-15.00	–	–	–	–	–	–	–	–	–	1.0
	6	15.50-16.75	–	–	–	–	–	–	–	–	3	–
	7	16.50-17.25	2.77	2.63	0.21	0.71	0.089	0.079	127	2057	–	–
	8	17.25-18.00	–	–	–	–	–	–	–	–	3	–
	9	18.75-20.25	2.77	2.62	0.14	0.71	0.095	0.095	–	910	–	–
	10	24.00-24.50	–	–	–	–	–	–	–	–	–	0.0

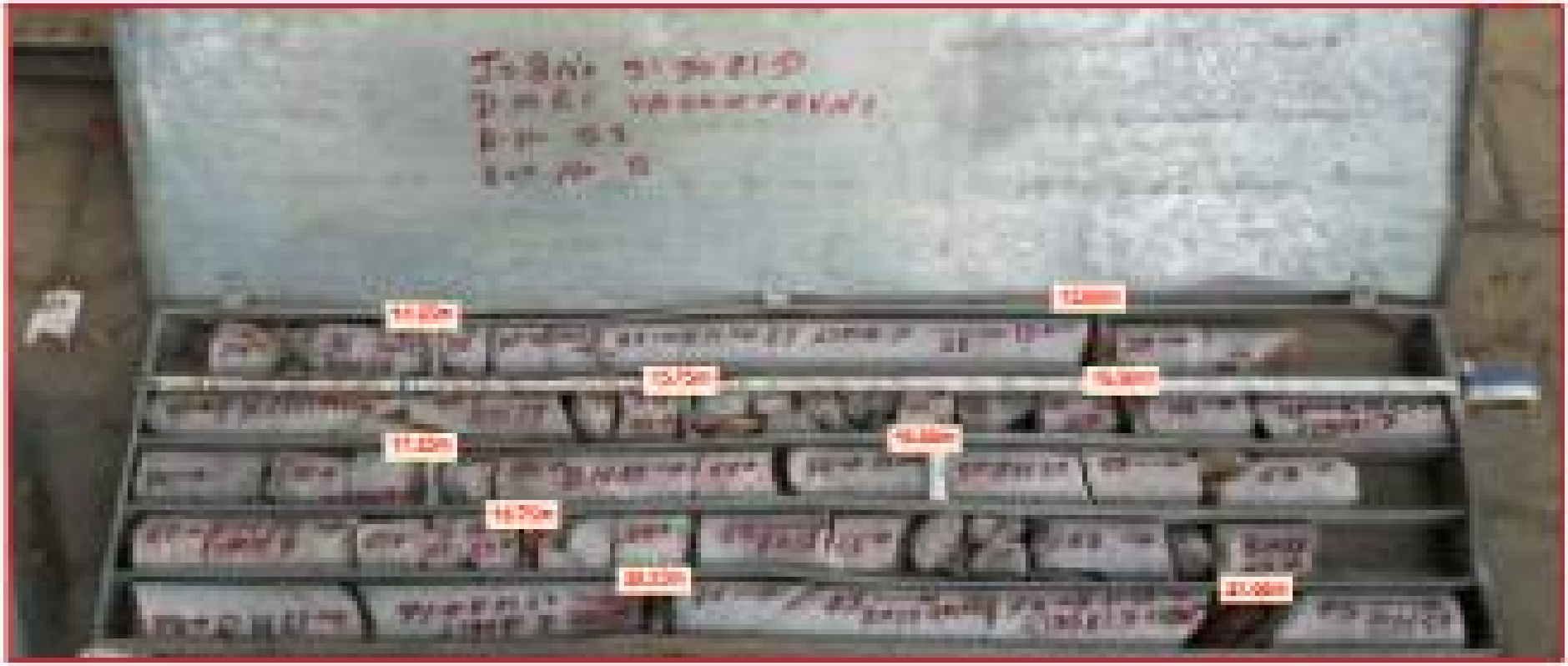
* Equivalent Unconfined Compressive Strength, based on Point Load Strength Index
** Denotes Rock's Sample

[illegible] Properties of Rock



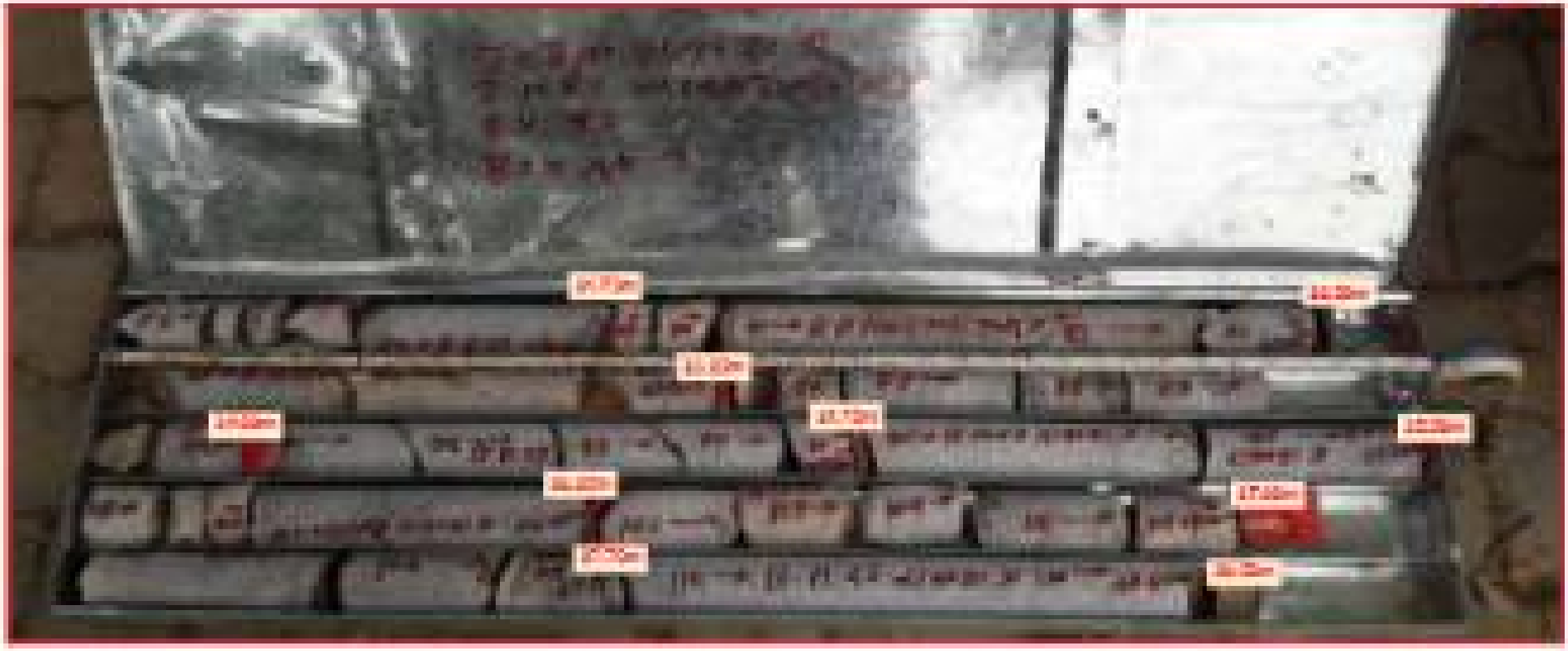
Borehole No. BH-02

Photographs of Rock Core Sample



Borehole No. BH-02

Photograph of Rock Core Sample



Borehole No. BH-42

Photograph of Rock Core Sample



Borehole No. BH-42

Photograph of Rock Core Sample

APPENDIX-BH-24

Caption	Plate
Soil & Rock Profiles	1 to 5
Atterberg Test	6
Grain Size Analysis	7
Sheans Test Results	8 to 11
Uniaxial Compressive Strength Test	12
Chemical Test Results	13
Physical Properties of Rock	14
Corebox Photographs	15 to 16

Soil Profile (BH 04)

Location: –
UTM Coordinates: [illegible]

Surface Elevation: 20.1 m
Ground Water Depth: Not met
Termination Depth: 30 m (RL 230.0 m)

Boring Method: Shell & Auger
Casing Depth: 15.0 m
Boring Date: 09-Jul-15
Boring Finish: 15-Jul-15

Depth, m		Sample No.	SPT (N)		Graphic Log	SOIL DESCRIPTION	Depth of Strata, m	Grain Size Analysis				Atterberg Limits			Density and Moisture				Water Table (m)	Other Tests					
From	To		Blows/0.15m	Blows/0.30m				Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Dry Density (kN/m³)	Bulk Density (kN/m³)	Saturated Density (kN/m³)	Moisture Content (%)		Specific Gravity	Void Ratio	Porosity (%)	Degree of Saturation (%)	Permeability (m/s)	Unconfined Compressive Strength (kPa)	Undrained Shear Strength (kPa)
0.00	1.00	S101				Laterite Fill	1.00																		
1.00	1.50	SPT1	20	33		Very stiff to hard brown clayey silt						34.0	18.0	16.0					3.00						
1.50	3.00	U101				– low plastic (CL), 1.0 to 2.0 m		0	10	70	20				1.80	1.82	11.0			18.0	1.21.3	1.0	32.1			
3.00	3.45	SPT2	21	37								33.0	19.0	14.0											
4.00	4.80	SPT3	30	33		– medium (MED) (CI), 4.5 to 5.0 m – intermixed with gravels, 4.8 to 5.00 m		20	10	30	30	32.0	17.7	17.0											
5.00	5.00	U202				– low plastic (CL), 5.0 to 10.0 m						33.1	17.0	16.1	1.80	1.87	11.9			18.0	1.21.3	1.0	31.2		
6.00	6.45	SPT4	31	50		– with traces of gravel, 6.0 to 7.0 m		1	10	50	37	33.1	16.1	14.0											
7.00	7.45	SPT5	50	45																					
8.00	8.00	U303													1.84	1.88	11.7			18.0	1.21.3	1.0	32.7		
9.00	9.45	SPT6	45	50				0	10	60	20	31.0	16.0	13.0					3.00						
10.00	10.45	SPT7	50	40								32.0	16.0	14.0											
11.00	11.00	U304													1.87	1.89	10.8			18.0	1.21.3	1.0	31.2		

Soil Profile (BH1-14)

Location : –
UTM Coordinates : [illegible]

Surface Elevation : 28.1 m
Ground Water Depth : Not met
Termination Depth : 30 m (RL 2.9 m)

Boring Method : Shell & Auger
Casing Depth : 12.0 m
Boring Date : 09-Jul-15
Boring Finish : 15-Jul-15

Depth, m		Legend	SPT N		Soil Type	SOIL DESCRIPTION	Depth of Strata, m	Grain Size Analysis				Atterberg Limits			Density and Moisture				Water Level (m)	Direct Tests					Triaxial Tests		
From	To		Recorded N	Corrected N				Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Total Unit Weight (kN/m³)	Dry Unit Weight (kN/m³)	Void Ratio	Moisture Content (%)		Cohesion (kPa)	Friction Angle (°)	Cohesion (kPa)	Friction Angle (°)	Undrained Shear Strength (kPa)	Total Cohesion (kPa)	Effective Friction Angle (°)
12.00	12.30	SPT12	12			Dark brown clayey silt, low plastic (CL)	12.30	0	11	39	50															
						Refusal met on Rock. Core drilling through rock adopted. Refer to next page for details.																					

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Hole no. (SDH-04)

Location :	--	Surface Elevation :	350.344
UTM Coordinates :	7331771.32, 3107320.16	Ground Water Depth :	Not met
		Termination Depth :	25.00 m, (25.3 m)
Boring Method :	Rotary Drilling
Casing Depth :	12.0 m
Casing Date :	09-Jul-18
Boring Finish :	10-Jul-18

Depth (m)	Depth (m)	Sample No.	Core Run (% Core)	Core Log/Point Load	Symbol	ROCK DESCRIPTION	Depth (Thickness) (m)	Bulk Density (Compacted) (kN/m³)	Dry Density (kN/m³)	Point Load Index (MPa)	Water Content (%)	Core Diameter (mm)	Core Length (mm)	Core Recovery (%)	Core Recovery (%)	Rock Quality Designation (RQD) (%)	Rock Quality Designation (RQD) (%)	Uniaxial Compressive Strength (MPa)	Uniaxial Compressive Strength (MPa)	Uniaxial Compressive Strength (MPa)
12.00	12.00					Groundwater not met in boring upto 12.0 m depth.														
12.00						SILICIFIED, medium to moderately hard, moderately weathered															
14.50		R001	1-5					42	30									0.48	0.73	0.60
15.00	15.00					-- Occasional thin strong, moderately fractured, moderately weathered, 13.1 to 17.20 m														
15.00		R002	7					50	50									1.41	2.73	2.04
16.75	16.75									50										
16.75		R003	9-10					37	33											
18.00	18.00																			
17.00		R004	11-13					43	44											
17.00	17.00																			
17.70		R005	10-12			-- strong, moderately fractured, 17.20 m to 18.70 m		52	50									0.97		1.40
18.70	18.70									50										
19.45		R006	21-25			-- moderately strong, very thickly laminated, 18.70 m to 19.80 m		58	55									0.91	2.73	1.33

Hole Number (BH1-24)

Location:	--	Surface Elevation:	(m)
uTM Coordinates:	(E) (N)	Ground Water Depth:	Not met
		Termination Depth:	(m)
		Working Method:	Rotary Drilling
		Casing Depth:	(m)
		Casing Date:	
		Boring Finish:	

Depth (m)	Level (mOD)	Legend	Sample No. / Type	Field Records	Graphic Log	Description	Depth (Thickness) (m)	Water Strikes (m)	Insitu Testing / Results	Backfill Details	Water Strikes (m)	Casing Depth (m)	Casing Diameter (mm)	Water Level (m)	Date	Time

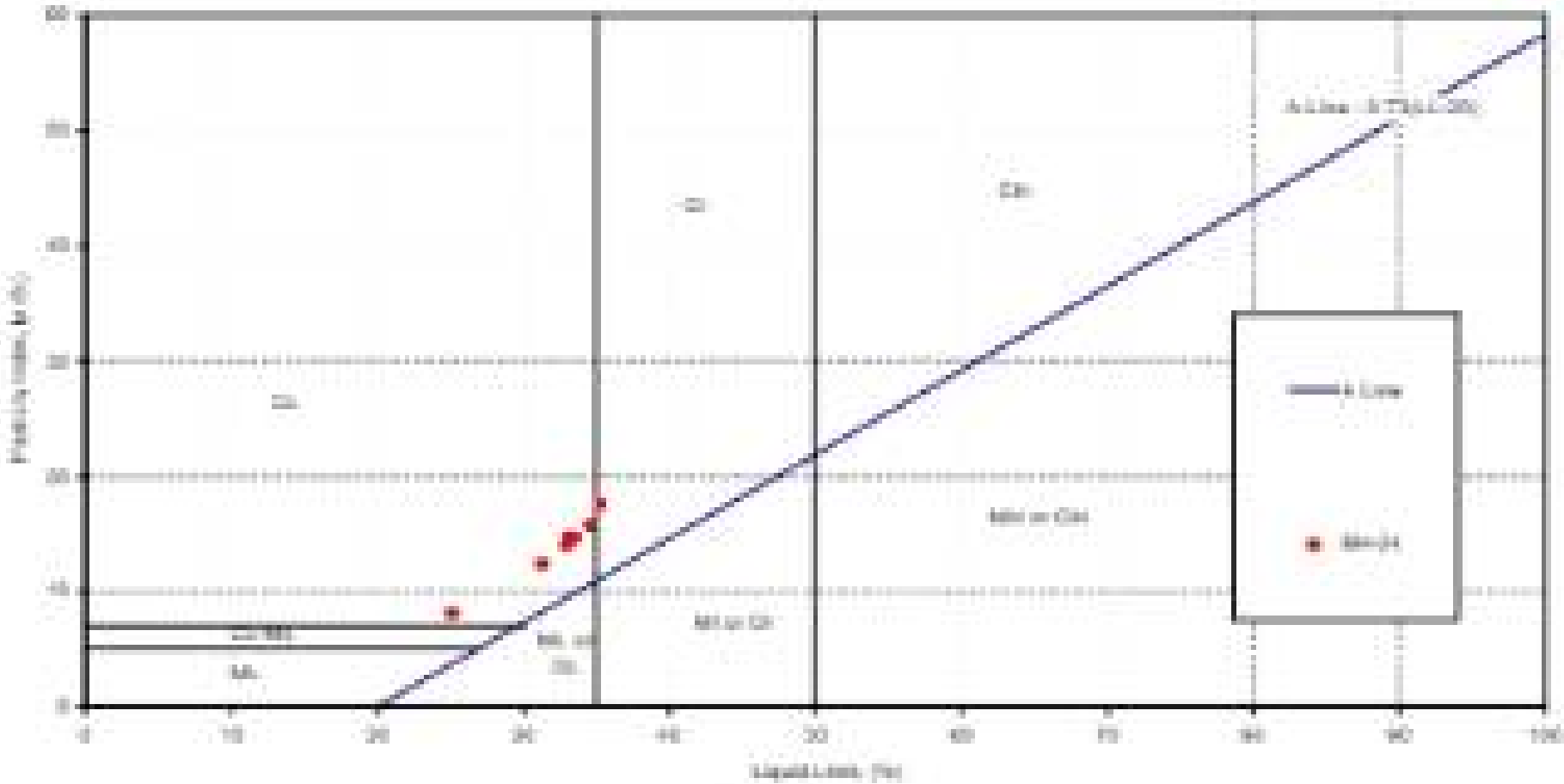
Hole No.(Name of Hole)

Location : --
UTM Coordinates : [illegible]

Surface Elevation : [illegible]
Ground Water Depth : [illegible]
Termination Depth : [illegible]

Boring Method : Rotary Drilling
Casing Depth : [illegible]
Casing Date : [illegible]
Boring Finish : [illegible]

Depth (m)	Thickness (m)	Graphic Log	Sample No.	Core Run (%)	Core Recovery (%)	RQD (%)	Description	Depth of Hole (m)	Water Return	Water Level	Core Run	Core Recovery (%)	RQD (%)	Fracture Index	Fracture Density (No./m)	Joint Condition	Joint Roughness Number	Joint Alteration Number
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Moderately strong, intensely fractured completely weathered, [illegible] to [illegible] m	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

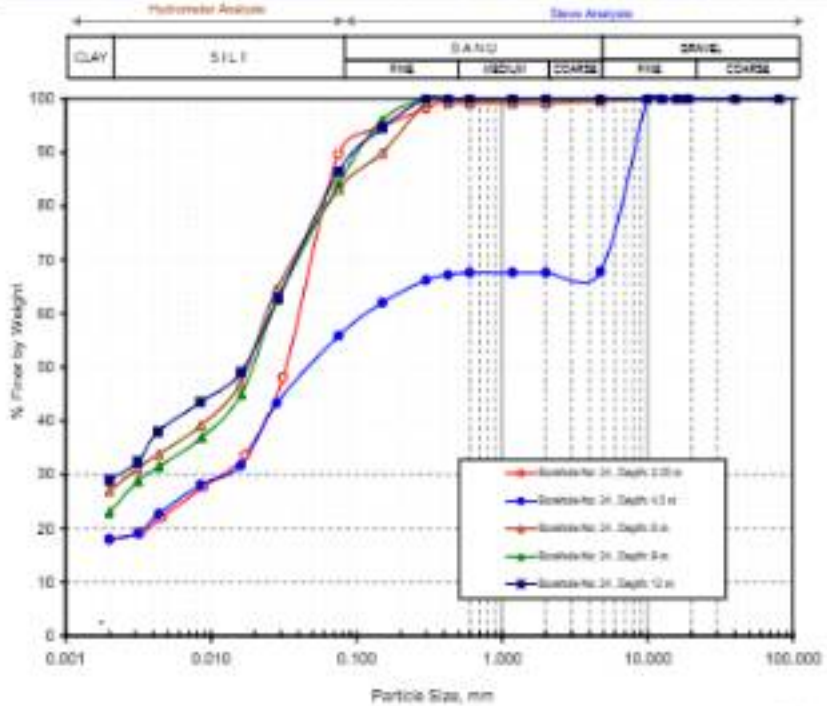


Plasticity Chart

Grain Size Analysis

IS : 2720 (Part 4) - 1985, RA-2010

Sample Details			Test Results								
Borehole Number	Sample Depth, m	Sample Description	% Gravel	% Sand	% Silt	% Clay	D_{60}	D_{10}	D_{30}	C_u	C_c
BH-24	2.25	Clayey silt (CL)	0	10	72	18	0.044	0.012			
BH-24	4.50	Clayey silt intermixed with gravels (CI)	32	12	38	18	0.129	0.012			
BH-24	6.00	Clayey silt with traces of gravel (CL)	1	16	56	27	0.025	0.003			
BH-24	9.00	Clayey silt (CL)	0	15	62	23	0.027	0.004			
BH-24	12.00	Clayey silt (CL)	0	13	58	29	0.026	0.002			

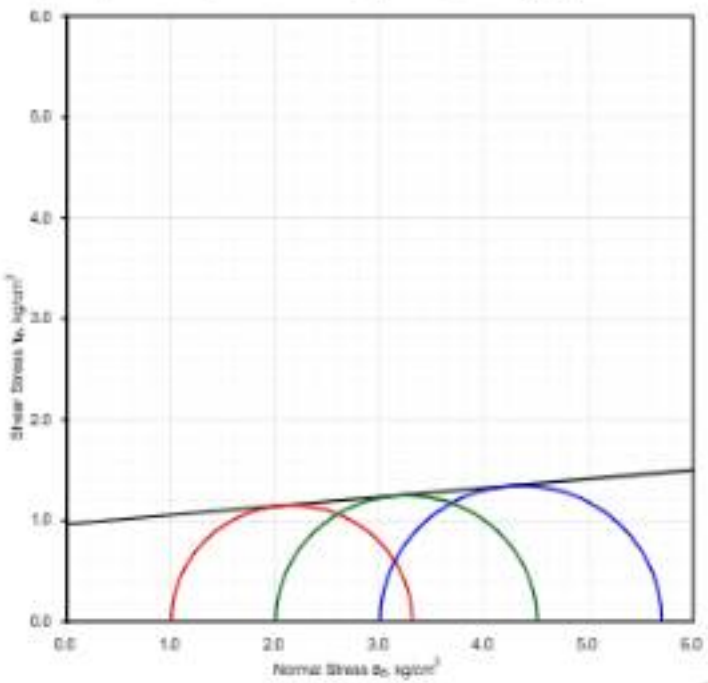


Grain Size Distribution Curve

Unconsolidated Undrained Triaxial Test

IS : 2720 (Part-11)-1993, RA-2007

Sample Details	Borehole No.: BH-24		Sample Depth: 2.25 m	
	Sample No.: UDS-1		Sample Description: Clayey silt	
	Confining Pressure, σ_3 (kg/cm^2)	1.0	2.0	3.0
	Initial diameter (cm)	3.8	3.8	3.8
	Initial Length (cm)	7.6	7.6	7.6
	Bulk Density (g/cc)	1.80	1.80	1.80
	Dry Density (g/cc)	1.62	1.62	1.62
	Moisture Content (%)	11.3	11.1	11.4
Test Results	Peak Deviator Stress, $(\sigma_1-\sigma_3)_f$ (kg/cm^2)	2.31	2.50	2.70
	Failure Strain, ε_f (%)	22.4	22.4	22.4
	Cohesion intercept, c:	**1.00**	**kg/cm^2**	
	Angle of internal Friction, ϕ:	**5.1**	**degree**	

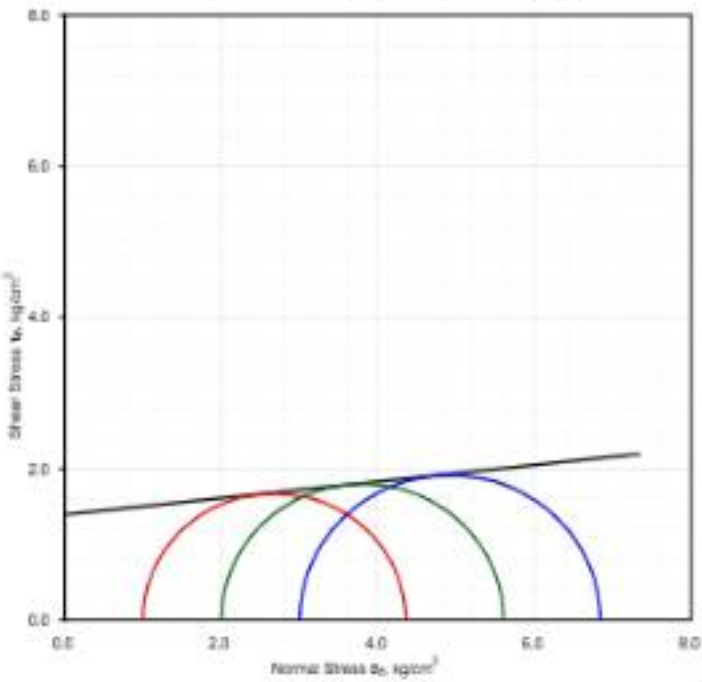


Mohr-Coulomb Failure Envelope

Unconsolidated Undrained Triaxial Test

IS : 2720 (Part-11)-1993, RA-2007

Sample Details	Borehole No.: BH-24		Sample Depth: 5.25 m	
	Sample No.: UDS-2		Sample Description: Clayey silt	
	Confining Pressure, σ_3 (kg/cm^2)	1.0	2.0	3.0
	Initial diameter (cm)	3.8	3.8	3.8
	Initial Length (cm)	7.6	7.6	7.6
	Bulk Density (g/cc)	1.90	1.90	1.90
	Dry Density (g/cc)	1.67	1.67	1.67
	Moisture Content (%)	13.8	13.7	13.8
Test Results	Peak Deviator Stress, $(\sigma_1-\sigma_3)_f$ (kg/cm^2)	3.39	3.60	3.84
	Failure Strain, ε_f (%)	22.4	22.4	22.4
	Cohesion intercept, c:	**1.40**	**kg/cm^2**	
	Angle of internal Friction, ϕ:	**6.2**	**degree**	

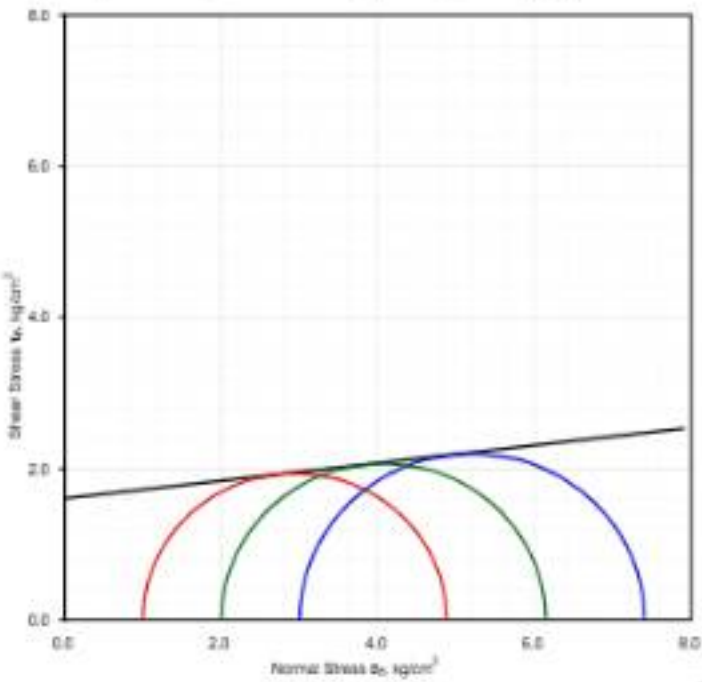


Mohr-Coulomb Failure Envelope

Unconsolidated Undrained Triaxial Test

IS : 2720 (Part-11)-1993, RA-2007

	Borehole No.: BH-24	Sample Depth: 8.25 m		
	Sample No.: UDS-3	Sample Description: Clayey silt		
Sample Details	Confining Pressure, σ_3 (kg/cm^2)	1.0	2.0	3.0
	Initial diameter (cm)	3.8	3.8	3.8
	Initial Length (cm)	7.6	7.6	7.6
	Bulk Density (g/cc)	1.94	1.94	1.94
	Dry Density (g/cc)	1.68	1.68	1.68
	Moisture Content (%)	15.7	15.6	15.6
Test Results	Peak Deviator Stress, $(\sigma_1-\sigma_3)_f$ (kg/cm^2)	3.89	4.14	4.40
	Failure Strain, ε_f (%)	22.4	22.4	22.4
	Cohesion intercept, c:	**1.89**	**kg/cm^2**	
	Angle of internal Friction, ϕ:	**6.7**	**degree**	

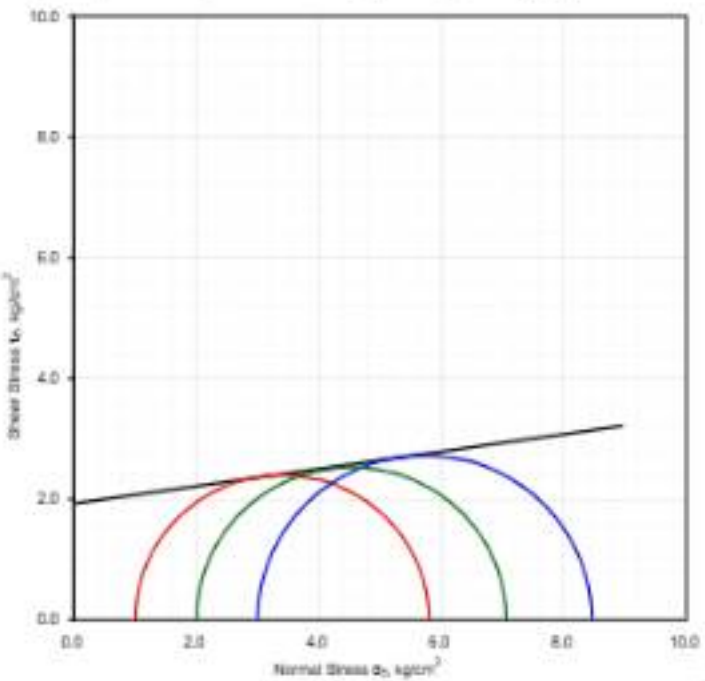


Mohr-Coulomb Failure Envelope

Unconsolidated Undrained Triaxial Test

IS : 2720 (Part-11)-1993, RA-2007

Sample Details	Borehole No.: BH-24		Sample Depth: 11.25 m	
	Sample No.: UDS-4		Sample Description: Clayey silt	
	Confining Pressure, σ_3 (kg/cm^2)	1.0	2.0	3.0
	Initial diameter (cm)	3.8	3.8	3.8
	Initial Length (cm)	7.6	7.6	7.6
	Bulk Density (g/cc)	1.97	1.97	1.97
	Dry Density (g/cc)	1.69	1.69	1.69
	Moisture Content (%)	16.9	16.8	16.7
Test Results	Peak Deviator Stress, $(\sigma_1-\sigma_3)_f$ (kg/cm^2)	4.80	5.06	5.46
	Failure Strain, ε_f (%)	22.4	22.4	22.4
	Cohesion intercept, c:	**1.90**	**kg/cm^2**	
	Angle of internal Friction, ϕ:	**8.2**	**degree**	

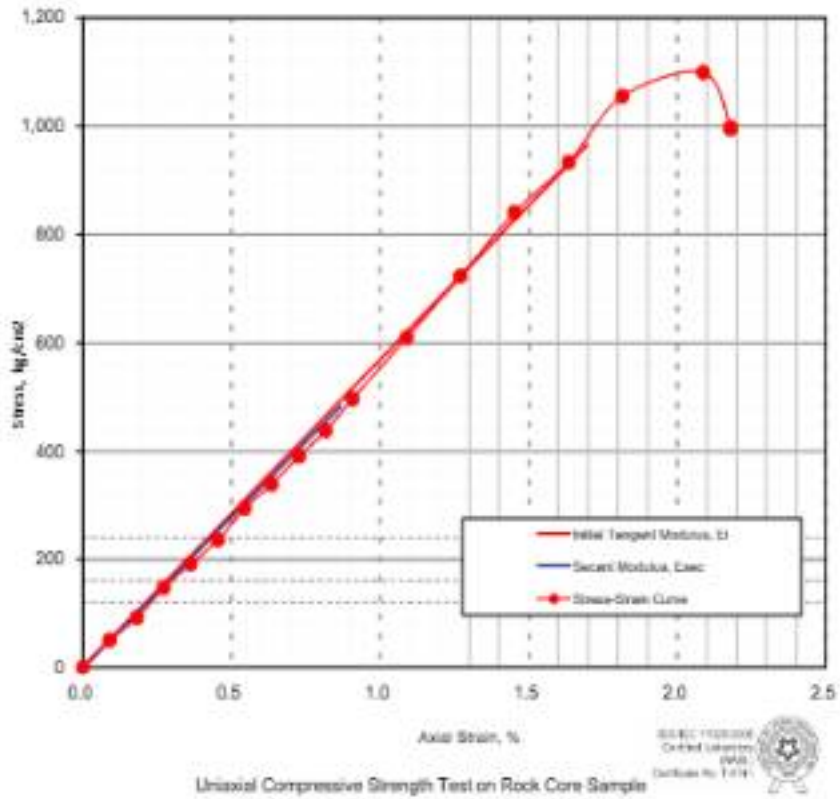


Mohr-Coulomb Failure Envelope

Uniaxial Compressive Strength Test

(IS:9143-1979 RA-2006)

Borehole No. 24	Depth: 24 m	Sr. No. of Core : 49
SAMPLE DETAILS	TEST RESULTS	
Serial No. of Core.: 49	Unconfined Compressive Strength: 1099 kg/sq.cm	
Rock Type: QUARTZITE		
Sample diameter (cm): 5.50	Failure Strain, ε_f: 2.1 %	
Sample Length (cm): 11.01	Secant Modulus, E_{sec}: 55660 kg/sq.cm	
Initial Bulk Density (g/cm^3): 2.63		
Sample Condition: Unsoaked	Initial Tangent Modulus, E_i: 58008 kg/sq.cm	



Uniaxial Compressive Strength Test on Rock Core Sample

TEST RESULTS

Soil-Water Extract Test Results				
Borehole No.	Depth, (m)	Sulphate Content (SO_3), %	Chloride Content (Cl), %	pH Value
BH-24	5.25	0.11	0.03	8.3

IS : 456-2000, SPECIFICATIONS

Requirements for Concrete Exposed to Sulphate Attack as per IS : 456-2000, Clauses 8.2.2.4 and 9.1.2, Table 4, Page-19

Class	Concentration of Sulphates, expressed as SO_3 In- Soil-Water Extract (Total) Percent	In Groundwater (mg/l)
1	Traces (<0.2)	Less than 300
2	0.2 to 0.5	300-1200
3	0.5 to 1.0	1200-2500
4	1.0 to 2.0	2500-5000
5	> 2.0	> 5000

Classification of Chloride Conditions in Groundwater*

Classification	Chloride Limits	
	Tropical Climate	Temperate Climate
Negligible	0-2000 ppm	Not Applicable
Moderate	2000-10,000 ppm	0-2000 ppm
High	More than 10,000 ppm	2000-20,000 ppm
Very High	Generally not applicable	Only if considerably in excess of 20,000 ppm

*Source : Institution of Civil Engineers, London (1976)

Chemical Test Results

Bor. no.	Rock symbols No.	Depth, m	[illegible]	[illegible]			By Calculation		[illegible]	[illegible]	*Rock's Grade	Cavities Encountered in Holes
			Specific Gravity	Density (g/cm3)	Moisture Content, %	Water Absorption, %	Void Index	Porosity	Point Load Index (kg/cm2) (1)	Equivalent Unconfined Compressive Strength (kg/cm2) (1)		
	2	13.50~13.65	2.72	2.64	0.19	0.38	0.020	0.054	147	3220*	1	-
	7	15.00~15.15	2.70	1.91	--	--	0.716	0.363	--	561	--	--
	12	16.50~17.23	--	--	--	--	--	--	--	--	--	0
	15	17.25~18.75	-	2.29	0.56	0.33	-	-	-	683	-	-
FV	24	18.75~19.50	2.76	2.61	--	--	0.057	0.450	161	3352*	--	-
	34	21.00~21.15	--	2.64	0.31	0.60	--	--	--	--	--	0
	40	22.50~23.25	--	2.18	2.03	0.56	-	-	7	127	0	-
	43	23.25~24.00	--	--	--	--	--	--	--	--	--	0
	49	24.00~25.05	2.76	2.63	0.09	0.13	0.037	0.254	--	1066	--	-

[1] Equivalent Unconfined Compressive Strength based on Point Load Strength Index

** Outside NWBL Scope

[illegible]
Central Laboratory
[illegible]
Cambodia

(Physical Properties of Rock)



Borehole No. BH-01

Photographs of Rock Core Sample



Borehole No. BH-01

Photograph of Rock Core Sample

APPENDIX-BH-25

Caption	Plate
Soil & Rock Profiles	1 to 4
Standard Penetration Test	5 to 6
Atterberg Test	7
Grain Size Analysis	8
Shears Test Results	9 to 11
Consolidation Test Results	12
Uniaxial Compressive Strength Test	13 to 14
Chemical Test Results	15
Physical Properties of Rock	16
Corebox Photographs	17 to 18

Soil Profile (BH-04)

Location : –
UTM Coordinates : [illegible]

Surface Elevation : 203.4 m
Ground Water Depth : Not met
Termination Depth : 30 m (EL 233.4 m)

Boring Method : Shell & Auger
Casing Depth : +1.0 m
Boring Date : 30-Jun-15
Boring Finish : 01-Jul-15

Depth, m		Sample No.	SPT N-value		Graphic Log	SOIL DESCRIPTION	Depth of Strata, m	Grain Size Analysis				Atterberg Limits			Density and Moisture			Bulk Density (kN/m³)	Direct Tests				Chemical Tests	
From	To		Blow Counts (N)	Corrected N-value (N1)60				Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Moisture Content (%)	Dry Density (kN/m³)	Degree of Saturation (%)		Cohesion (kPa)	Friction Angle (°)	Shear Strength (kPa)	Sulphate (%)	Chloride (%)
0.00	1.00	SS01				Utility Pit	1.00																	
1.00	1.80	SPT1	22	22		Very stiff to hard brown clayey silt																		
1.80	3.00	SS02				- low plastic (CL), 1.0 to 1.8 m		0	12	53	35	28.1	20.1	8.0	1.79	1.60	12.1	2.02	18.7	1.2	2.3	0.6	0.1	
3.00	3.45	SPT2	22	22		- silty clay, 1.8 to 3.0 m - with traces of gravel, 3.0 to 3.45 m						21.3	19.2	1.0										
4.20	4.80	SPT3	44	44		- hard, 4.2 to 4.8 m		10	9	39	42	21.6	19.0	1.6				2.03						
5.20	5.80	SS04				- with gravel, 4.8 to 5.8 m									1.80	1.62	11.1		18.7	1.2	2.3	1.0	0.6	
6.80	6.90	SPT4	56	56				11	17	52	24	26.3	16.7	9.6				2.06						
7.20	7.80	SPT5	45	45		- medium plastic (CI), 7.0 to 8.0 m	8.00					25.3	17.9	7.3				2.05						
8.20	8.80	SS06				Hard brown sandy silt, low plastic (CL)	9.00	0	20	59	19	24.1	20.1	3.9	1.91	1.65	15.8	2.04	18.7	1.2	2.3	1.7	0.7	
9.20	9.45	SPT6	45	45		Hard brown clayey silt (CL)		0	15	57	28													
10.00	10.00	SS07	Sampler Refusal			- with gravels, 9.0 to 10.0 m	10.00																	
12.00	12.45	SPT8	50	50		Extremely dense to hard brown silty sand to sandy silt (glacial till)																		

[illegible]

Hole [illegible]

Location: –
Surface Elevation: [illegible]
Ground Water Depth: [illegible]
Termination Depth: [illegible]
Boring Method: Rotary Drilling
Casing Depth: [illegible]
Casing Size: [illegible]
Boring Finish: [illegible]

Depth (m)	Legend	Sample No.	Core Run (Core Recovery)	Core Fracture Index (Core Recovery)	Graphic Log	ROCK DESCRIPTION	Point Load Strength Index (MPa)	Fracture Density (Fractures per m)	Rock Quality Designation (RQD) (%)	Discontinuities	Water Strike (m)	Water Level (m)	Water Loss (L/min)	Uniaxial Compressive Strength (MPa)	Modulus of Deformation (GPa)
12.00						Very weak to moderately strong, very [illegible] SLIGHTLY TO [illegible] fractured, highly to [illegible] weathered									
12.50															
13.00															
13.50															
14.00															
14.50															
15.00															
15.50															
16.00															
16.50															
17.00															
17.50															
18.00															
18.50															

- [illegible] weathered, [illegible] 12.00 to 12.50 m
- very weak, disintegrated, completely weathered, 12.00 to 13.0 m
- moderately strong, moderately fractured, moderately weathered, 13.00 to 16.00 m

Core Run (m): Log Run 3.00; Core 3.00; Core Run 3.00

Project No. [illegible]

[illegible]

Page 2 of 10

Hole [illegible]

Location :	--	Surface Elevation :	[illegible]
UTM Coordinates :	[illegible]	Ground Water Depth :	Not met
		Termination Depth :	[illegible]
Boring Method :	Rotary Drilling
Casing Depth :	[illegible]
Casing Date :	[illegible]
Boring Finish :	[illegible]

Depth (ft)	Depth (m)	Sample No.	Recovery (%)	Core Run (ft)	Description	Graphic Log	Depth (ft)	Bulk Density (kN/m³)	Dry Density (kN/m³)	Moisture Content (%)	Point Load Index (MPa)	Uniaxial Compressive Strength (MPa)	Modulus Ratio
[illegible]					Moderately strong, grey fine/coarse-grained limestone, moderately to moderately fractured, and laminated to highly weathered		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]					- Occasionally strong, intensely fractured, highly weathered ~[illegible] m [illegible] m		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]					- Occasionally strong, moderately fractured, highly weathered [illegible] m [illegible] m		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]							[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]							[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]							[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]							[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]							[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]							[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]							[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Hole Number (BH-01)

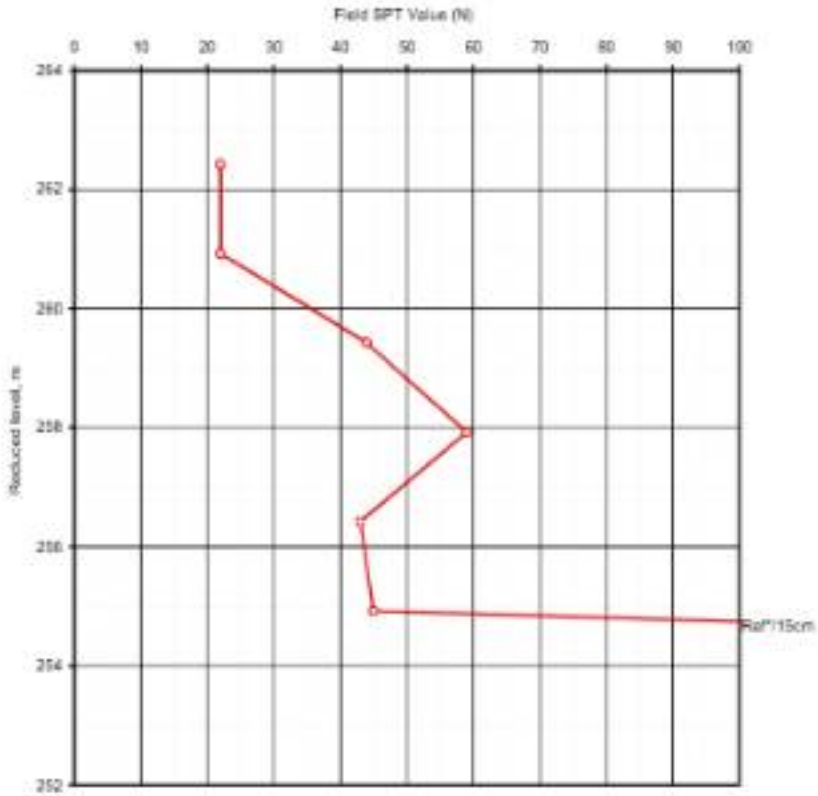
Location :	--	Surface Elevation :	(RL) 0.00 m	Working Method :	Rotary Drilling
UTM Coordinates :	713241 E, 3107823 N	Ground Water Depth :	Not met	Casing Depth :	11.00 m
		Termination Depth :	(T.D) (RL -21.00 m)	Casing Size :	6in (150 mm)
				Boring Finish :	30-Jun-19

Depth (m)	Legend	Description	Depth (RL) (m)	Sample Number	Sample Type	Sample Depth (m)	Sample Depth (RL) (m)	Blow Count (Number of Hits per 150mm)			SPT 'N' Value (Blows/300mm)	Dynamic Cone Penetrometer (DCP) Value (Blows/300mm)	Undrained Shear Strength (kPa)	Remarks
								0-150mm	150-300mm	300-450mm				
0.00 - 21.00		Moderately strong, grey Hornblende-Muscovite-Biotite Gneiss, moderately fractured, moderately weathered												

Standard Penetration Test

IS : 2131-1981, RA-2007

Borehole Details			
Symbol	Borehole Number	Reduced Level,m	Location
	BH-20	263.9	-

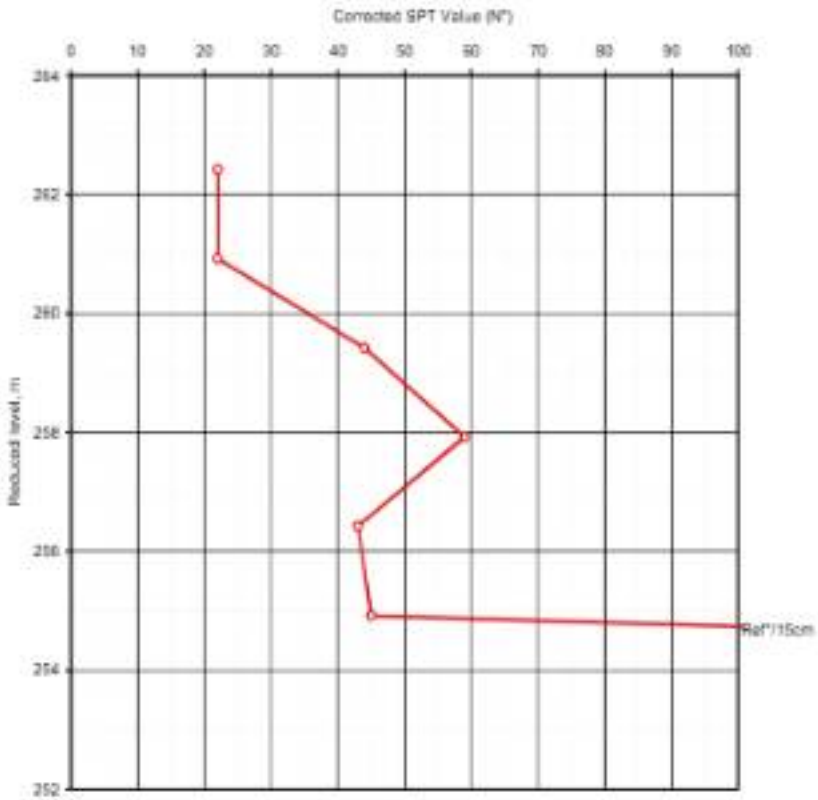


Field SPT Values vs Reduced level

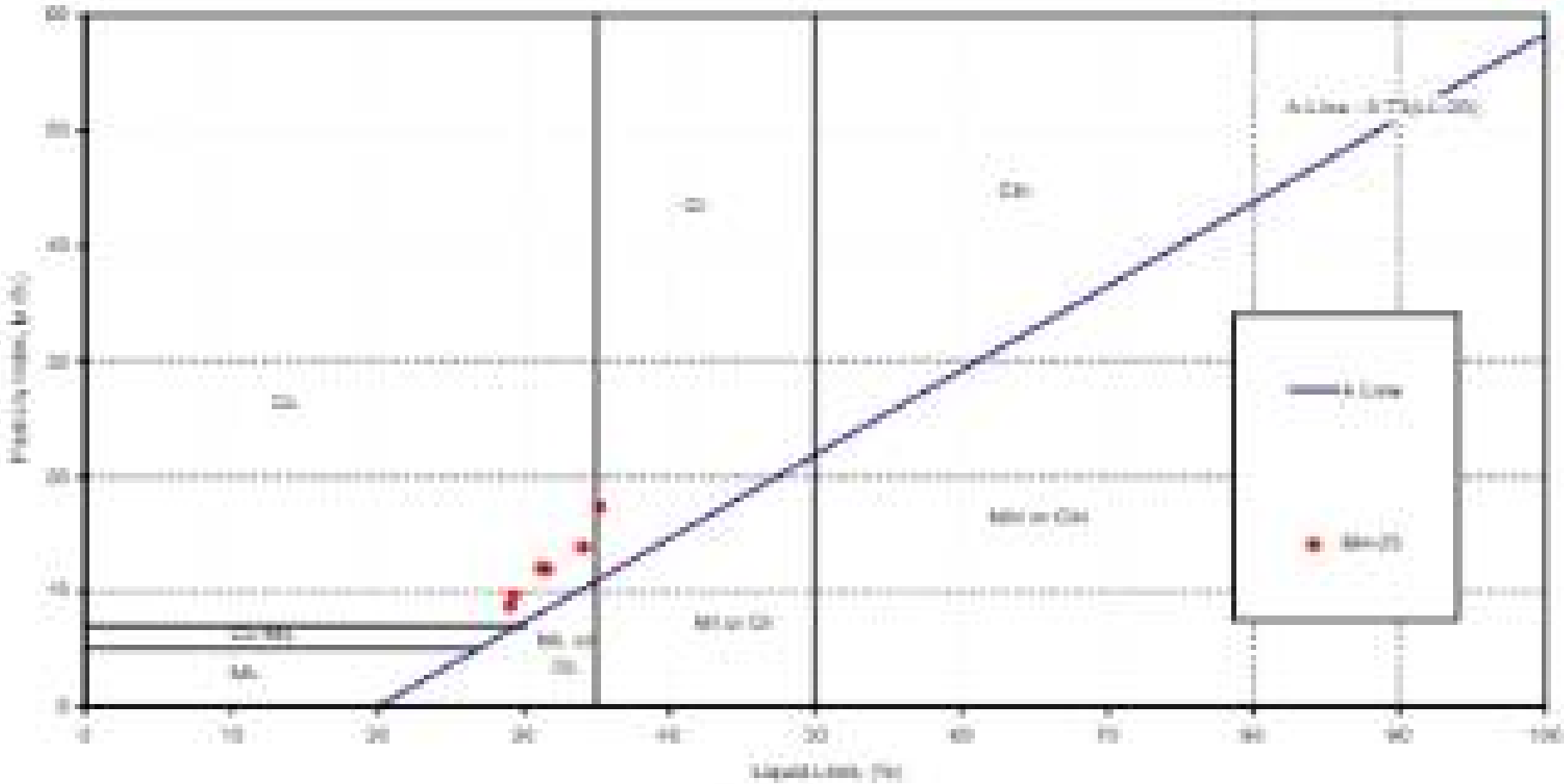
Standard Penetration Test

IS : 2131-1981, RA-2007

Borehole Details			
Symbol	Borehole Number	Reduced Level,m	Location
	BH-20	263.9	-



Corrected SPT Values vs Reduced level

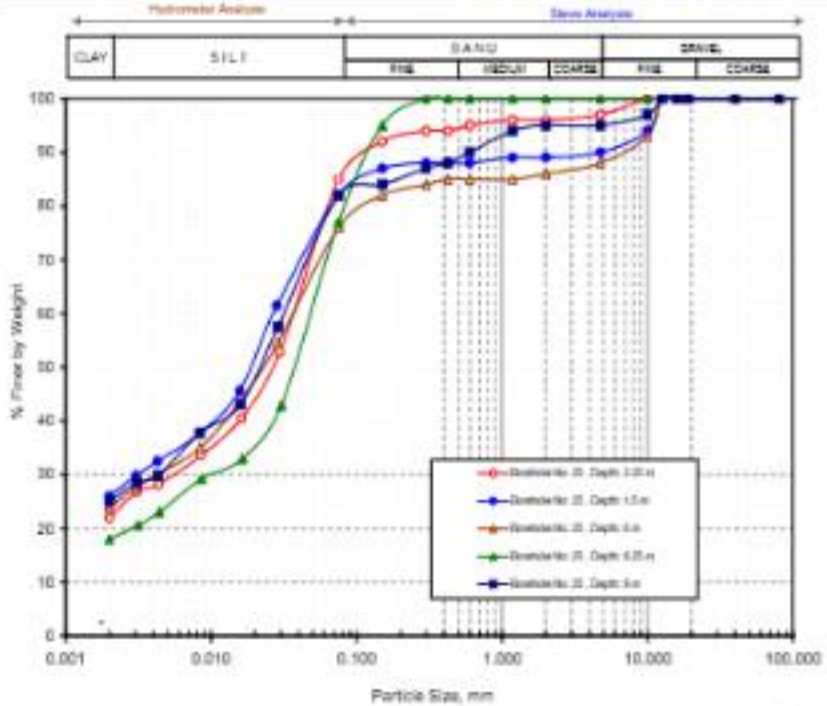


Plasticity Chart

Grain Size Analysis

IS : 2720 (Part 4) - 1985, RA-2010

Sample Details			Test Results								
Borehole Number	Sample Depth, m	Sample Description	% Gravel	% Sand	% Silt	% Clay	D_{60}	D_{30}	D_{10}	C_u	C_c
BH-25	2.25	Clayey silt with traces of gravel (CL)	3	12	63	22	0.043	0.006			
BH-25	4.50	Clayey silt with gravels (CL)	10	8	56	26	0.027	0.003			
BH-25	6.00	Clayey silt with gravels (CL)	12	12	52	24	0.040	0.004			
BH-25	6.25	Sandy silt (CL)	0	23	59	18	0.053	0.010			
BH-25	9.00	Clayey silt with gravels (CI)	5	13	57	25	0.043	0.004			

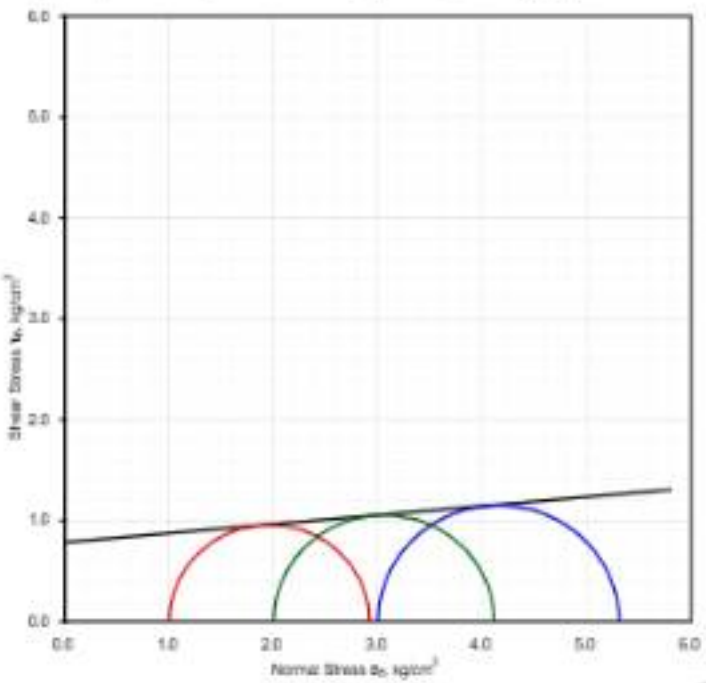


Grain Size Distribution Curve

Unconsolidated Undrained Triaxial Test

IS : 2720 (Part-11)-1993, RA-2007

Sample Details	Borehole No.: BH-25		Sample Depth: 2.25 m	
	Sample No.: UDS-1		Sample Description: Clayey silt	
	Confining Pressure, σ_3 (kg/cm^2)	1.0	2.0	3.0
	Initial diameter (cm)	3.8	3.8	3.8
	Initial Length (cm)	7.6	7.6	7.6
	Bulk Density (g/cc)	1.79	1.79	1.79
	Dry Density (g/cc)	1.60	1.59	1.60
	Moisture Content (%)	12.1	12.3	12.2
Test Results	Peak Deviator Stress, $(\sigma_1-\sigma_3)_f$ (kg/cm^2)	1.92	2.11	2.31
	Failure Strain, ε_f (%)	22.4	22.4	22.4
	Cohesion intercept, c:	**0.89**	**kg/cm^2**	
	Angle of internal Friction, ϕ:	**6.1**	**degree**	

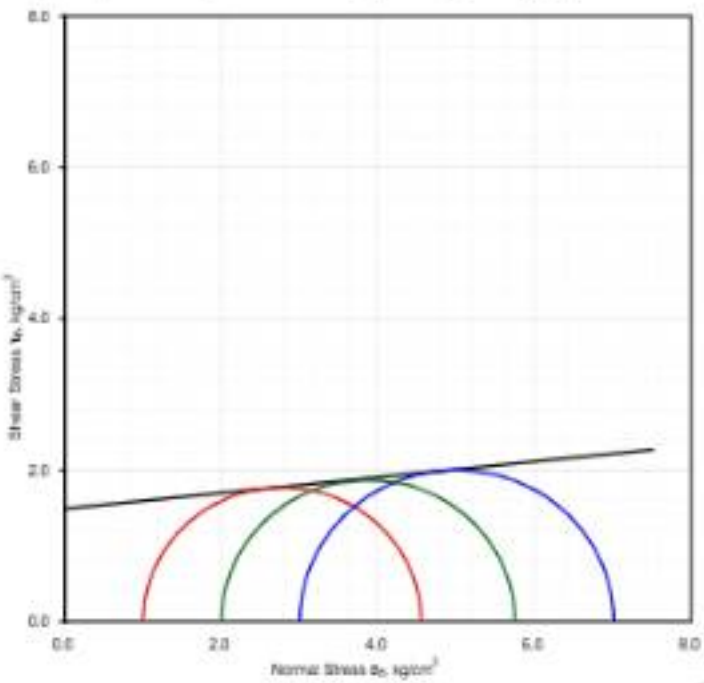


Mohr-Coulomb Failure Envelope

Unconsolidated Undrained Triaxial Test

IS : 2720 (Part-11)-1993, RA-2007

	Borehole No.: BH-25	Sample Depth: 5.25 m		
Sample Details	Sample No.: UDS-2	Sample Description: Clayey silt		
	Confining Pressure, σ_3 (kg/cm^2)	1.0	2.0	3.0
	Initial diameter (cm)	3.8	3.8	3.8
	Initial Length (cm)	7.6	7.6	7.6
	Bulk Density (g/cc)	1.90	1.90	1.90
	Dry Density (g/cc)	1.65	1.65	1.65
	Moisture Content (%)	15.1	15.2	15.2
Test Results	Peak Deviator Stress, $(\sigma_1-\sigma_3)_f$ (kg/cm^2)	3.59	3.75	4.01
	Failure Strain, ε_f (%)	22.4	22.4	22.4
	Cohesion intercept, c:	**1.59**	**kg/cm^2**	
	Angle of internal Friction, ϕ:	**6.6**	**degree**	

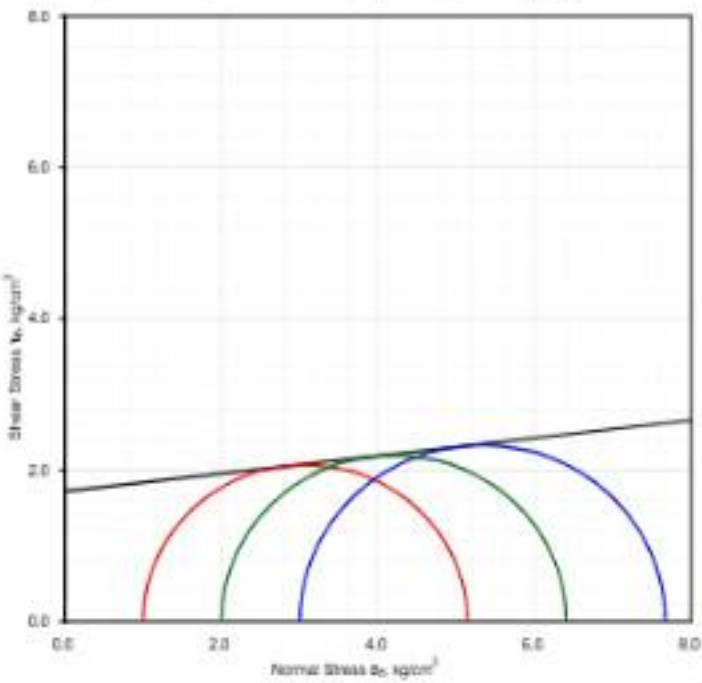


Mohr-Coulomb Failure Envelope

Unconsolidated Undrained Triaxial Test

IS : 2720 (Part-11)-1993, RA-2007

Sample Details	Borehole No.: BH-25		Sample Depth: 8.25 m	
	Sample No.: UDS-3		Sample Description: Sandy silt	
	Confining Pressure, σ_3 (kg/cm^2)	1.0	2.0	3.0
	Initial diameter (cm)	3.8	3.8	3.8
	Initial Length (cm)	7.6	7.6	7.6
	Bulk Density (g/cc)	1.91	1.91	1.91
	Dry Density (g/cc)	1.65	1.65	1.65
	Moisture Content (%)	15.8	15.7	15.8
Test Results	Peak Deviator Stress, $(\sigma_1-\sigma_3)_f$ (kg/cm^2)	4.14	4.40	4.67
	Failure Strain, ε_f (%)	22.4	22.4	22.4
	Cohesion intercept, c:	**1.70**	**kg/cm^2**	
	Angle of internal Friction, ϕ:	**6.7**	**degree**	



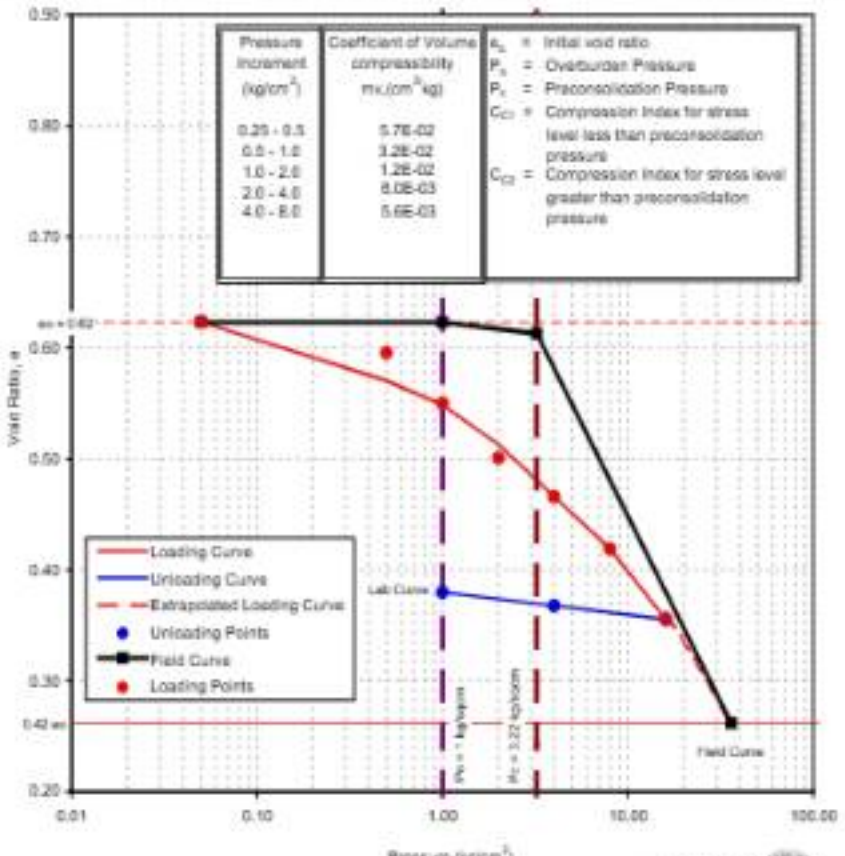
Mohr-Coulomb Failure Envelope

Consolidation Test Results
IS : 2720 (Part-15)-1986, RA-2007
(Field Curve from Casagrande's Method)

Sample Details				Test Results	
	Borehole No. : 25	Initial moisture content : 15.1%			Preconsolidation Pressure (P_c) kg/cm^2 : 3.22
	Sample Depth, m : 0.25	Final moisture content : 16%			Overconsolidation Ratio (OCR): 3.2
	Sample No. : UDS-2	Initial Void Ratio before test (e_o) : 0.62			Compression Index (C_{c1}) for $p < p_c$: 0.020
	Soil Classification : Clayey silt	Final Void Ratio after test (e_f) : 0.36			Compression Index (C_{c2}) for $p > p_c$: 0.335

Pressure increment (kg/cm^2)	Coefficient of Volume compressibility m_v (cm^2/kg)
0.25 - 0.5	5.7E-02
0.5 - 1.0	3.2E-02
1.0 - 2.0	1.2E-02
2.0 - 4.0	6.0E-03
4.0 - 8.0	5.6E-03

e_o = Initial void ratio
P_o = Overburden Pressure
P_c = Preconsolidation Pressure
C_{c1} = Compression Index for stress level less than preconsolidation pressure
C_{c2} = Compression Index for stress level greater than preconsolidation pressure

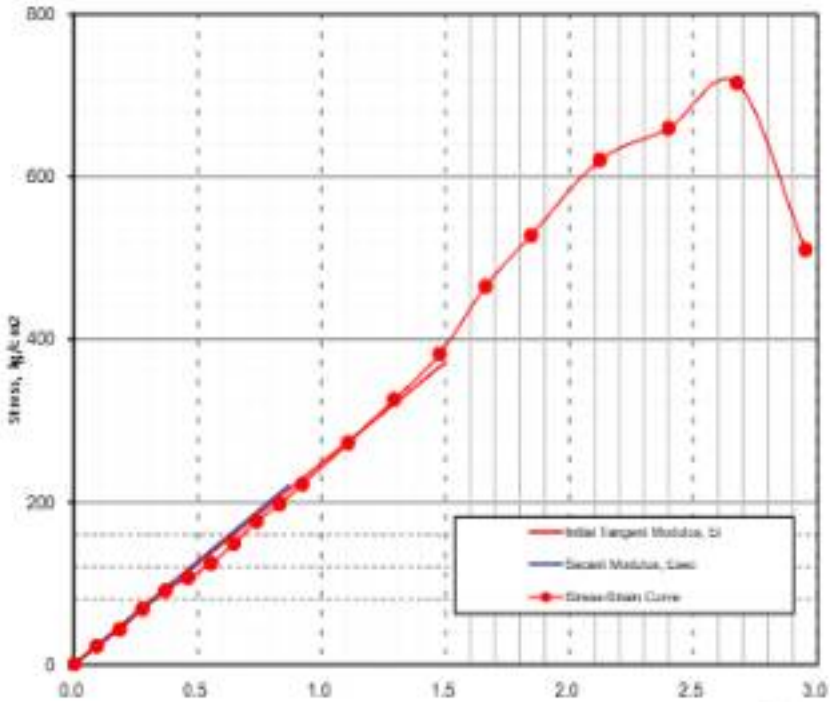


Void Ratio vs. Applied Pressure

Uniaxial Compressive Strength

Test (IS 9143-1979 RA-2008)

Borehole No. 25	Depth: 15 m	Sr. No. of Core : 16
SAMPLE DETAILS	TEST RESULTS	
Serial No. of Core.: 16	Unconfined Compressive Strength: 715 kg/sq.cm	
Rock Type: QUARTZITE		
Sample diameter (cm): 5.48	Failure Strain, ε: 2.7 %	
Sample Length (cm): 10.84	Secant Modulus, E_{sec}: 25424 kg/sq.cm	
Initial Bulk Density (g/cm^3): 2.52		
Sample Condition: **Uncoated**	Initial Tangent Modulus, E_i: 24833 kg/sq.cm	

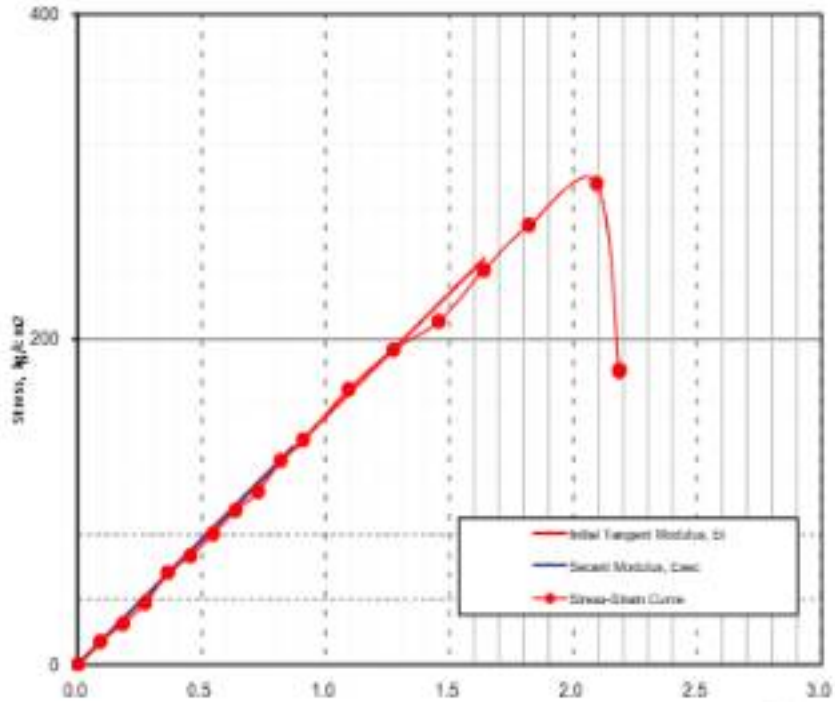


Uniaxial Compressive Strength Test on Rock Core Sample

Uniaxial Compressive Strength Test

(IS:9143-1979 RA-2006)

Borehole No. 25	Depth: 24 m	Sr. No. of Core : 40
SAMPLE DETAILS	TEST RESULTS	
Serial No. of Core.: 40	Unconfined Compressive Strength: 256 kg/sq.cm	
Rock Type: QUARTZITE		
Sample diameter (cm): 5.47	Failure Strain, ε: 2.1 %	
Sample Length (cm): 10.99	Secant Modulus, E_{sec}: 15437 kg/sq.cm	
Initial Bulk Density (g/cm^3): 2.66		
Sample Condition: **Uncoated**	Initial Tangent Modulus, E$_i$: 15235 kg/sq.cm	



Uniaxial Compressive Strength Test on Rock Core Sample

TEST RESULTS

Soil-Water Extract Test Results				
Borehole No.	Depth, (m)	Sulphate Content (SO_3), %	Chloride Content (Cl), %	pH Value
BH-25	1.50	0.10	below detectable limit	7.7

IS : 456-2000, SPECIFICATIONS

Requirements for Concrete Exposed to Sulphate Attack as per IS : 456-2000, Clauses 8.2.2.4 and 9.1.2, Table 4, Page-19

Class	Concentration of Sulphates, expressed as SO_3 In-Soil-Water Extract (Total) Percent	In Groundwater (mg/l)
1	Traces (<0.2)	Less than 300
2	0.2 to 0.5	300-1200
3	0.5 to 1.0	1200-2500
4	1.0 to 2.0	2500-5000
5	> 2.0	> 5000

Classification of Chloride Conditions in Groundwater*

Classification	Chloride Limits	
	Tropical Climate	Temperate Climate
Negligible	0-2000 ppm	Not Applicable
Moderate	2000-10,000 ppm	0-2000 ppm
High	More than 10,000 ppm	2000-20,000 ppm
Very High	Generally not applicable	Only if considerably in excess of 20,000 ppm

*Source : Institution of Civil Engineers, London (1976)

Chemical Test Results

Bor. no.	Rock Formation No.	Depth, cm	(a) [illegible] (Core Dia=NQ2, NX=2.997)	(b) [illegible]			(b) Calculations		(c) [illegible] IS:[illegible]	(c) [illegible] IS:[illegible]	**Rock's Grade Designation	Geological Discontinuities in Index
			Specific Gravity	Density (g/cm3)	Moisture Content, %	Water Absorption, %	Void Ratio	Porosity	Point Load Index, (kg/cm2) (1)	Unconfined Compressive Strength (kg/cm2) (1)		
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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* Equivalent Unconfined Compressive Strength, based on Point Load Strength Index

** Classification Groups

[illegible] [illegible] [illegible]



Borehole No. BH-02

Photograph of Rock Core Sample



Borehole No. BH-01

Photograph of Rock Core Sample

APPENDIX-BH-26

Caption	Plate
Soil & Rock Profiles	1 to 5
Standard Penetration Test	6 to 7
Atterberg Test	8
Grain Size Analysis	9
Shears Test Results	10 to 13
Consolidation Test Results	14
Uniaxial Compressive Strength Test	15 to 16
Chemical Test Results	17
Physical Properties of Rock	18
Corebox Photographs	19 to 20

Soil Profile (BH-04)

Location : –
UTM Coordinates : [illegible]

Surface Elevation : 203.3 m
Ground Water Depth : Not met
Termination Depth : 22 m (RL 181 m)

Boring Method : Shell & Auger
Casing Depth : [illegible]
Boring Date : [illegible]
Boring Finish : [illegible]

Depth, m		Sample No.	SPT (N)		Soil Symbol	SOIL DESCRIPTION	Depth of Strata, m	Grain Size Analysis				Atterberg Limits			Density and Moisture			Bulk Density (kN/m³)	Direct Tests				Consolidation Test	
From	To		Field Value	Corrected Value				Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Dry Density (kN/m³)	Moisture Content (%)	Void Ratio		Cohesion (kN/m²)	Angle of Friction (°)	Cohesion (kN/m²)	Angle of Friction (°)	Pre-Consolidation Pressure (kPa)	Compression Index
0.00	1.00	[illegible]				Utility Pit	1.00																	
1.00	1.50	[illegible]	19	19		Very stiff to hard brown Clayey Silt, medium plastic (CL)		6	11	37	33							2.00						
1.50	2.00	[illegible]				– very stiff, 1.0 to 1.5 m						47.0	17.0	29.7	1.80	19.0	0.54		19.7	1.2	0.7	32.4		
2.00	3.45	[illegible]	22	22		– with gravels, 1.5 to 2.0 m						41.7	19.0	21.3										
4.00	4.50	[illegible]	21	21				0	21	51	28	36.0	21.1	17.0										
5.00	5.50	[illegible]													1.82	1.64	0.54		19.1	1.2	0.8	0.8		
6.00	6.45	[illegible]	26	26								41.0	20.1	20.9										
7.00	7.45	[illegible]	44	44		– hard, 7.0 to 8.0 m		0	17	70	13													
8.00	8.00	[illegible]				– with gravels, 7.5 to 8.0 m						43.0	21.0	24.0	1.82	1.65	0.54	2.00	19.7	1.2	1.3	0.8		
8.00	9.45	[illegible]	28	28		– very stiff, 8.0 to 10.0 m		0	17	61	22													
10.00	10.45	[illegible]	31	31		– hard, 10.0 to 12.0 m																		
11.00	11.50	[illegible]													1.80	1.65	0.54		19.4	1.2	1.5	0.7		

[illegible]

Soil Profile (BH-04)

Location : –
UTM Coordinates : [illegible]

Surface Elevation : 203.3 m
Ground Water Depth : Not met
Termination Depth : 30 m (RL 173 m)

Boring Method : Shell & Auger
Casing Depth : [illegible]
Boring Date : [illegible]
Boring Finish : [illegible]

Depth, m		Sample No.	SPT[1]		Symbol	SOIL DESCRIPTION	Depth of Strata, m	Grain Size Analysis				Atterberg Limits			Density and Moisture				Water Table	Water Tests					Unconfined Compressive Strength, kPa	Soil Type
From	To		N, Blows/0.3m	Rec, %				Gravel, %	Sand, %	Silt, %	Clay, %	Liquid Limit, %	Plastic Limit, %	Plasticity Index, %	Dry Density, kN/m³	Moisture Content, %	Void Ratio	Degree of Saturation, %		Hydraulic Conductivity, cm/s	Transmissivity, m²/day	Storativity, dimensionless	Specific Capacity, L/s/m		
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		Light brown clayey silt, medium plastic, [illegible]	[illegible]																		
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			11.00																		
						Refusal met on Rock. Core drilling through rock initiated. Refer to next page for details.																			

[1] N = number blows/0.3m

Soil Profile (BH-04)

Location : –
UTM Coordinates : [illegible]

Surface Elevation : 203.3 m
Ground Water Depth : Not met
Termination Depth : 30 m (RL 173 m)

Boring Method : Shell & Auger
Casing Depth : [illegible]
Boring Date : [illegible]
Boring Finish : [illegible]

Depth, m		Sample No.	SPT[1]		Symbol	SOIL DESCRIPTION	Depth of Strata, m	Grain Size Analysis				Atterberg Limits			Density and Moisture				Water Table	Water Tests					Soil Classification	
From	To		Blow Count, N	Blow Count, N'				Gravel, %	Sand, %	Silt, %	Clay, %	Liquid Limit, %	Plastic Limit, %	Plasticity Index, %	Dry Density, kN/m³	Moisture Content, %	Degree of Saturation, %	Void Ratio		Permeability, cm/s	Consolidation Coefficient, m²/yr	Compression Index	Shear Strength, kPa		
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	

[1] N = uncorrected blow count

Hole [illegible]

[illegible] Limited
Certified Laboratory
[illegible]
Certificate No: [illegible]

Location: [illegible]
mTM Coordinates: [illegible]
Surface Elevation: [illegible]
Ground Water Depth: Not met
Termination Depth: [illegible]
Boring Method: Rotary Drilling
Casing Depth: [illegible]
Casing Date: [illegible]
Boring Finish: [illegible]

Depth (m)	Depth (m)	Graphic Log	Core Run (Core Loss)	Core Type/Core Size	Notes	ROCK DESCRIPTION	Defect Spacing (mm)	Point Load Strength Index (MPa)	Core Recovery (%)	RQD (%)	Fracture Index	Core Loss (m)	Core Run (m)	Core Recovery (m)	Point Load Strength Index (MPa)	Unconfined Compressive Strength (MPa)	Is(50) (MPa)
[illegible]	[illegible]					[illegible]											
[illegible]			[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]					[illegible]											



Hole No. [illegible]

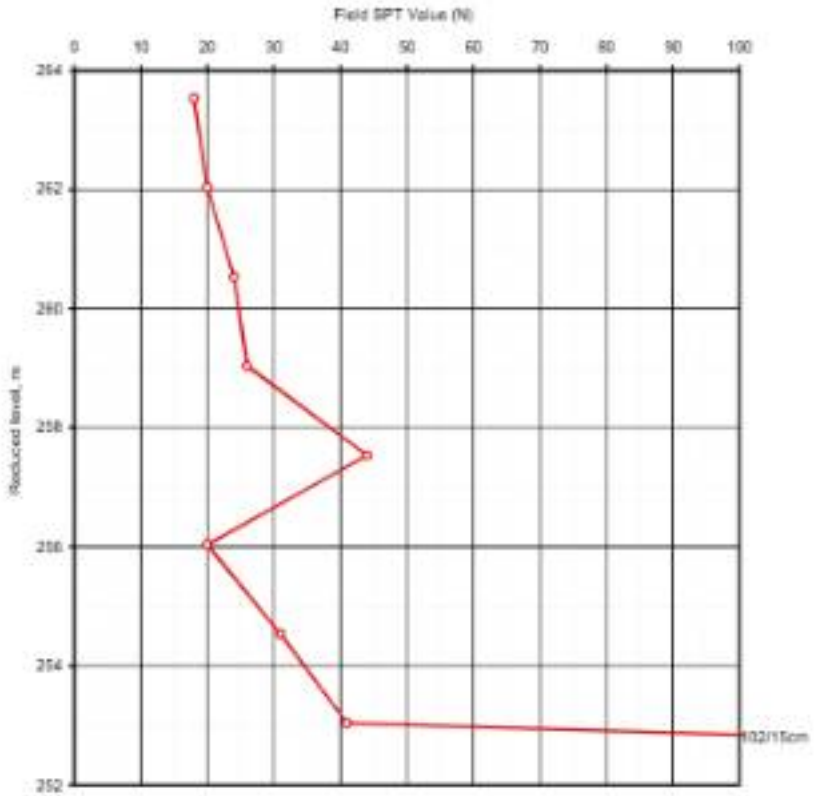
Location :	--	Surface Elevation :	[illegible]
UTM Coordinates :	[illegible]	Ground Water Depth :	Not met
		Termination Depth :	[illegible]
Boring Method :	Rotary Drilling
Casing Depth :	[illegible]
Casing Date :	[illegible]
Boring Finish :	[illegible]

Depth (m)	Run No. & Core Loss	Recovery (%)	RQD (%)	Fracture Index (Nos./m)	Strength Index (Is50) MPa	Core Photograph	ROCK DESCRIPTION	Depth of Strata (m)	Core Recovery (%)	Core Quality (RQD) (%)	Fracture Index (Nos./m)	Point Load Strength Index (Is50) MPa	Core Photograph	Water Loss (%)	Water Pressure (Lugeon)	Grout Quantity (Cement) (Bags)	Grout Pressure (kg/cm²)	Grout Take (Lugeon)	Grout Take (kg/cm²)	Grout Take (Bags)	Grout Take (kg/cm²)
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Moderately weak to moderately strong, grey CLAYSTONE, laminated to moderately thin bedded, highly to moderately weathered	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	- Moderately Strong, moderately thin bed, moderately weathered, 10.15 to 12.00 m	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	- Moderately weak, thinned, laminated, highly weathered, 20.20 to 23.0 m	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	- Moderately strong, intensely fractured, moderately weathered, 23.0 m to 25.00 m	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Standard Penetration Test

IS : 2131-1981, RA-2007

Borehole Details			
Symbol	Borehole Number	Reduced Level,m	Location
	BH-26	263.0	-

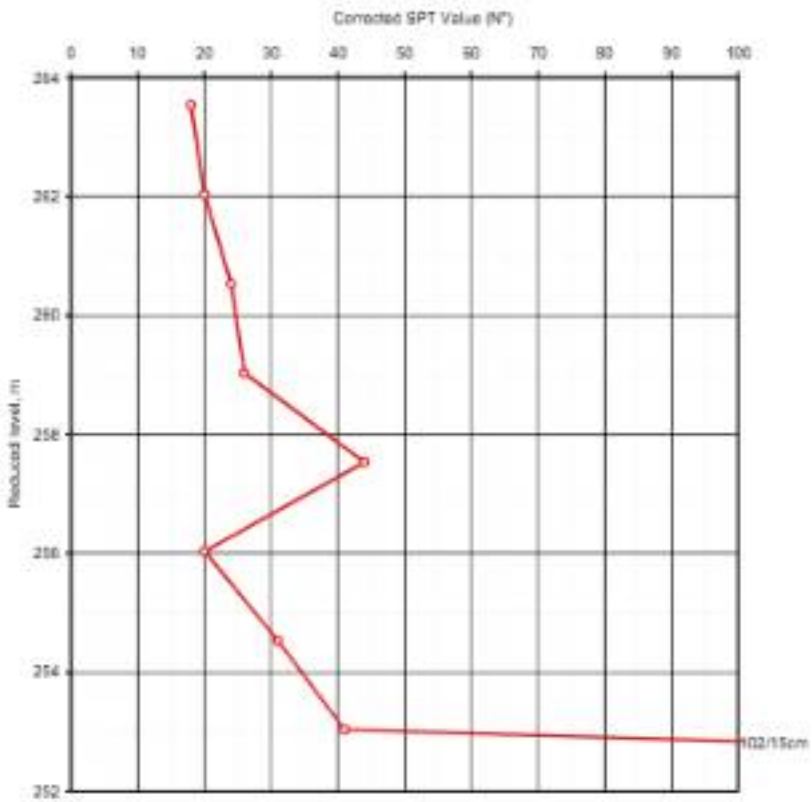


Field SPT Values vs Reduced level

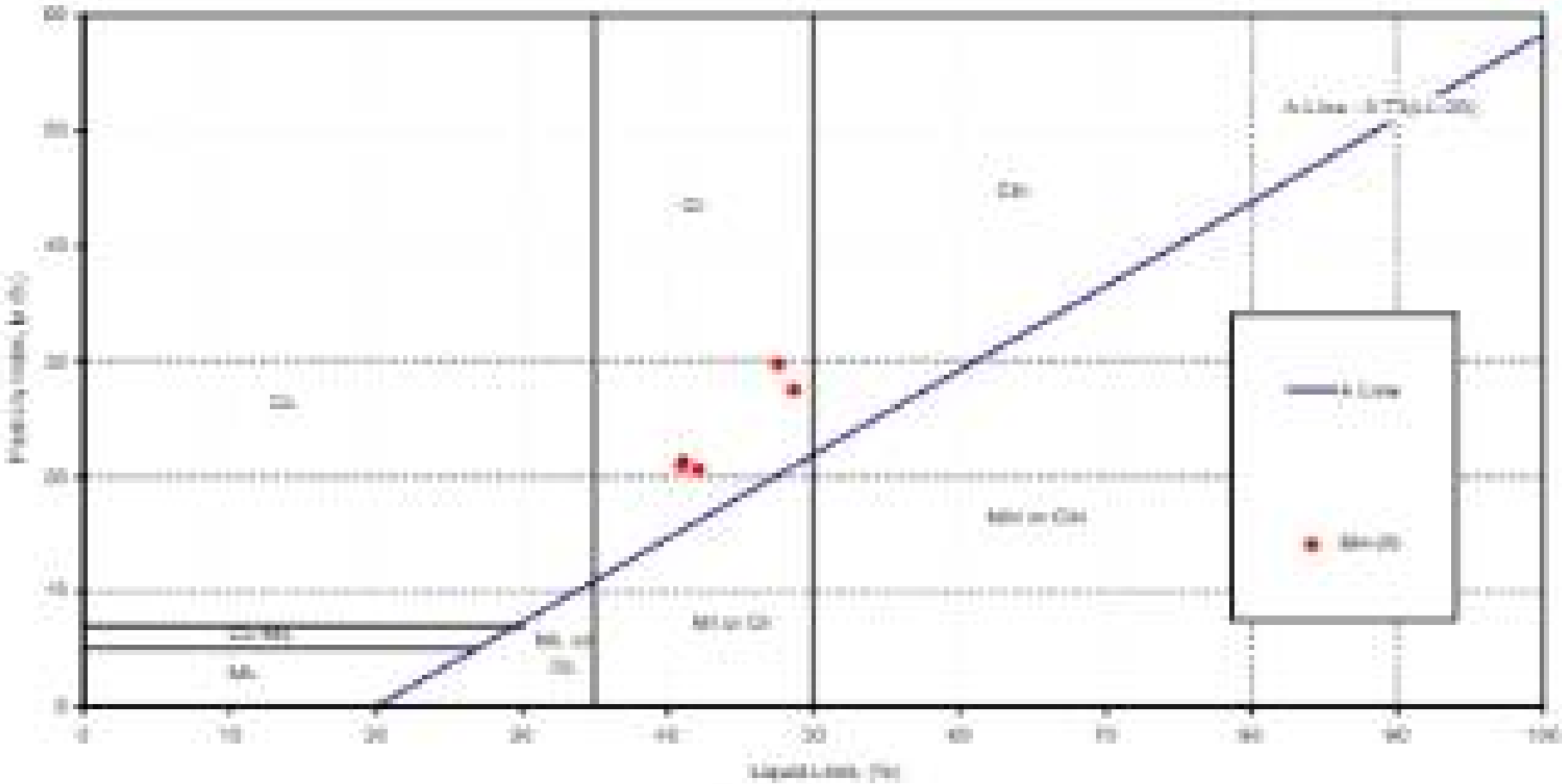
Standard Penetration Test

IS : 2131-1981, RA-2007

Borehole Details			
Symbol	Borehole Number	Reduced Level,m	Location
	BH-26	263.0	-



Corrected SPT Values vs Reduced level

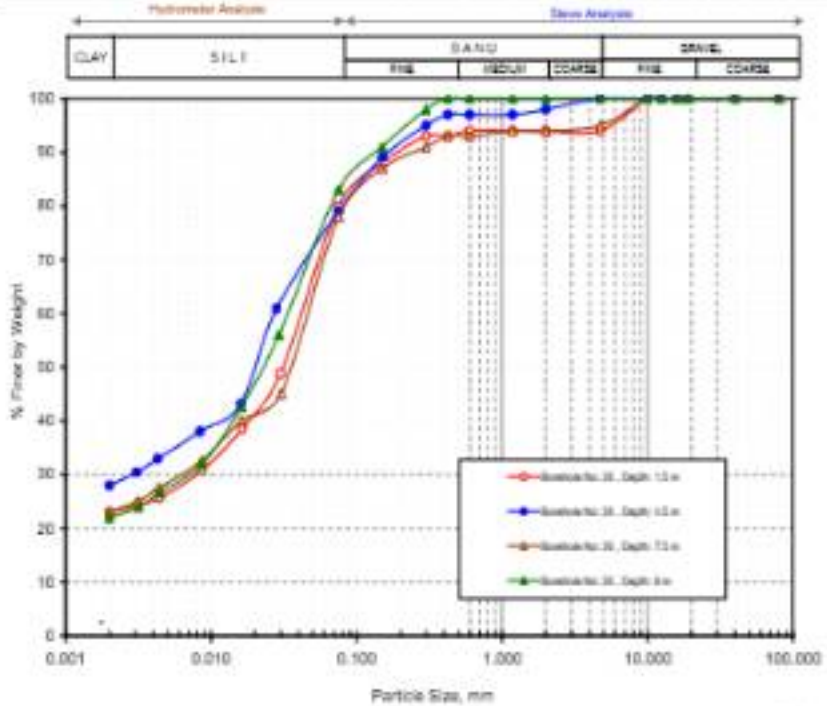


Plasticity Chart

Grain Size Analysis

IS : 2720 (Part 4) - 1985, RA-2010

Sample Details			Test Results								
Borehole Number	Sample Depth, m	Sample Description	% Gravel	% Sand	% Silt	% Clay	D_{60}	D_{10}	D_{30}	C_u	C_c
BH-25	1.50	Clayey silt with gravels (CI)	9	14	57	23	0.049	0.006			
BH-25	4.50	Clayey silt (CI)	0	21	51	28	0.027	0.003			
BH-25	7.50	Clayey silt with gravels (CI)	5	17	55	23	0.051	0.006			
BH-25	9.00	Clayey silt (CI)	0	17	61	22	0.038	0.007			

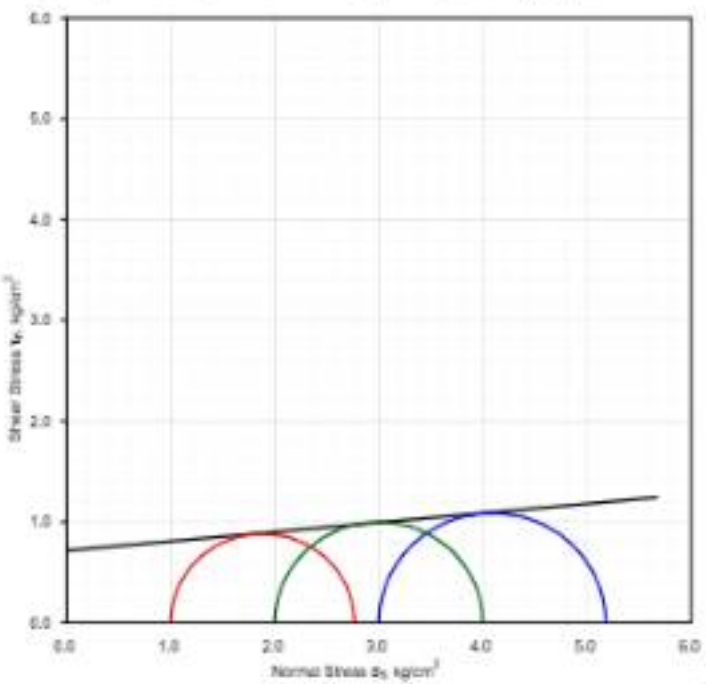


Grain Size Distribution Curve

Unconsolidated Undrained Triaxial Test

IS : 2720 (Part-11)-1993, RA-2007

	Borehole No.: BH-26	Sample Depth: 2.25 m		
	Sample No.: UDS-1	Sample Description: Clayey silt		
Sample Details	Confining Pressure, σ_3 (kg/cm^2)	1.0	2.0	3.0
	Initial diameter (cm)	3.8	3.8	3.8
	Initial Length (cm)	7.6	7.6	7.6
	Bulk Density (g/cc)	1.80	1.80	1.80
	Dry Density (g/cc)	1.63	1.62	1.62
	Moisture Content (%)	10.7	10.9	10.8
Test Results	Peak Deviator Stress, $(\sigma_1-\sigma_3)_f$ (kg/cm^2)	1.76	2.00	2.18
	Failure Strain, ε_f (%)	22.4	22.4	22.4
	Cohesion intercept, c:	**0.70**	**kg/cm^2**	
	Angle of internal Friction, ϕ:	**6.4**	**degree**	

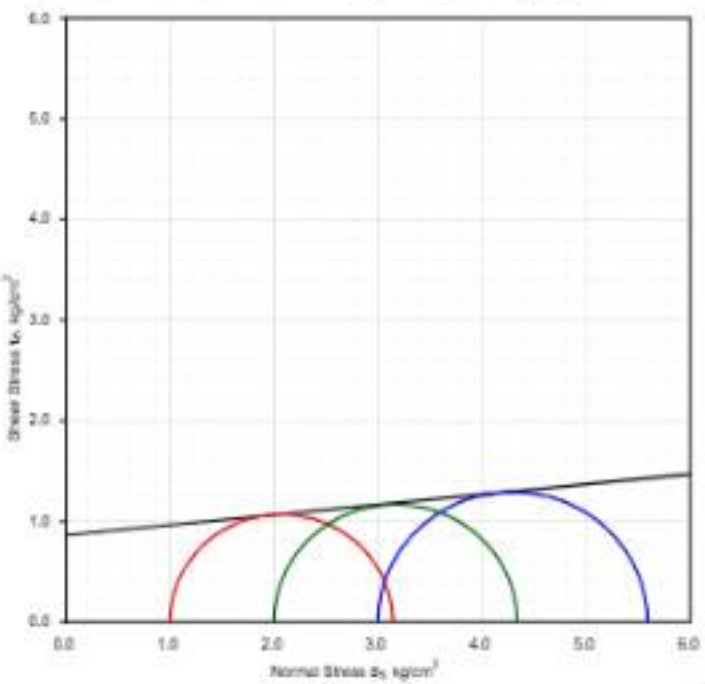


Mohr-Coulomb Failure Envelope

Unconsolidated Undrained Triaxial Test

IS : 2720 (Part-11)-1993, RA-2007

Sample Details	Borehole No.: BH-26		Sample Depth: 5.25 m	
	Sample No.: UDS-2		Sample Description: Clayey silt	
	Confining Pressure, σ_3 (kg/cm^2)	1.0	2.0	3.0
	Initial diameter (cm)	3.8	3.8	3.8
	Initial Length (cm)	7.6	7.6	7.6
	Bulk Density (g/cc)	1.85	1.85	1.85
	Dry Density (g/cc)	1.64	1.65	1.64
	Moisture Content (%)	12.8	12.1	12.9
Test Results	Peak Deviator Stress, $(\sigma_1-\sigma_3)_f$ (kg/cm^2)	2.14	2.34	2.59
	Failure Strain, ε_f (%)	22.4	22.4	22.4
	Cohesion intercept, c:	**0.90**	**kg/cm^2**	
	Angle of internal Friction, ϕ:	**6.5**	**degree**	

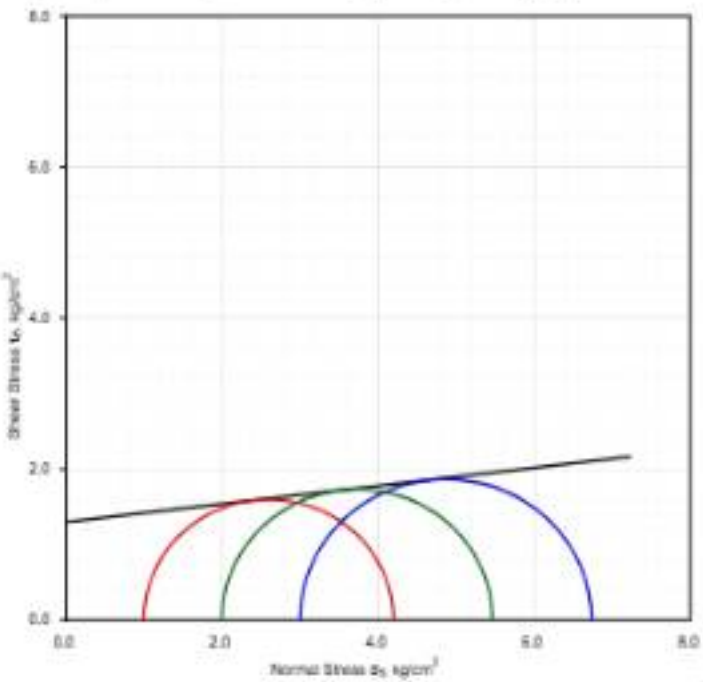


Mohr-Coulomb Failure Envelope

Unconsolidated Undrained Triaxial Test

IS : 2720 (Part-11)-1993, RA-2007

	Borehole No.: BH-26	Sample Depth: 8.25 m		
	Sample No.: UDS-3	Sample Description: Clayey silt		
Sample Details	Confining Pressure, σ_3 (kg/cm^2)	1.0	2.0	3.0
	Initial diameter (cm)	3.8	3.8	3.8
	Initial Length (cm)	7.6	7.6	7.6
	Bulk Density (g/cc)	1.89	1.89	1.89
	Dry Density (g/cc)	1.65	1.65	1.65
	Moisture Content (%)	14.8	14.6	14.7
Test Results	Peak Deviator Stress, $(\sigma_1-\sigma_3)_f$ (kg/cm^2)	3.20	3.47	3.73
	Failure Strain, ε_f (%)	22.4	22.4	22.4
	Cohesion intercept, c:	**1.33**	**kg/cm^2**	
	Angle of internal Friction, ϕ:	**6.5**	**degree**	

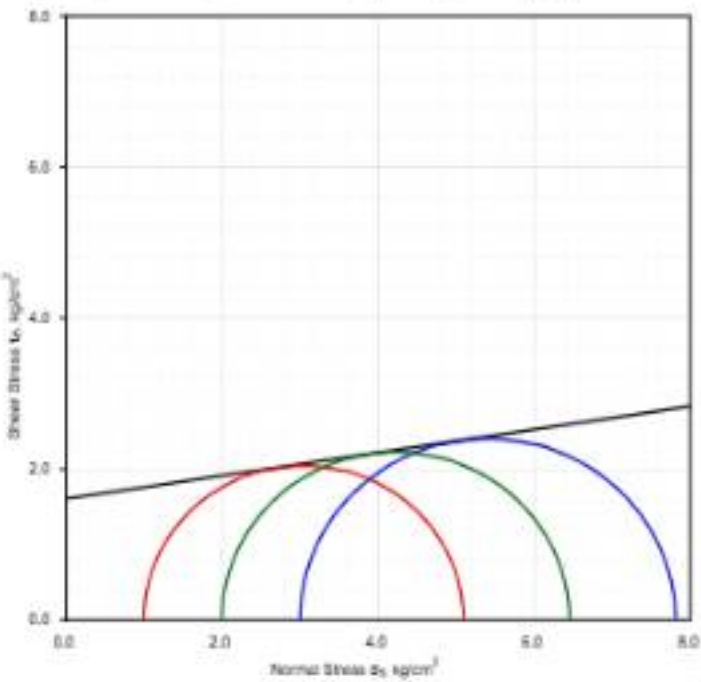


Mohr-Coulomb Failure Envelope

Unconsolidated Undrained Triaxial Test

IS : 2720 (Part-11)-1993, RA-2007

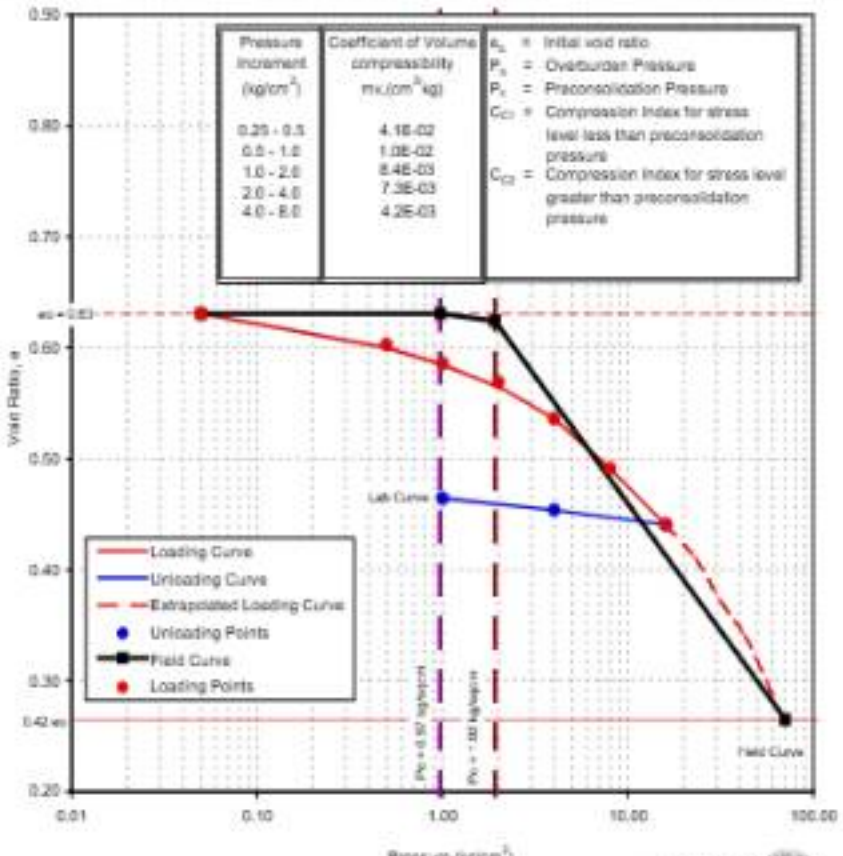
Sample Details	Borehole No.: BH-26		Sample Depth: 11.25 m	
	Sample No.: UDS-4		Sample Description: Clayey silt	
	Confining Pressure, σ_3 (kg/cm^2)	1.0	2.0	3.0
	Initial diameter (cm)	3.8	3.8	3.8
	Initial Length (cm)	7.6	7.6	7.6
	Bulk Density (g/cc)	1.56	1.56	1.56
	Dry Density (g/cc)	1.66	1.66	1.67
	Moisture Content (%)	17.8	17.9	17.7
Test Results	Peak Deviator Stress, $(\sigma_1-\sigma_3)_f$ (kg/cm^2)	4.09	4.45	4.81
	Failure Strain, ε_f (%)	22.4	22.4	22.4
	Cohesion intercept, c:	**1.89**	**kg/cm^2**	
	Angle of internal Friction, ϕ:	**8.7**	**degree**	



Mohr-Coulomb Failure Envelope

Consolidation Test Results
IS : 2720 (Part-15)-1986, RA-2007
(Field Curve from Casagrande's Method)

Sample Details				Test Results	
	Borehole No. : 25	Initial moisture content : 13%			Preconsolidation Pressure (P_c) kg/cm^2 : 1.62
	Sample Depth, m : 0.25	Final moisture content : 16.2%			Overconsolidation Ratio (OCR): 2.0
	Sample No. : UDS-2	Initial Void Ratio before test (e_o) : 0.63			Compression Index (C_{c1}) for $p < p_c$: 0.022
	Soil Classification : Clayey silt	Final Void Ratio after test (e_f) : 0.44			Compression Index (C_{c2}) for $p > p_c$: 0.239

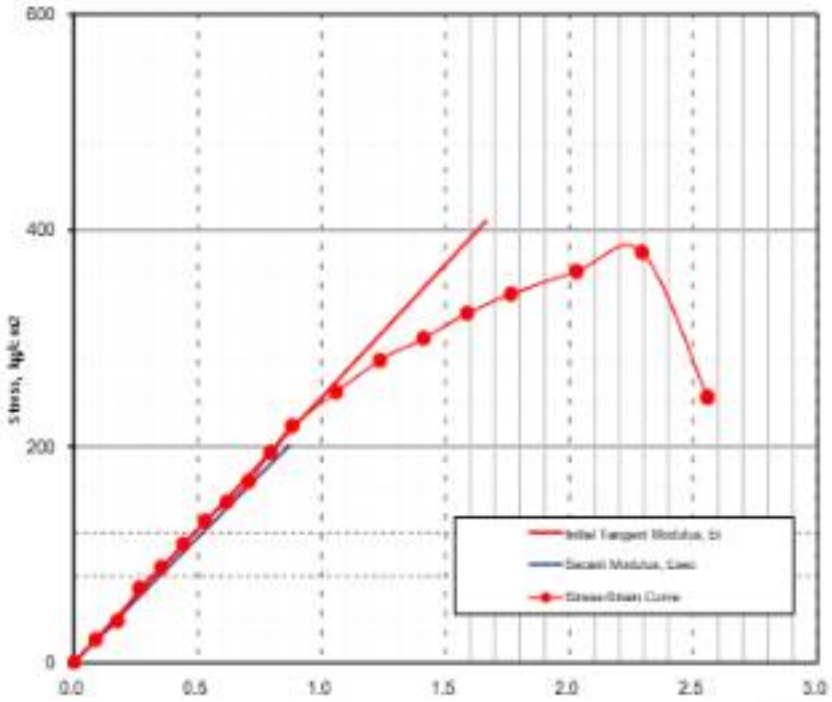


Void Ratio vs. Applied Pressure

Uniaxial Compressive Strength Test

(IS:9143-1979 RA-2006)

Borehole No. 26	Depth: 19.8 m	Sr. No. of Core : 15
SAMPLE DETAILS	TEST RESULTS	
Serial No. of Core.: 15	Unconfined Compressive Strength: 360 kg/sq.cm	
Rock Type: QUARTZITE		
Sample diameter (cm): 5.45	Failure Strain, ε: 2.3 %	
Sample Length (cm): 11.34	Secant Modulus, E_{sec}: 23118 kg/sq.cm	
Initial Bulk Density (g/cm^3): 2.46		
Sample Condition: Unsoaked	Initial Tangent Modulus, Ei: 24004 kg/sq.cm	

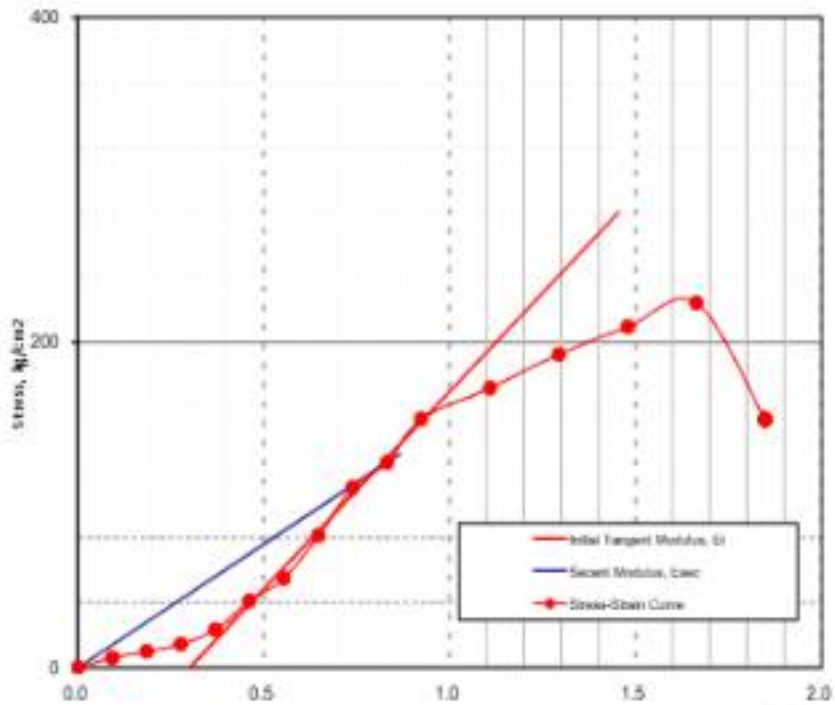


Uniaxial Compressive Strength Test on Rock Core Sample

Uniaxial Compressive Strength Test

(IS:9143-1979 RA-2006)

Borehole No. 26	Depth: 23.5 m	Sr. No. of Core : 31
SAMPLE DETAILS	TEST RESULTS	
Serial No. of Core : 31	Unconfined Compressive Strength: 224 kg/sq.cm	
Rock Type: QUARTZITE		
Sample diameter (cm): 5.43	Failure Strain, ε: 1.7 %	
Sample Length (cm): 10.82	Secant Modulus, E_{sec}: 15171 kg/sq.cm	
Initial Bulk Density (g/cm^3): 2.47		
Sample Condition: Unsoaked	Initial Tangent Modulus, Ei: 24242 kg/sq.cm	



Uniaxial Compressive Strength Test on Rock Core Sample

TEST RESULTS

Soil-Water Extract Test Results				
Borehole No.	Depth, (m)	Sulphate Content (SO_3), %	Chloride Content (Cl), %	pH Value
BH-26	1.50	0.10	below detectable limit	7.7

IS : 456-2000, SPECIFICATIONS

Requirements for Concrete Exposed to Sulphate Attack as per IS : 456-2000, Clauses 8.2.2.4 and 9.1.2, Table 4, Page-19

Class	Concentration of Sulphates, expressed as SO_3 In- Soil-Water Extract (Total) Percent	In Groundwater (mg/l)
1	Traces (<0.2)	Less than 300
2	0.2 to 0.5	300-1200
3	0.5 to 1.0	1200-2500
4	1.0 to 2.0	2500-5000
5	> 2.0	> 5000

Classification of Chloride Conditions in Groundwater*

Classification	Chloride Limits	
	Tropical Climate	Temperate Climate
Negligible	0-2000 ppm	Not Applicable
Moderate	2000-10,000 ppm	0-2000 ppm
High	More than 10,000 ppm	2000-20,000 ppm
Very High	Generally not applicable	Only if considerably in excess of 20,000 ppm

*Source : Institution of Civil Engineers, London (1976)

Chemical Test Results

Bor. no.	Rock formation No.	Depth, (m)	(i) [illegible] (Cl-1997, BS+ 1377)	(ii) [illegible]			(iii) Calculations		(iv) [illegible] BS-1924)	(v) [illegible] BS-1924)	*Rock's Grade Weathered	Cavities encountered in holes
			Specific Gravity	Density (g/cm3)	Moisture Content, %	Water absorption, %	Void Ratio	Porosity	Point Load Index, (kg/cm2)	Unconfined Compressive Strength (kg/cm2)		
20	3	14.00–15.00	–	2.34	–	–	–	–	–	–	2	–
	4	15.00–16.75	–	–	6.23	3.52	–	–	–	–	–	–
	8	17.00–18.23	2.79	2.38	–	–	0.168	0.144	–	–	–	0
	10	18.25–19.00	–	2.51	6.37	3.63	–	–	15	219*	–	–
	11	19.00–19.75	–	2.52	–	–	–	–	–	–	–	–
	12	19.75–20.20	–	2.44	6.12	3.58	–	–	–	350	–	–
	16	21.00–22.00	2.82	2.43	–	–	0.173	0.121	–	–	–	0
	24	23.00–23.75	–	2.53	6.34	3.56	–	–	–	504	1	–
	26	23.75–23.50	–	2.50	–	–	–	–	49*	354*	–	0
	31	25.00–25.60	–	2.47	6.17	3.43	–	–	–	324	–	–

* Equivalent Unconfined Compressive Strength, based on Point Load Strength Index
** Denotes Nodule, Sample

[illegible] Properties of Rock.



Borehole No. BH-05

Photographs of Rock Core Samples



Borehole No. BH-01

Photographs of Rock Core Samples

APPENDIX-BH-30

Caption	Plate
Soil & Rock Profiles	1 to 3
Standard Penetration Test	4 to 5
Atterberg Test	6
Grain Size Analysis	7 to 8
Shears Test Results	9 to 15
Uniaxial Compressive Strength Test	16 to 17
Physical Properties of Rock	18
Corebox Photographs	19

Soil Profile (BH 1A)

Location: –
UTM Coordinates: [illegible]

Surface Elevation: 20.0 m
Ground Water Depth: Not met
Termination Depth: 30 m (RL 230 m)

Boring Method: Shell & Auger
Casing Depth: 15.0 m
Boring Date: 28-Jul-15
Boring Crew: [illegible]

Depth, m		Sample No.	SPT		Graphic Log	SOIL DESCRIPTION	Depth of Strata, m	Grain Size Analysis				Atterberg Limits			Density and Moisture			Bearing Pressure (kPa)	Direct Shear Tests				Consolidation Tests	
From	To		Blow Counts, N	Corrected N, N_{60}				Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Dry Density, γ_d (kN/m³)	Moisture Content, w (%)	Void Ratio, e		Test No.	Normal Stress, σ_n (kPa)	Peak Shear Stress, τ_p (kPa)	Residual Shear Stress, τ_r (kPa)	Pre-Consolidation Pressure, σ_p' (kPa)	Compression Index, C_c
0.00	0.50	S101				Jetty Fill	1.00																	
1.00	1.50	SPT1	11	16		SPT-N Hard to hard sandy silt - Fine Sheets (13.)						29.1	15.2	13.9										
2.00	2.50	U501				– stiff, 1.0 to 3.0 m									1.72	1.26	12.1		1&2	1, 2, 3	0.5	3.5		
3.00	3.45	SPT2	10	13		– very stiff, 3.0 to 4.0 m		1	14	69	17	25.8	16.2	14.4				3.00						
4.00	4.50	SPT3	20	26		– with traces of gravel, 4.0 to 6.0 m																		
5.00	5.50	U502				– hard, 6.0 to 13.0 m						28.8	21.2	13.6	1.79	1.08	11.0		1&2	1, 2, 3	1.2	6.2		
6.00	6.45	SPT4	44	43																				
7.00	7.45	SPT5	35	34				1	13	67	19	31.1	21.3	14.8										
8.00	8.50	U503													1.65	1.62	14.3		1&2	1, 2, 3	1.4	7.6		
9.00	9.45	SPT6	34	33														2.00						
10.00	10.45	SPT7	36	34				0	20	59	22	33.8	19.2	14.6										
11.00	11.50	U504													1.68	1.64	15.1		1&2	1, 2, 3	1.6	7.7		

[illegible]

Soil Profile (BH [illegible])

[illegible]

Location : –

UTM Coordinates : [illegible]

Surface Elevation : [illegible] m

Ground Water Depth : [illegible] mbgl

Termination Depth : [illegible] m ([illegible] mbgl)

Boring Method : Shell & Auger

Casing Depth : [illegible] m

Boring Date : [illegible]

Boring Crew : [illegible]

Depth, m		Sample No.	SPT [illegible]		Symbol	SOIL DESCRIPTION	Depth of Strata, m	Grain Size Analysis				Atterberg Limits			Density and Moisture				Water Table (mbgl)	Direct Tests					Triaxial Test	Consolidation Test
From	To		Number of Blows, N	Corrected Value, N'				Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Natural Moisture Content, w (%)	Dry Unit Weight, γ_d (kN/m³)	Bulk Unit Weight, γ (kN/m³)	Void Ratio, e		Cohesion, c (kPa)	Friction Angle, ϕ (°)	Cohesion, c (kPa)	Friction Angle, ϕ (°)	Specific Gravity, G_s	Pre-consolidation Pressure, σ_p (kPa)	Compression Index, C_c
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		Dark brown sandy silt mix plastic (OL)						[illegible]	[illegible]	[illegible]												
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		- with gravels, 13.0 to 14.3 m		6	31	32	19															
[illegible]	[illegible]	[illegible]													1.80	1.66	17.7			32.1	1.2	1.7	31			
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]								[illegible]	[illegible]	[illegible]												
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]																						
[illegible]	[illegible]	[illegible]																								
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		- with interval of gravels, 19.0 to 19.3 m		4	20	61	15	[illegible]	[illegible]	[illegible]												
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]																						
[illegible]	[illegible]	[illegible]																								
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		- with gravels, 21.0 to 22.5 m	[illegible]	14	12	55	19															
						Defined over ex Ends / Core drilling through rock adopted. Refer to next page for details																				

[illegible]

Hole No. BH-01

Location:	--	Surface Elevation:	0.00 m
UTM Coordinates:	7551125 E, 0327773 N	Ground Water Depth:	Not met
		Termination Depth:	25.00 m
		Boring Method:	Rotary Drilling
		Casing Depth:	18.00 m
		Casing Date:	09-Jul-19
		Boring Finish:	01-Aug-19

Depth (m)	Legend	Sample No.	Core Run (m)	Core Recovery (%)	Core RQD (%)	Rock Description	Depth (m)	Bulk Density (kN/m³)	Specific Gravity (Gs)	Water Content (%)	Void Ratio (e)	Degree of Saturation (%)	Point Load Strength Index (MPa)	Uniaxial Compressive Strength (MPa)	Modulus Ratio
0.00						Quaternary cover or moderately strong, grey CLAY/SILT/SAND (Alluvium) Partly/wet, highly weathered									
15.00		R001	1-6			- Quaternary cover, Alluvium, fractured, highly weathered, 15.0 to 23.00 m		2.61	0	24			0.38	0.83	0.1842
23.00		R002	6-10			- moderately strong, low intensity fractured, moderately weathered, 23.00 to 25.0 m		2.65	1.5	28			0.43	2.73	0.1577
25.00		R003	10-13					2.70	3.5	30			0.48	3.78	0.1269

Standard Penetration Test

IS : 2131-1981, RA-2007

Borehole Details			
Symbol	Borehole Number	Reduced Level,m	Location
	BH-30	264.0	-



Field SPT Values vs Reduced level

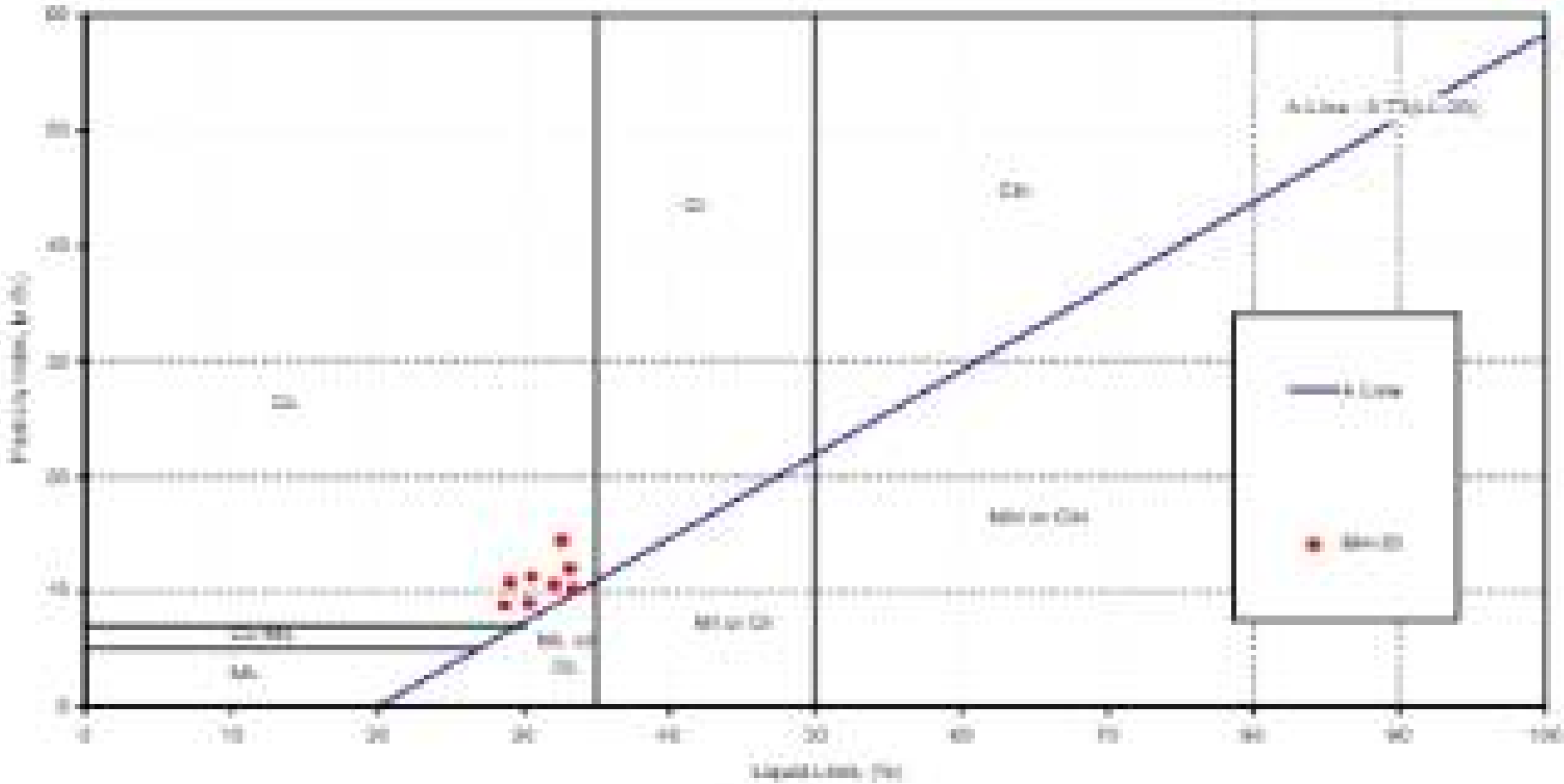
Standard Penetration Test

IS : 2131-1981, RA-2007

Borehole Details			
Symbol	Borehole Number	Reduced Level,m	Location
	BH-30	264.0	-



Corrected SPT Values vs Reduced level

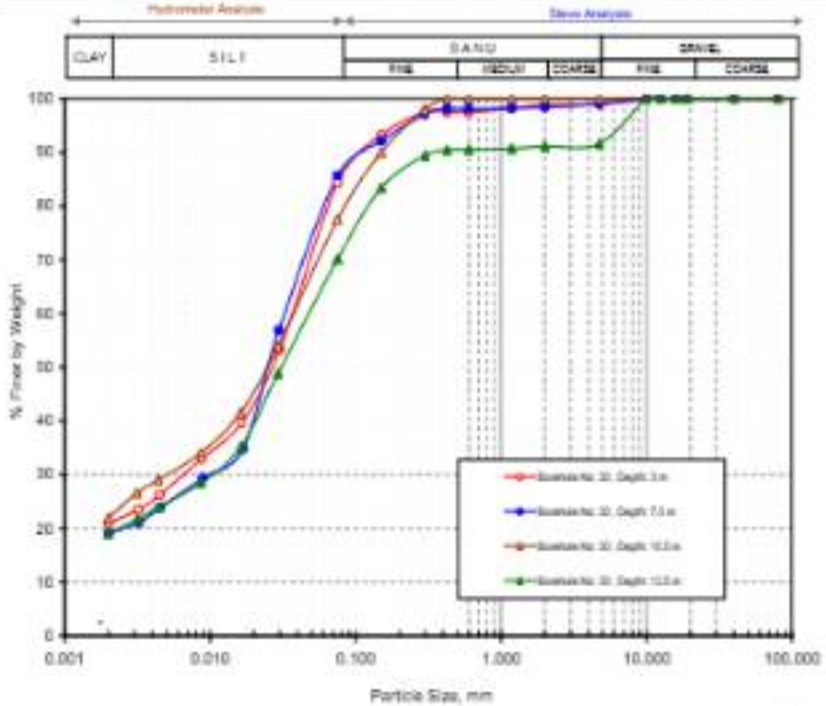


Plasticity Chart

Grain Size Analysis

IS : 2720 (Part 4) - 1985, RA-2010

Sample Details			Test Results								
Borehole Number	Sample Depth, m	Sample Description	% Gravel	% Sand	% Silt	% Clay	D_{60}	D_{30}	D_{10}	C_u	C_c
BH-30	3.00	Sandy silt with traces of gravel (CL)	1	14	64	21	0.043	0.007			
BH-30	7.50	Sandy silt with traces of gravel (CL)	1	13	67	19	0.033	0.010			
BH-30	10.50	Sandy silt (CL)	0	22	56	22	0.041	0.005			
BH-30	13.50	Sandy silt with gravels (CL)	8	21	52	19	0.053	0.010			

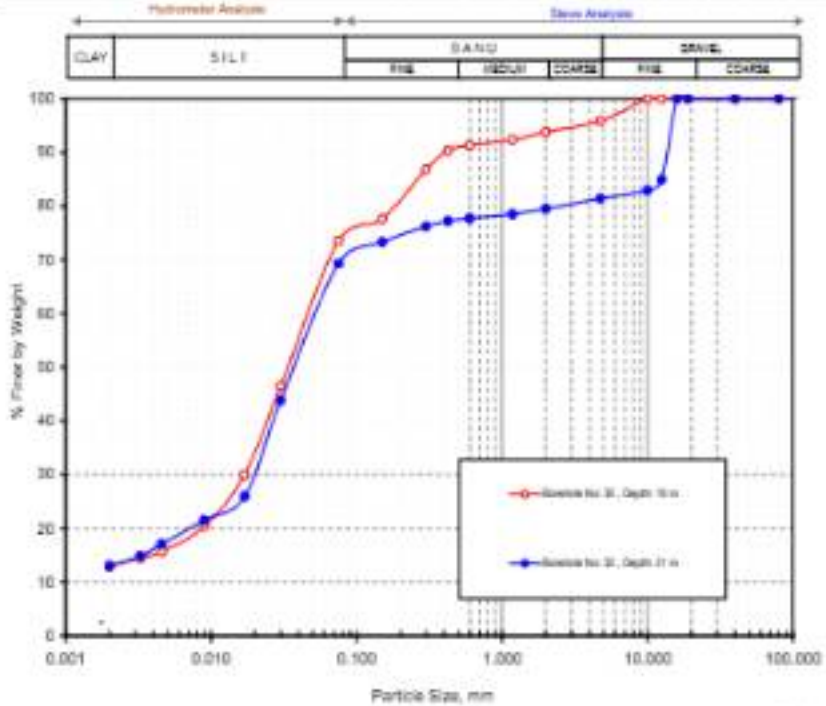


Grain Size Distribution Curve

Grain Size Analysis

IS : 2720 (Part 4) - 1985, RA-2010

Sample Details			Test Results								
Borehole Number	Sample Depth, m	Sample Description	% Gravel	% Sand	% Silt	% Clay	D_{60}	D_{10}	D_{30}	C_u	C_c
BH-30	18.00	Sandy silt with traces of gravel (CL)	4	22	61	13	0.053	0.017			
BH-30	21.00	Sandy silt with gravels (CL)	15	12	56	13	0.059	0.020			

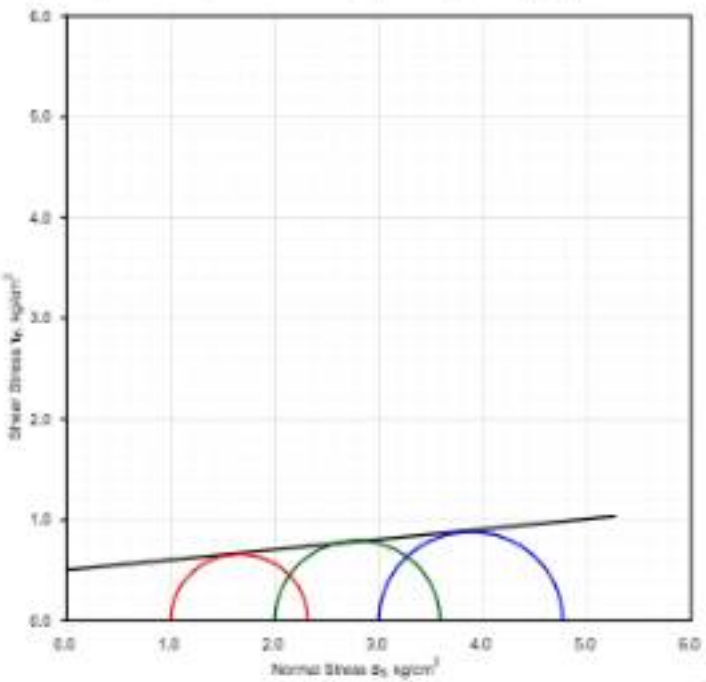


Grain Size Distribution Curve

Unconsolidated Undrained Triaxial Test

IS : 2720 (Part-11)-1993, RA-2007

Sample Details	Borehole No.: BH-30		Sample Depth: 2.25 m	
	Sample No.: UDS-1		Sample Description: Sandy silt	
	Confining Pressure, σ_3 (kg/cm^2)	1.0	2.0	3.0
	Initial diameter (cm)	3.8	3.8	3.8
	Initial Length (cm)	7.6	7.6	7.6
	Bulk Density (g/cc)	1.75	1.75	1.75
	Dry Density (g/cc)	1.56	1.56	1.56
	Moisture Content (%)	12.1	12.3	12.2
Test Results	Peak Deviator Stress, $(\sigma_1-\sigma_3)_f$ (kg/cm^2)	1.32	1.59	1.76
	Failure Strain, ε_f (%)	22.4	22.4	22.4
	Cohesion intercept, c:	**0.59**	**kg/cm^2**	
	Angle of internal Friction, ϕ:	**6.5**	**degree**	

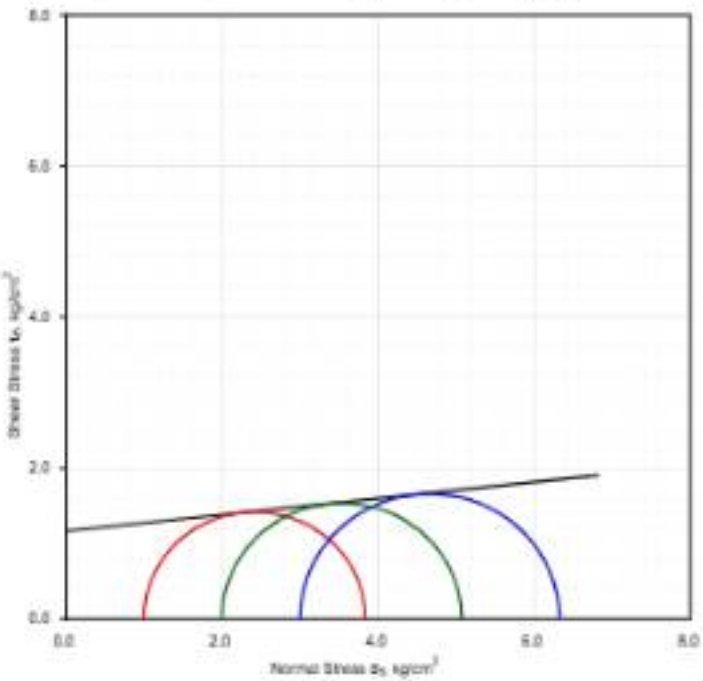


Mohr-Coulomb Failure Envelope

Unconsolidated Undrained Triaxial Test

IS : 2720 (Part-11)-1993, RA-2007

Sample Details	Borehole No.: BH-30		Sample Depth: 5.25 m	
	Sample No.: UDS-2		Sample Description: Sandy silt	
	Confining Pressure, σ_3 (kg/cm^2)	1.0	2.0	3.0
	Initial diameter (cm)	3.8	3.8	3.8
	Initial Length (cm)	7.6	7.6	7.6
	Bulk Density (g/cc)	1.79	1.79	1.79
	Dry Density (g/cc)	1.59	1.59	1.59
	Moisture Content (%)	13.0	12.8	12.6
Test Results	Peak Deviator Stress, $(\sigma_1-\sigma_3)_f$ (kg/cm^2)	2.84	3.07	3.32
	Failure Strain, ε_f (%)	22.4	22.4	22.4
	Cohesion intercept, c:	**1.20**	**kg/cm^2**	
	Angle of internal Friction, ϕ:	**6.2**	**degree**	

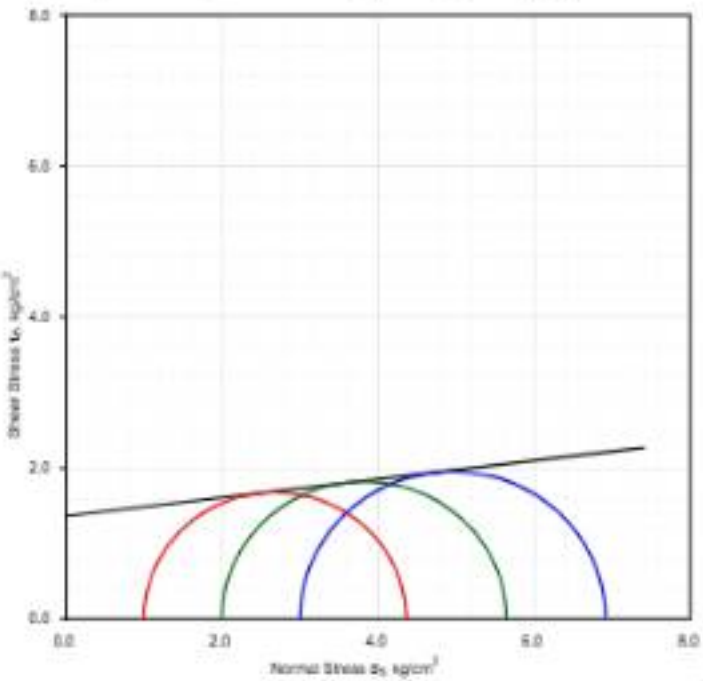


Mohr-Coulomb Failure Envelope

Unconsolidated Undrained Triaxial Test

IS : 2720 (Part-11)-1993, RA-2007

Sample Details	Borehole No.: BH-30		Sample Depth: 8.25 m	
	Sample No.: UDS-3		Sample Description: Sandy silt	
	Confining Pressure, σ_3 (kg/cm^2)	1.0	2.0	3.0
	Initial diameter (cm)	3.8	3.8	3.8
	Initial Length (cm)	7.6	7.6	7.6
	Bulk Density (g/cc)	1.85	1.85	1.85
	Dry Density (g/cc)	1.62	1.62	1.62
	Moisture Content (%)	14.3	14.2	14.4
Test Results	Peak Deviator Stress, $(\sigma_1-\sigma_3)_f$ (kg/cm^2)	3.36	3.64	3.91
	Failure Strain, ε_f (%)	22.4	22.4	22.4
	Cohesion intercept, c:	**1.49**	**kg/cm^2**	
	Angle of internal Friction, ϕ:	**7.0**	**degree**	

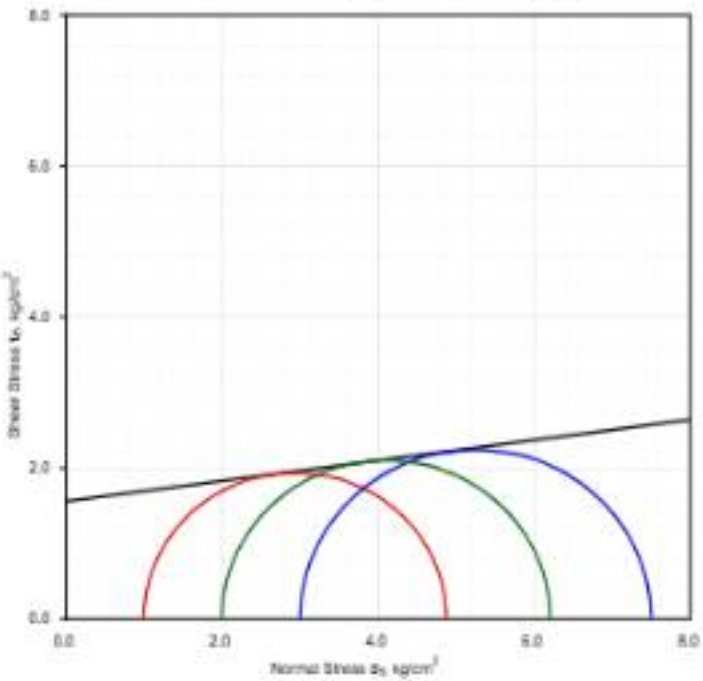


Mohr-Coulomb Failure Envelope

Unconsolidated Undrained Triaxial Test

IS : 2720 (Part-11)-1993, RA-2007

Sample Details	Borehole No.: BH-30		Sample Depth: 11.25 m	
	Sample No.: UDS-4		Sample Description: Sandy silt	
	Confining Pressure, σ_3 (kg/cm^2)	1.0	2.0	3.0
	Initial diameter (cm)	3.8	3.8	3.8
	Initial Length (cm)	7.6	7.6	7.6
	Bulk Density (g/cc)	1.89	1.89	1.89
	Dry Density (g/cc)	1.64	1.64	1.64
	Moisture Content (%)	15.1	15.2	15.1
Test Results	Peak Deviator Stress, $(\sigma_1-\sigma_3)_f$ (kg/cm^2)	3.88	4.21	4.49
	Failure Strain, ε_f (%)	22.4	22.4	22.4
	Cohesion intercept, c:	**1.89**	**kg/cm^2**	
	Angle of internal Friction, ϕ:	**7.7**	**degree**	

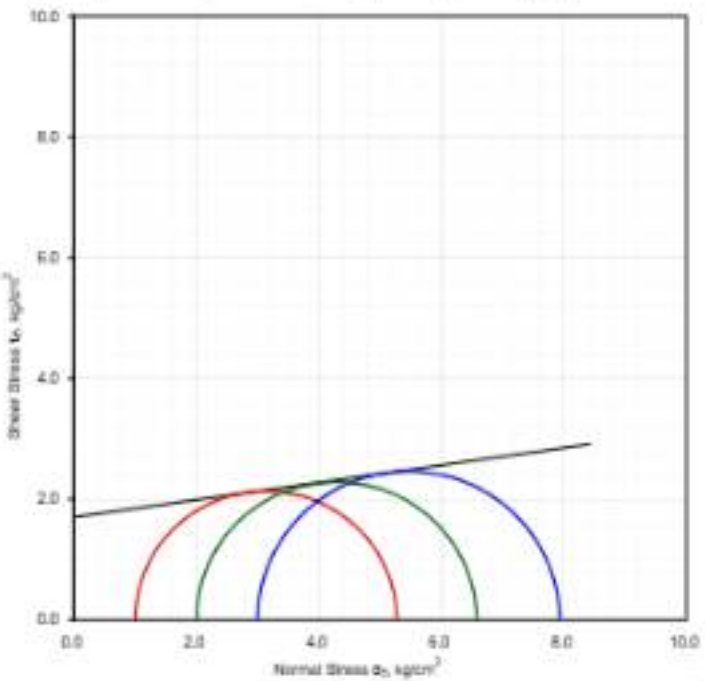


Mohr-Coulomb Failure Envelope

Unconsolidated Undrained Triaxial Test

IS : 2720 (Part-11)-1993, RA-2007

Sample Details	Borehole No.: BH-30		Sample Depth: 14.25 m	
	Sample No.: UDS-5		Sample Description: Sandy silt	
	Confining Pressure, σ_3 (kg/cm^2)	1.0	2.0	3.0
	Initial diameter (cm)	3.8	3.8	3.8
	Initial Length (cm)	7.6	7.6	7.6
	Bulk Density (g/cc)	1.95	1.95	1.95
	Dry Density (g/cc)	1.66	1.66	1.66
	Moisture Content (%)	17.7	17.6	17.7
Test Results	Peak Deviator Stress, (σ_1-σ_3)$_f$ (kg/cm^2)	4.27	4.57	4.93
	Failure Strain, ε_f (%)	22.4	22.4	22.4
	Cohesion intercept, c:	**1.70**	**kg/cm^2**	
	Angle of internal Friction, ϕ:	**8.1**	**degree**	

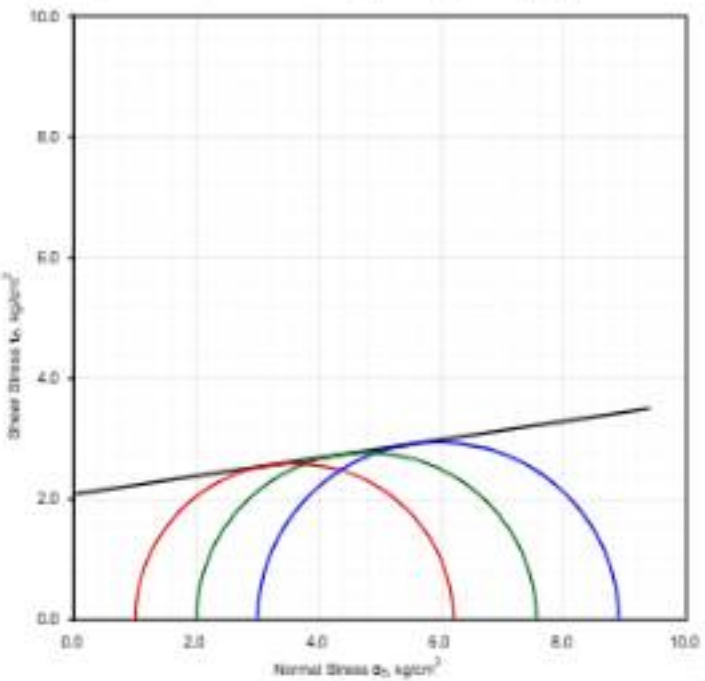


Mohr-Coulomb Failure Envelope

Unconsolidated Undrained Triaxial Test

IS : 2720 (Part-11)-1993, RA-2007

Sample Details	Borehole No.: BH-30		Sample Depth: 17.25 m	
	Sample No.: UDS-6		Sample Description: Sandy silt	
	Confining Pressure, σ_3 (kg/cm^2)	1.0	2.0	3.0
	Initial diameter (cm)	3.8	3.8	3.8
	Initial Length (cm)	7.6	7.6	7.6
	Bulk Density (g/cc)	1.99	1.99	1.99
	Dry Density (g/cc)	1.68	1.68	1.68
	Moisture Content (%)	18.2	18.3	18.4
Test Results	Peak Deviator Stress, $(\sigma_1-\sigma_3)_f$ (kg/cm^2)	5.19	5.55	5.90
	Failure Strain, ε_f (%)	22.4	22.4	22.4
	Cohesion intercept, c:	**2.19**	**kg/cm^2**	
	Angle of internal Friction, ϕ:	**3.6**	**degree**	

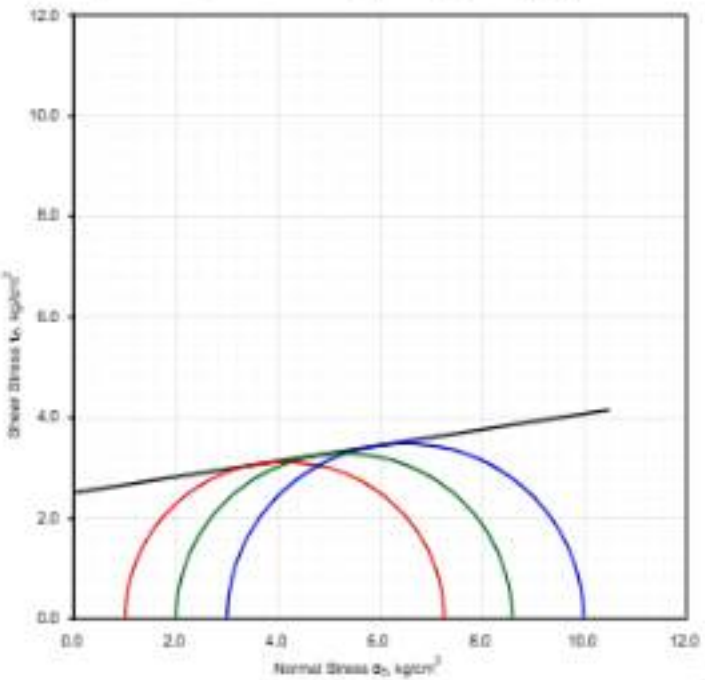


Mohr-Coulomb Failure Envelope

Unconsolidated Undrained Triaxial Test

IS : 2720 (Part-11)-1993, RA-2007

	Borehole No.: BH-30	Sample Depth: 20.25 m		
	Sample No.: UDS-7	Sample Description: Sandy silt		
Sample Details	Confining Pressure, σ_3 (kg/cm^2)	1.0	2.0	3.0
	Initial diameter (cm)	3.8	3.8	3.8
	Initial Length (cm)	7.6	7.6	7.6
	Bulk Density (g/cc)	2.02	2.02	2.02
	Dry Density (g/cc)	1.70	1.70	1.70
	Moisture Content (%)	18.9	18.8	18.7
Test Results	Peak Deviator Stress, $(\sigma_1-\sigma_3)_f$ (kg/cm^2)	6.25	6.59	6.99
	Failure Strain, ε_f (%)	22.4	22.4	22.4
	Cohesion intercept, c:	**2.59**	**kg/cm^2**	
	Angle of internal Friction, ϕ:	**3.5**	**degree**	

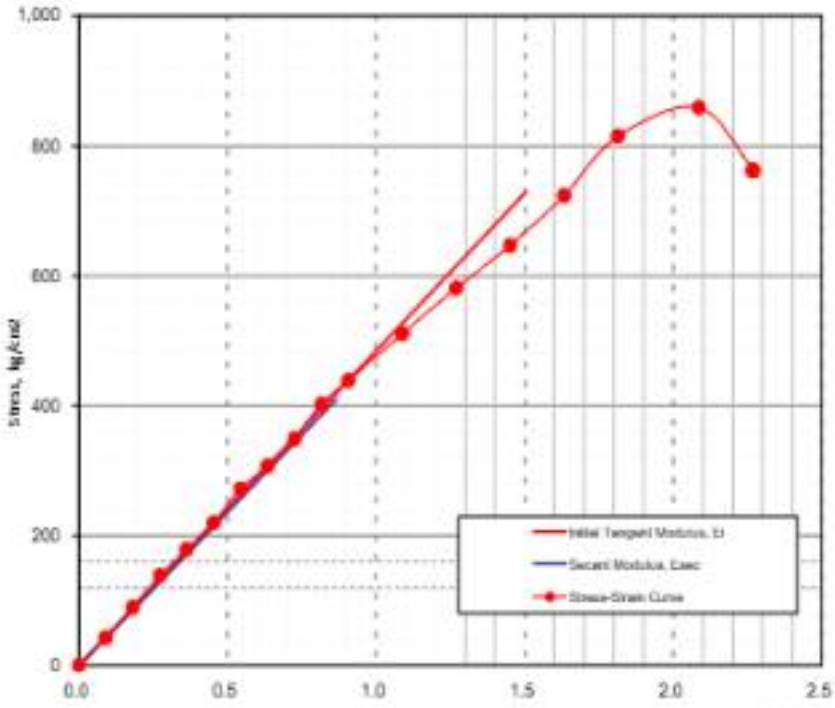


Mohr-Coulomb Failure Envelope

Uniaxial Compressive Strength Test

(IS:9143-1979 RA-2006)

Borehole No. 30	Depth: 24.3 m	Sr. No. of Core : 15
SAMPLE DETAILS	TEST RESULTS	
Serial No. of Core.: 15	Unconfined Compressive Strength: 856 kg/sq.cm	
Rock Type: QUARTZITE		
Sample diameter (cm): 5.47	Failure Strain, ε: 2.1 %	
Sample Length (cm): 11.02	Secant Modulus, E_{sec}: 47237 kg/sq.cm	
Initial Bulk Density (g/cm^3): 2.40		
Sample Condition: Unsoaked	Initial Tangent Modulus, E_i: 48439 kg/sq.cm	

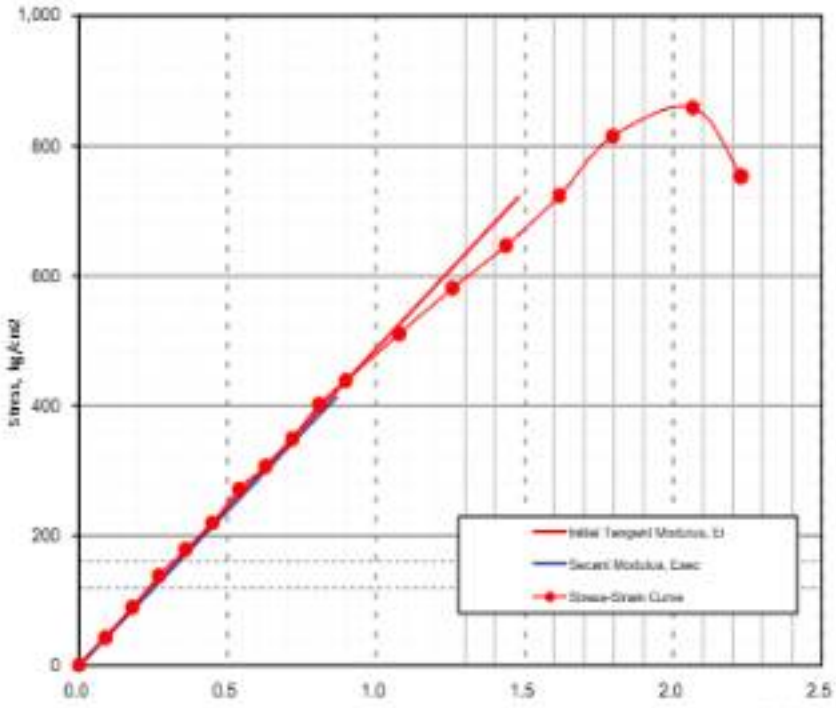


Uniaxial Compressive Strength Test on Rock Core Sample

Uniaxial Compressive Strength Test

(IS:9143-1979 RA-2006)

Borehole No. 30	Depth: 24.3 m	Sr. No. of Core : 18
SAMPLE DETAILS	TEST RESULTS	
Serial No. of Core.: 18	Unconfined Compressive Strength: 856 kg/sq.cm	
Rock Type: QUARTZITE		
Sample diameter (cm): 5.47	Failure Strain, ε: 2.1 %	
Sample Length (cm): 11.13	Secant Modulus, E_{sec}: 47685 kg/sq.cm	
Initial Bulk Density (g/cm^3): 2.50		
Sample Condition: Unsoaked	Initial Tangent Modulus, E_i: 48782 kg/sq.cm	



Uniaxial Compressive Strength Test on Rock Core Sample

Bor. No.	Rock Individuals	Depths (m)	IS : 2720 (Part 5)-1985, Reaffirmed 2007	IS : 13030-1991, Reaffirmed 2009			By Calculations		IS : 9143-1980, Reaffirmed 2009	IS : 10101-1979, Reaffirmed 2009	*Slaking Grade, Individual	Calcium Montmorillonite Index
			Specific Gravity	Density (g/cm3)	Moisture Content, %	Water Absorption %	Void Ratio	Porosity	Rock Quality Index (Approximate)	Unconfined Compressive Strength (kg/cm2)		
[illegible]	7	[illegible]	3.60	3.28	2.52	4.62	[illegible]	[illegible]	0	–	0	–
	9	[illegible]	3.73	3.43	0.80	3.01	[illegible]	[illegible]	14	2430	0	1
	15	[illegible]	3.76	3.44	0.57	1.77	[illegible]	[illegible]	–	533	–	5
	19	[illegible]	3.60	3.30	0.28	1.44	[illegible]	[illegible]	–	803	–	3

* Equivalent Unconfined Compressive Strength based on Point Load Strength Index

** Cassidy Index, Jeager

Physical Properties of Rock

[illegible]
Central Laboratory
[illegible]
Coimbatore [illegible]



Borehole No. [redacted]

Photograph of Rock Core Sample

Annexure – VI
Note on Ventilation Arrangement

SMEC

Member of the Surbana Jurong Group

Preparation of Detailed Project Report Including Pre-Construction Activities for Construction of a Road Tunnel For NH-148AE with its Approach and Connection to NH-248BB and Existing Delhi Internal Roads in the State of Delhi

Note on ventilation arrangement



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1 NATIONAL HIGHWAY NH-48

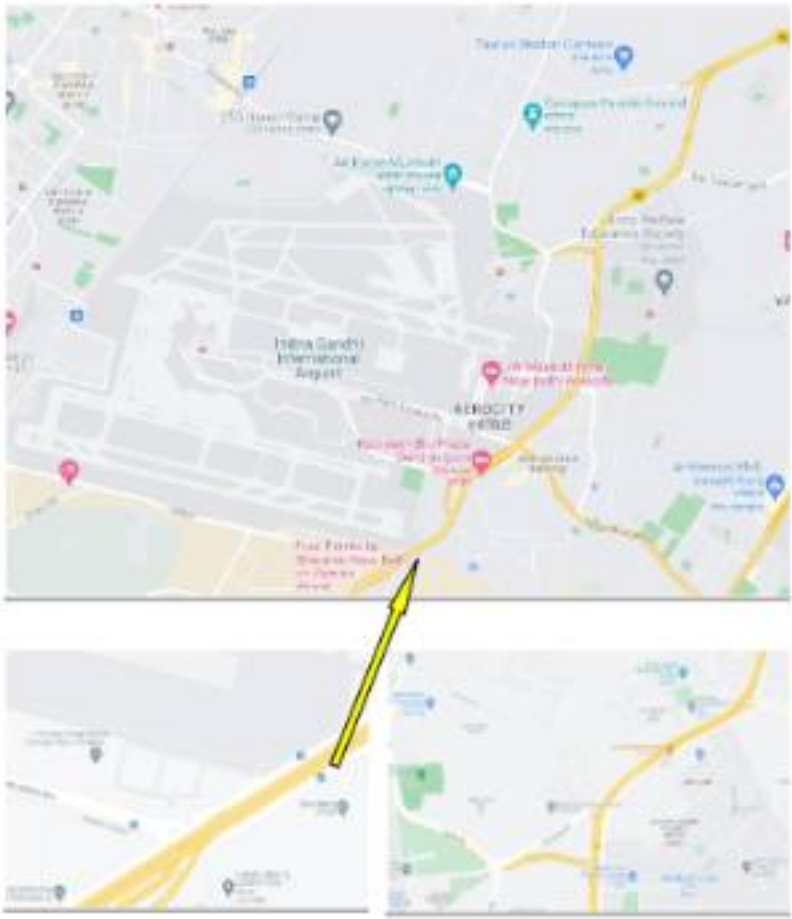


Fig. 1: Location Map

2 PROJECT ROAD DESCRIPTION

The project road length is around 4.935 km. It consists of Two Twin Tube Uni-directional Tunnels at Dwarka in between Shiv Murti and Vasant Kunj on from Design Ch. 0+000 to Ch. 4+306 having length of 4306/4306 m (Tube-1/Tube-2) having total length 4.935 km. A brief description of road project is as follows:

2.1 EXISTING ROAD ALIGNMENT

The project road comprises of new construction of road and no existing road improvement is proposed two sections. Project road length is 4.950 km proposed for Two Lane with Paved Shoulder Configuration comprising of two sections.

This proposed new alignment will act as an alternative to the existing NH.

2.2 TERRAIN

The Project section is primarily lying in Plain Area.

2.3 SEISMICITY

According to 2014 seismic zoning map of India, the state of New Delhi falls in Zone IV on the basis seismic hazard. The project falls under seismic intensity Zone IV, which is classified as high damage risk zone.



Fig. 2: Seismic Zone Map of India

2.3.1 GEOMETRIC DESIGN

Geometric design standards shall been laid down keeping the above in view. The geometric design will be mainly prepared based on adopting relevant standards from IRC SP for Highways, IRC:73-Geometric Design Standard of Rural (Non-Urban) Highway.

2.3.2 TERRAIN CLASSIFICATION

The project road lies in plain terrain. The geometric standards relevant to Plain terrain as contained in other relevant IRC standards and codes shall be adopted.

The Table below indicates the Terrain classification considered for existing road length which is being improved for Lane section as per proposed widening scheme for the project road.

Table 1: Terrain classification for the roads based on percent cross slope of the country

Terrain classification	Percentcross slope of the country
Plain	0-10
Rolling	>10-25
Mountainous	>25-60
Steep	>60

2.3.3 DESIGN SPEED

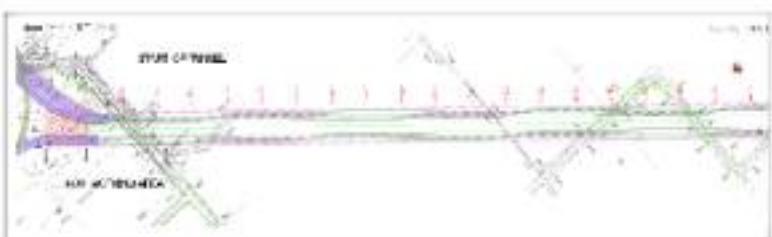
It is the basic parameter, which determines all other geometric design features. The adopted design speed for this project is 50 km/hr to 80 km/hr. Where the site conditions or economic considerations do not permit the ruling design speed, same will be reviewed in consultation with the Client.

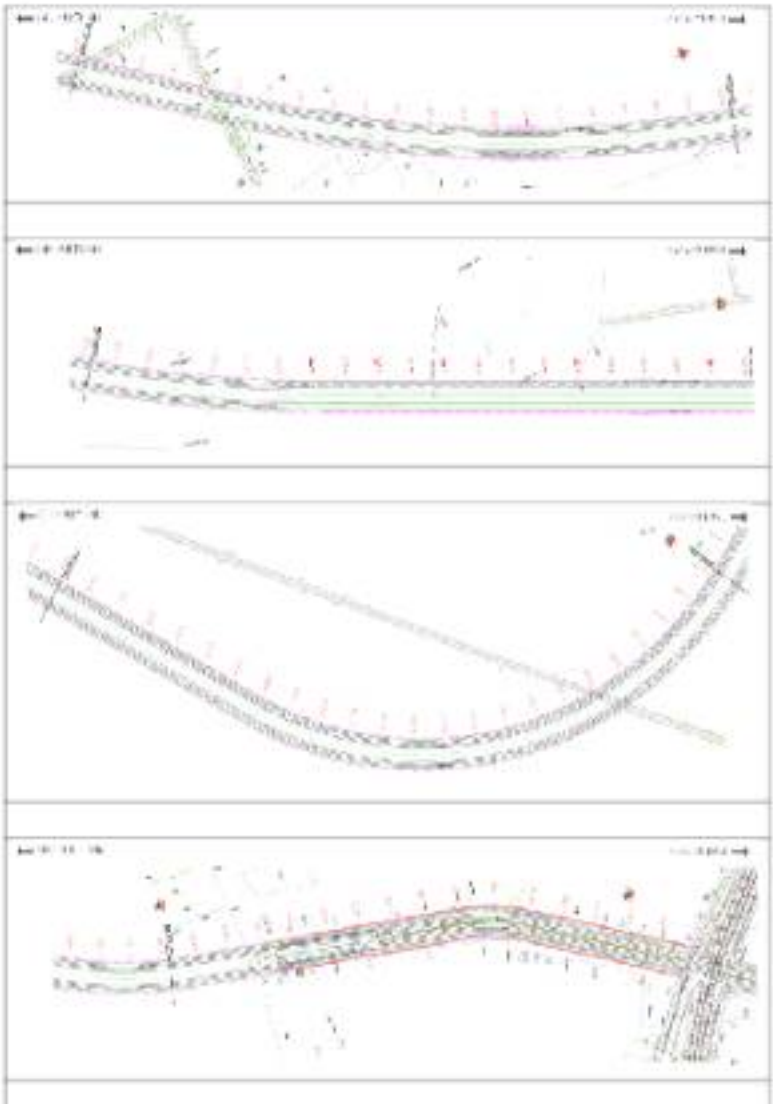
2.3.4 LANE WIDTH

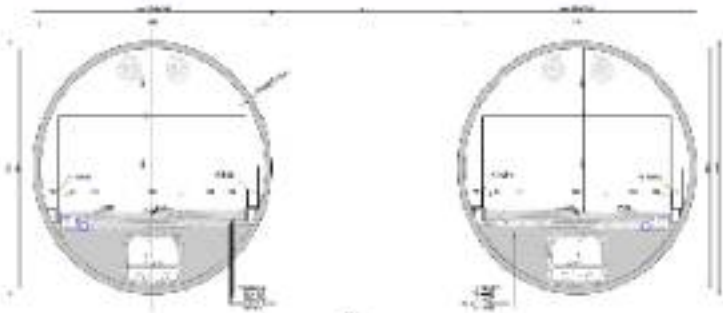
The standard lane width of the Project Highway is 3.5 m.

The Uni-directional Twin Tube Tunnel plan includes the provision of Vehicles cross passage (VCP) and Laybye at suitable locations from each portal, emergency telephones and fire-fighting cabinets and Traffic management System.

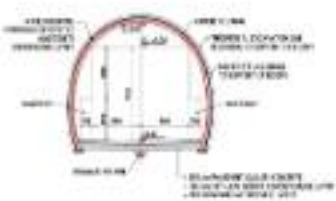
2.3.5 TUNNEL: PLAN & PROFILE











3 OVERVIEW

The main objectives of this document are as follows:

- To summarize the scope of works of the design of the tunnel ventilation system for Tunnels, define the relevant design standards and codes of practice to be followed and confirm the design criteria.
- To state the design methodology, consideration and calculation.
- To recommend the scheme of the tunnel ventilation system, control philosophy and equipment specification of major equipment.
- To be the base of reference in the preliminary design stage.

4 SCOPE AND REQUIREMENTS

The tunnel ventilation system is designed for two purposes:

1. To provide Ventilation during normal operating conditions in order to maintain air quality conditions below the maximum allowable emission limits inside tunnels.
2. Provide a means of smoke control during the event of a fire, in order to help with the safe evacuation of occupants as well as to provide a safe means of approach for fire-fighting and emergency services.

5 DESIGN STANDARDS AND CRITERIA

The ventilation system design complies with the following:

- PIARC Vehicle Emissions Air Demand Environment Longitudinal Ventilation, 2019 and Vehicle Emissions and Air Demand for Ventilation, 2019.
- NFPA 502 2020 Edition "Standard for Road Tunnels, Bridges, and Other Limited Access Highways".
- IRC SP-91:2010 "Guidelines for Road Tunnels".
- IRC SP-84:2014 "Manual of Specifications & Standards for Four Laning of Highways through Public Private Partnership".

5.1 AIR QUALITY REQUIREMENTS

The PIARC publications are used to outline the recommended in-tunnel pollution limits; these are listed in the table below:

Table 2: Design and Operation Value for CO

Design and Operation Value for CO			
Traffic situation	**Design value**	**Operation condition**	**Operation limits**
Free flowing peak traffic 50 – 100km/h	70 ppm	Normal operation*	<100 ppm
* Intermediate set points and thresholds may be set at levels below the design values			

The design criterion of CO in PIARC current trend of improving the air quality inside tunnel as per 'Road Tunnels: Vehicle Emissions and Air Demand for Ventilation' PIARC 2019, the CO limit for standstill and free flowing condition are taken as 70ppm and 90ppm, respectively.

5.2 TRAFFIC DESIGN SPEED

Design speed for ventilation; posted speed limit of 80 km/h and 20 km/h is taken as the congested case for ventilation design purposes.

5.3 TUNNEL AIR VELOCITY

For safety purposes, the in-tunnel air velocity is not to exceed 10 m/s during emergency operation, as recommended by PIARC.

5.4 TUNNEL DESIGN FIRE

The design fire size for the tunnel is taken as 50 MW for structure design and 30MW for ventilation design corresponding to the traffic in the tunnel as per NPFA 502 2020 Edition and PIARC guide line. Fuel tankers are not expected to run through the tunnels.

A summary of the heat release rates for vehicle fires from some of the guidelines for tunnels is listed below:

Table 3: *PIARC & NFPA-502 Fire Release Value for Various Type of Vehicle*

PIARC & NFPA-502 Fire Release Value for Various Type of Vehicle		
Type of Vehicle	**PIARC**	**NFPA-502**
Passenger Car	2.5-5 MW	5-10 MW
Multiple Passenger Cars (2-4 Vehicles)	8-15 MW	10-20 MW
Bus	10 MW	20 MW
General Goods Truck	20 MW	-
Heavy Goods Truck	50 MW	30 MW

Heavy Goods Vehicle	100-120 MW	70-200 MW
Tanker	30-250 MW	200-300 MW
Tankers, Trailer, Container	20-30 MW	70 MW
Gasoline, Diesel Tanker	100 MW	200 MW

6 CONSIDERATIONS & ASSUMPTIONS

The desired considerations / assumptions regarding Vehicle Emissions Data, Existing Air Quality, Traffic Composition, etc. shall be made during the design of the ventilation system.

Vehicle emissions information with correction factors are based on data tables in 'Road Tunnels: Vehicle Emissions and Air Demand for Ventilation' PIARC 2019. Extraction can be found in Appendix 1.

Each carriageway shall be designed for unidirectional traffic flow at all times. According to the design report / the traffic provided for the Design Purpose.

7 DESIGN METHODOLOGY

The design process which was followed in determining the ventilation system design for tunnels T1 & T2 is based on the following steps:

1. Calculate the emissions levels during normal operating conditions, based on PIARC Vehicle Emissions Air Demand Environment Longitudinal Ventilation, 2019 and Vehicle Emissions and Air Demand for Ventilation, 2019.
2. Determine if mechanical ventilation is required during normal operation and if so, the number of fans which are required to operate.
3. Determine critical velocity required for smoke control in the event of a fire. Typically, this is calculated using NFPA 502- Standard for Road Tunnels, Bridges, and Other Limited Access Highways, 2020 Edition, Annex D also the Kennedy formula will be applied.
4. Calculate the number of fans required to generate adequate smoke control based on the required critical velocity.
5. Determine fan layout and numbers including redundant fans using the physical size of the tunnel, available fan locations and risk of fans being damaged during a fire.
6. Check noise level based on the Jet fan selection.

8 DESIGN PROPOSAL

8.1 NORMAL OPERATION

During normal operation of the tunnel, the piston effect of the vehicles shall draw through enough fresh air in order to ventilate the tunnel and maintain pollution levels below the max-

imum allowable limits which are listed in the design criteria. Air monitoring sensors will be installed within the tunnel to monitor the pollution levels with each carriageway. If pollution levels approach the allowable limits, the jet fans will begin to operate.

Based on the assumed traffic flow and composition, the air flow required to adequately ventilate the tunnel shall be determined for the traffic speeds, 20kph to 80kph as well as the extreme congested condition where all cars are at a standstill. Using the calculation methods outlined in PIARC Vehicle Emissions Air Demand Environment Longitudinal Ventilation, 2019, the vehicle emissions and fresh air requirements for the tunnel shall be determined.

The traffic speed also will create a piston effect in tunnel. The capacity will depend on vehicle speed and the quantity of Vehicle in Tunnel. That will related to the Traffic Density (Car speed=0 km/h), and vehicle quantity in tunnel (Car speed >0 km/h).

** The ventilation calculation for normal operation will be based between a range of 20km/hr min and 80km/hr, the max design speed. Maximum speed limit for the tunnel is 80km/h only.

Fire Mode

- Critical Velocity

Determine critical velocity required for smoke control in the event of a fire. Typically, this shall be calculated using NFPA 502- Standard for Road Tunnels, Bridges, and Other Limited Access Highways, 2020 Edition, Annex D also the Kennedy formula will be applied. We set smoke back layering length equal to zero, then the longitudinal velocity will be equal to Critical Velocity. The calculation result in terms of m/s shall be achieved based on the calculation equation as follows:-

Set $\frac{2}{\rho_0 C_p T_f g^{1/2} H^{5/2}} = Term1$ $0.15c\frac{H}{W}^{1/3} = Term2$

When Term 1 ≤ Term 2

$$\frac{v}{\sqrt{GH}} = 0.1\left(\frac{Q}{\rho_0 C_p T_f g^{1/2} H^{5/2}}\right)^{\frac{1}{3}} \left(\frac{H}{W}\right)^{\frac{1}{3}} F_r^{\left(-\frac{1}{3}\right)}$$ Equation D.1

When Term 1< Term 2

$$\frac{v}{\sqrt{GH}} = 0.45c^{\left(-\frac{c_1}{0.15}\right)}$$ Equation D.1

Where,

ρ_0 = Ambient Density (kg/m³)

C_p = Unit Capacity (kJ/kg K)

g = Horizontal Acceleration (m/sec²)

H = Tunnel Height (m)

L_b Back layering length (m)
Where L_b=0, denotes contaminant velocity (velocity corresponding to the corrected backlayering length)

T_f Ambient gas temperature (K)
u Longitudinal velocity (m/s)
Q Tunnel heat release rate (HRR) (KW)
W Tunnel width (m)

The effect of the tunnel grading is obtained by multiplying the calculated critical velocity uc, by the grade Kg, given in Figure D.1.

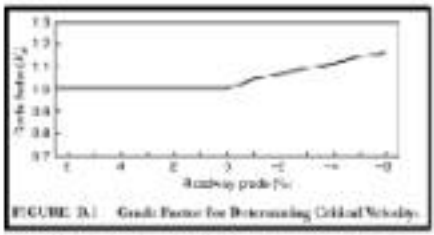


FIGURE D.1 Grade Factor for Determining Critical Velocity

Fig. 3: Grade Factor for Determining Critical Velocity

To prevent smoke back-layering during a fire, the number of jet fans installed within the tunnels shall be sufficient to generate a suitable tunnel critical air velocity for both tube of Tunnel, upstream of the fire.

The number of jet fans required in the tunnel is a function of the in tunnel air velocity, average air temperature, geometry of the tunnel and the jet fan performance. The main factor affecting the number of fans is the amount of thrust each fan can produce. This analysis assumes the jet fan performance shall be outlined in Table format with required quantity of Jet fans.

Upon receiving fire signal from the tunnel fire detection system, all jet fans in the incident tube will operate in the direction of traffic flow.

Suitable arrangement to prevent the risk of smoke re-circulating into the non-incident tube shall be considered.

- Pressurized the Vehicular Cross Passage (VCP)

When the fire incident happens, the emergency door will be opened. The positive pressure in passage is required, in order to prevent the smoke spread flow into the passage and flow into the non-incident tube.

A standard pedestrian door is 2m x 1m = 2 m² door. The standard velocity through the cross passage door in the event of a fire is expected to be 1m/s.

8.2 TRAFFIC STANDSTILL (0 KM/H) CONDITION

In the extreme traffic condition where all traffic within the tunnel is at a standstill for an extended period of time, the ventilation system will operate based on air quality sensors within the tunnel. These sensors will monitor the pollution levels within the tunnel at all times. When pollution levels exceed the set limits, jet fans will start to operate for a set period of time until the pollution levels decrease. The jet fans will be turned on one pair by one pair until the pollution level is below the allowable limit.

(**Note**: This is a traffic management scenario. The patrons will be informed to turn their engines off and walk out of the tunnel until it is safe to return. This is for fire mode ventilation design condition only.)

- **Jet Fan Layout and Performance**

As established above, the requirement of ventilation for emergency operation is greater than that under free flowing and standstill condition. So the proposed fan plan is emergency dominated and is described below.

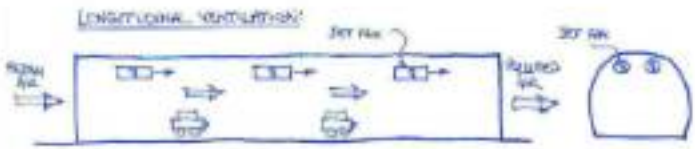


Fig. 4: Longitudinal Ventilation System

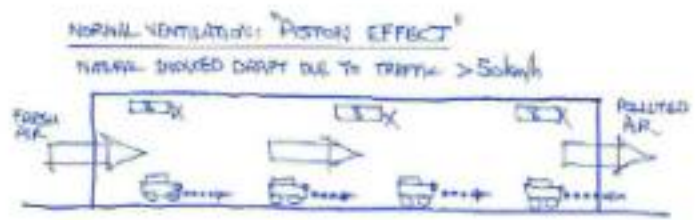


Fig. 5: Piston Effect

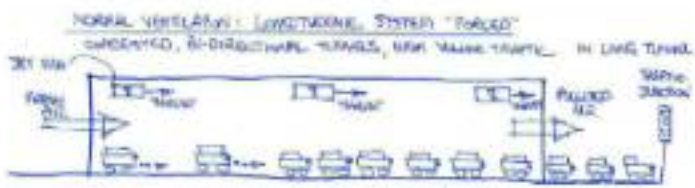


Fig. 6 Longitudinal Mechanical Ventilation



Fig. 7: Emergency Ventilation with Longitudinal System

The jet ventilation effect mainly depends on the jet's effect, but also it is related to the suction flow state of the fan into the n part. Perfect inhalation conditions and fully developed jets are necessary for the normal operation of jet fans.

The necessary conditions are also the basic guarantee for obtaining a good ventilation effect to this end.

A reasonable longitudinal separation should be maintained between the wind turbines to produce jets fan the best ventilation effect. The minimum distance control can be used in the application.

With reference to the test data of the Japanese **HABARA tunnel**, the experimental equation is as follows

$$L_p = (9+6.5^{*}\alpha-1.1(i^{*}\alpha^{*}\beta)^{*}de$$

Where, L_p = Optimal Distance (m)
α= Non-unit Factor (3.00.4 - 0.15C°)
i= Every Sets of Jet fan Installation at the same location =1
β= Non-unit Factor (C.20185 - 0.0002)
de=Tunnel Hydraulic Diameter (m)=9.5

To prevent non-incident tunnel (polluted air or smoke extraction), the 1st set of Jet Fan near the entrance /exit portal of Tunnel, normally the Jet fan should be arrange to reverse flow operation and increase the quantity of operational Jet Fan in this tunnel.

Note: The configuration should be adjusted evenly to meet the data of the real tunnel length.

2 units per tube of considered destroyed by Fire and same redundant units will be added. (Total will be 4 units), if total quantity in odd number then, suggest additional one unit will be added to form as 2 units per set installation.

8.3 CONTROL PHILOSOPHY

- Normal Mode

The purpose of normal mode ventilation system is to maintain air quality conditions below the maximum allowable emission limits.

During normal operation of the tunnel, the piston effect of the vehicles will draw through enough fresh air in order to ventilate the tunnel and maintain pollution levels below the maximum allowable limits which are listed in the design criteria. Air monitoring sensors will be installed within the tunnel to monitor the pollution levels with each carriageway. In congested traffic conditions pollution may reach the allowable limits, this will cause a pair of jet fans to operate. If the pollution limits remain high, an additional pair of fans will operate. All of the fans will have the ability to be manually operated at any time by the tunnel operator. The ventilation calculation for normal operation is based between a range of 20km/hr min and 80km/hr, the max design speed

The control philosophy during normal operation is summarized as follows:

Table 4: Levels Control Philosophy for Jet Fan Operation

2 Levels Control Philosophy for Jet Fan Operation						
Any reading exceeding the pre-determined (adjusted) set point					Nos. of Jet fan in operation	
Level	CO	NO2	Visibility	Temperature	Right Tunnel	Left Tunnel
1	50 ppm	0.7 ppm	$0.003m^{-1}$	50°C	1 pair by pair start until the set point reached	1 pair by pair start until the set point reached
2	60 ppm	0.7 ppm	$0.004m^{-1}$	55°C	1 pair by pair start until the set point reached	1 pair by pair start until the set point reached

- Fire Mode

The aim of the fire mode ventilation system is to provide a means of smoke control during the event of a fire. This is in order to help with the safe evacuation of occupants as well as to provide a safe means of approach for firefighting and emergency services.

When a fire is detected in the tunnel by tunnel fire alarm system, all jet fans will be signaled to operate automatically via the fire control system. All jet fans in the incident tube will operate in the direction of traffic flow whereas two jet fans in the non-incident tube will be electrically reversed to operate against the flow of traffic. This will prevent the risk of smoke recirculating into the non-incident tube. All of the fans will have the ability to be manually overridden during fire mode via the fire control system. Furthermore, all fan protections will be disabled during fire mode; this will ensure that the motors will not trip in the elevated temperature.

Annexure – VII
Muck Disposal Plan

Muck Disposal Plan

Construction of a Road Tunnel for NH-148AE with its approach and connection to NH-248BB and existing Delhi internal roads in the State of Delhi.

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3 Traffic Forecast and Projections 3
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1 Project Background

The National Highways Authority of India has been assigned the work of "Construction of a Road Tunnel for NH-148AE with its approach and connection to NH-248BB and existing Delhi Internal roads in the State of Delhi." The project road takes off from proposed Bhumurti Interchange to Nelson Mandela Marg. A Bypass to Rangpuri will connect Dwarka Expressway with Vasant Kunj through Nelson Mandela Marg. The proposed project site is shown in Figure 1.1.



Figure 1-1 : Proposed Project Location

A large quantity of muck is expected to be generated as a result of construction of this project. Muck generated from excavation of any project component is required to be disposed in a planned manner so that it takes a least possible space and is not hazardous to the environment. Thereby, a muck disposal plan has been proposed.



Figure 1-2 Proposed Project on Google Earth

2 Need of the Project

The purpose of the project is to provide connectivity directly from Delhi- Gurgaon Expressway (NH 24BB and NH-48) to Nelson Mandela Road by way of an underground road tunnel (NH 148AE). Traffic congestion/ traffic jam takes place at Delhi- Gurgaon Expressway near Mahipalpur/ Rangpuri etc. and such type of situations cause significant delay to commuters and creates local pollution due to slow-moving traffic. Widening along this route is almost difficult due to heavy settlement, and therefore, implementation of the proposed project will create a shorter distance route reducing the travel time, and hence, resolve traffic congestions problem at the aforesaid places. In addition, it will improve local ambient air quality and reduction in carbon footprints during entire life cycle of the project. The junctions with existing road will be planned in the form of interchanges and flyover to ensure uninterrupted flow of traffic. Further the availability of 6 lane road at Nelson Mandela Marg meets the design configuration of tunnel that has also been proposed a 6 lane tunnel. Traffic flow would be easy without any major hassles.

The proposed road would act as the prime artery for the economic flow to this region. It will enhance economic development, provide employment opportunities to locals, ensure road safety, and provide better transportation facilities. Vehicle operating cost will also be reduced due to improved road quality and shorter distance. The compensatory plantation shall further improve the air quality of the region.

3 Traffic Forecast and Projections

Classified Traffic volume survey is conducted to know the quantum of vehicles passing through a given section of road over a period of time. The survey is also important to understand the following:

- To check the efficiency of the network by comparing existing traffic with LOS or with the capacity.
- To estimate future traffic flows.

Traffic surveys were conducted at Nelson Mandela Marg, Ghitorni at UG Road and at Rao Tula Ram Marg. The map showing location of traffic surveys is shown in Figure 3-1 below. The analysis of the classified traffic volume counts at all 3 count stations was done to determine following traffic characteristics:

- Average Daily Traffic
- Daily Variation of Traffic
- Maximum, Minimum and Average Traffic
- Percentage Variation of Traffic
- Hourly Distribution and Directional Distribution of Traffic
- Traffic composition
- Annual Average Daily Traffic (AADT)

Data collected at the site was computerised for further analysis. The various vehicle types having different size and characteristics were converted into passenger car equivalents. Passenger Car Unit (PCU) equivalent values as suggested in IRC-64-1990 Guidelines for Capacity of Roads in Rural Areas were adopted. The traffic projections are presented in the table below.



Figure 3-1 : Location of Traffic Surveys

Year	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
PCUs	28547	29974	31473	33046	34699	35913	37170	38471	39816	41211
Year	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
PCUs	42342	43398	44380	45480	46627	47782	48967	50212	51467	52754
Year	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
PCUs	54079	55425	56810	58230	59686	61178	62708	64276	65882	67530

Based on IRC guidelines, base year traffic i.e., year 2021 is 28547 PCUs which is a 4-lane configuration which is triggered at the year 2021 itself. In the year 2030, traffic exceeds 41211 PCUs which is a 6-lane configuration required at the LOS B. Approach Road requires to be widened to 6 lane configuration at the LOS C by the year 2045 when it crosses 59686 PCUs mark.

4 Project Overview

The project road takes off from Proposed Bhalsvurti interchange (Dwarka Expressway Package-1) to Nelson Mandela Marg. A Bypass to Rangpuri will connect Dwarka Expressway (NH 248BB) with Vasant Kunj through Nelson Mandela Marg. The entire alignment is green field. The length of the proposed project is

4.883 km including 4.3 km long twin tunnels and RoW varies from 30m to 45 m. The twin tunnels, bearing a higher financial implication on the developer, NHAI, have been proposed to protect any kind of surface destruction in the Southern Ridge area, maintaining the ecology and biodiversity of the Ridge area.

The proposed twin tunnels run parallel to each other and are followed by a 670m long approach ramp towards Masoodpur flyover, which is also planned for improvement. The improvement works at Masoodpur junction will include construction of an one way flyover and a dedicated U turn. The junction is proposed to be developed as a signal free interchange and hence reducing the current traffic hassles at the junction.

Geometric design standards are adopted keeping the above in view. The project road lies in plain and rolling terrain. The twin tunnels are proposed at shallow depth of around 20 m. The proposed depth of the twin tunnels is governed by the entry and exit gradient of the tunnel road kept well within the prescribed IRC codal provisions.

The excavation of the twin tunnels will be carried out by Tunnel Boring Machine (TBM). *The length of the Southern Ridge involved in this project is about 2.03km. In this entire length of the Southern Ridge, underground tunnels are proposed to be constructed without any surface intervention.* The Project falls in the Ridge area of the New Delhi district of the state. As per the record of ISFR 2021, the total forest cover of New Delhi district is 16.47 sq km against the geographical area of 35 sq Km, for the district. ***The total ridge area falling under the proposed project alignment is 5.82 Ha, whereas the proposed project area under the deemed forest area (non-ridge) is 1.00 Ha.*** Around 3 Ha of non-forest land is required for the surface works of the Project, for which it is proposed to fell 665 trees. Hence overall for the project, 665 trees are proposed to be cut. However, the major portion of the project is underground for which no flora and fauna would be harmed. The 6.82 Ha Forest cover, including the ridge and non-ridge area above the proposed tunnel, will remain intact and **no harm will be done to over 7000 trees above the underground structure in that region.**

Geotechnical investigations revealed that the ground water table is below the tunnel invert level as none of the bore holes intersected water table to the depth of 40m. As per *CGWB-Ground Water Yearbook 2019-20*, the ground water table is at 62m below the surface level in Vikhaull area, which is significantly below the tunnel level, and therefore, any impact on the hydrology, aquifers, etc. is not envisaged.

5 Selection of Tunnel Methodology

Though tunnel through TBM is quite expensive as compared to the traditional Drill and Blast method, tunneling through TBM brings vast range of merits over the latter. Tunneling through TBM (See Figure 5-1) significantly reduces the potential environmental impacts in terms of noise, dust and visual on sensitive receives and restricts the impact close to launching and retrieval shafts. It also reduced the disturbance to the local traffic and environment. It also significantly reduces the quantity of C & D material generated.

In addition to above the impact of vibrations over the ground caused due to tunneling with TBM is quite negligible and bears no impact to the ecology over the ground. An assessment on the vibration induced by tunnel boring machine in urban areas with an in situ measurements and the respective analysis of the

measurements was published in Journal of Rock Mechanics and Geotechnical Engineering. The said technical paper is attached as Annexure 1 with the report. It was evident in the research paper that the amplitude of the velocities measured in the TBMs is of the order of 0.1 mm/s in clay soils, 1 mm/s in sand and gravel, and 10 mm/s in rocky soils. On the ground surface, the particle velocities between 10 m and 30 m in front of the cutting face are about 10 times lower than those inside the TBM (Refer Figure 5-2). The high contrast between velocities measured inside the TBM and on the surface reveals that only a part of the energy measured inside the TBM is transmitted to the ground. 80% of the energy of the vibration signals in the TBMs is in the range 0-40 Hz.

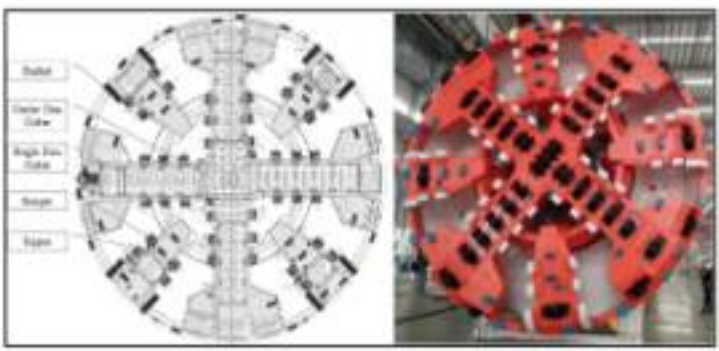


Figure 5-1 : Tunnel Boring Machine Cutterheads



Figure 5-2 : Vibrations meant at TBM at Surface and at Face

6 Objective

The main objectives of process of muck dumping and restoration of these muck disposal sites are:

- To protect and control soil erosion
- To create greenery in the muck disposal areas
- To improve and develop the sites into recreational sites
- To ensure maximum utilization of muck for the construction purpose
- To develop the muck disposal sites/ dumping yards to blend with the surrounding landscape and to minimize damages due to the spoilage of muck in the project area.

7 Approach and Methodology

The approach and methodology used for the muck disposal are:

- Ground truthing and identification of muck disposal sites
- Land acquisition of muck dumping site
- Civil works (construction of retaining walls, boulder crate walls etc.)
- Dumping of muck generated

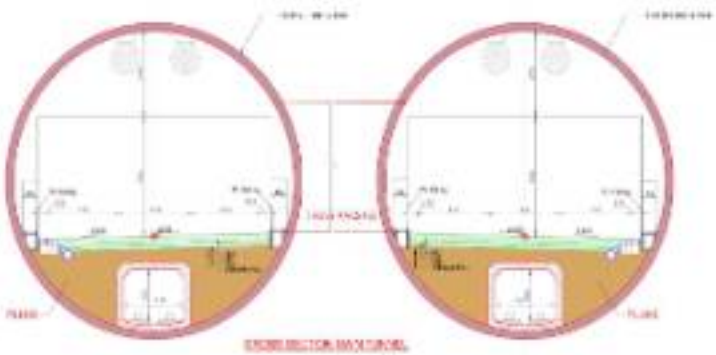


Figure 7-1 : TCS of twin Tunnels

7.1 Quantity of Muck Generated and Its Consumptive Use

During construction of the various components of the project, muck is generated both from soil or silce material and from rock excavation.

Total Length of Tunnel	:	4329m
Excavated Dia of tunnel	:	15.10 m

Excavated tunnel length in rock	:	2100 m
Excavated tunnel length in soil	:	2209 m
Volume of Muck generated (Rock)	:	7,51,749 cum
Volume of Muck generated (Soil, tunnels)	:	7,80,765 cum
Volume of Muck generated (Soil, open)	:	86,100 cum

The total estimated quantity of muck generated is estimated to be 16,68,047 cum and the quantity of muck generated is shown in Table 3.1.

Table 3.1 Quantity of muck being generated

Particulars	Muck Generated (Cum.)		
	Ridge Area	Non-Ridge Area	Total
Excavation in Rock	7,51,749	-	7,51,749
Add Swell factor (14%)	1,05,245	-	1,05,245
Total Quantity (Rock)			8,56,994
Excavation in Soil	-	8,86,899	8,86,899
Add Swell factor (14%)	-	1,24,164	1,24,164
Total Quantity (Soil)			10,11,053
Grand Total (Rock and Soil			**18,68,047**

Based on requirement of construction materials, approx. 46% quantity of rock muck (3,94,752 cum) and 18% quantity of soil muck (1,91,407 cum) has been planned to be reused in the construction of this project which is enumerated in Table 3.2. Remaining 54% quantity of rock muck (4,70,765 cum) and 81% of soil quantity (8,19,645 cum) would need to be shifted to another Project site of NHAI (Connector Corridor from Delhi Meerut Ex-way).

Table 3.2 Muck Consumption for Dwarka Project

PARTICULARS	Major Muck Consumption for Aggregates (Cum.)		
	Rock	Soil	Total
For GSB & WMM in Service Roads and Flyover	11,316		11,316
For GSB, Subgrade and DLC, PQC in tunnels	73,296		73,296
Concrete in Drains & escape tunnel	63,736		63,736
Concrete Lining in Tunnels	1,82,219		1,82,219
Subgrade Fill in Tunnels		1,85,257	1,85,257
Concrete for Pavement, D Wall in Ramp & Flyover	54,186		
Earthfill for Flyover		6,120	6,120
	3,94,752	1,91,407	5,31,972
Balance to be transported	**4,70,765**	**8,19,645**	**13,44,597**

7.2 Selection of Muck Disposal Site

The selection of muck disposal sites was carried out considering the quantity of the muck, landscape, cost effectiveness, nearness to source of generation, absence of ground and surface water, relief and scope for afforestation works. A muck dumping site have been identified matching the criteria. The details of dumping sites along with their total capacity and amount of muck to be disposed are enumerated in Table 3.3

Table 3.3 Details of Muck Disposal Site

S.No.	Name of Dumping site	Location of Dumping site	Type of Muck	Requirement in cum	Volume of muck to be dumped in cum
1.	Connector corridor from Delhi Meerut Expressway	75 km from Dwarka Project	Soil	29,10,829	8,19,648
			Rock	6,84,622	4,70,765

The balance unutilised muck generated from the proposed Dwarka Tunnel Project will be carried to the 8.50 KM long proposed Delhi Meerut Expressway Package V. The said section of the Delhi Meerut Expressway is proposed with 4 lanes and paved shoulder. A typical cross section of the pavement is shown below in Figure 7-2. The project is proposed as a Greenfield corridor with high embankments. The unutilised muck from the Dwarka Project will be transported to this site of NHAI for effective utilization.

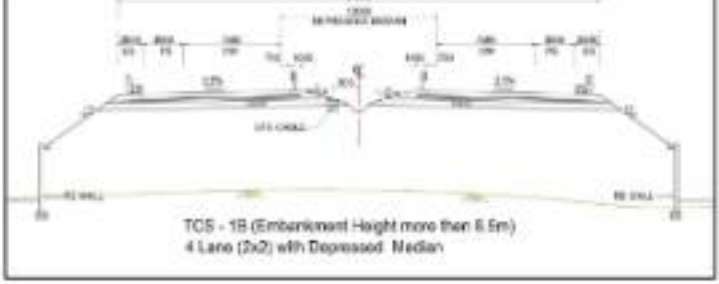


Figure 7-2 : TCS of Delhi Meerut Expressway Package V

7.3 Dumping Process

The generated muck will be carried in dumper trucks covered with heavy duty tarpaulin properly tied to the vehicle in accordance with best international practices. All precautionary measures will be followed during the dumping of muck. All dumpers will be well maintained to avoid any chances of loose soil from being

falling during the transportation. All routes will be periodically wetted with the help of sprinklers prior to the movement of dumper trucks. Dumping would be avoided during the high-speed wind, so that suspended particulate matters (SPM) level could be maintained. Further, the dumping will be avoided during heavy traffic. After the dumping the surface of dumps will be sprayed with water with the help of sprinklers and then compacted. Regular inspection by environmental expert of contractor and authority engineer (AE) shall be made to ensure complete avoidance of spilling of muck outside the boundary. Bio-engineering is the technique of utilizing vegetation in addressing geotechnical problems. Slope of muck disposal sites after completion of dumping to a particular site should be stabilized by stone pitching and turfing with geo mats (Coir Geotextile) & Indigenous species of soil stabilizing legumes like Vetiver grasses. Natural geotextiles degrade quicker than man-made counterpart but facilitate growth of vegetation quicker and better due to its inherent characteristics.

Total muck to be transported	:	13,44,587 Cum
Muck carrying capacity of single dumper	:	6 cum.
Total no. of trips envisaged	:	224,100 trips
Project Schedule	:	5 years
Trips per day	:	122

Annexure – VIII
Girth wise Tree Cutting Detail

Tree Enumeration

Nelson mandela marg

District/Forest Division: West

LHS

S.N.	Chainage	Tree Number	DBH/Girth (in Cm)	Tree Height (M)	Tree Name	Easting	Northing
1	0+000	1	157	20	Gooler	710191	3157845
2	0+033	2	88	8	Sagiyarni	710188	3157850
3	0+054	3	58	5	Kachnaar	710188	3157845
4	0+058	4	190	15	Shahtoot	710184	3157845
5	0+091	5	69	10	Sagiyarni	710181	3157841
6	0+047	6	127	10	Sagiyarni	710181	3157858
7	0+053	7	68	7	Sagiyarni	710178	3157854
8	0+080	8	90	10	Sagiyarni	710186	3157829
9	0+085	9	156	25	Subabul	710178	3157821
10	0+073	10	125	15	Sagiyarni	710172	3157814
11	0+080	11	50	6	Sagiyarni	710170	3157811
12	0+065	12	70	10	Sagiyarni	710169	3157807
13	0+092	13	50	8	Sagiyarni	710169	3157805
14	0+105	15	60	8	Jamun	710148	3157594
15	0+105	15A	40	5	Jamun	710149	3157594
16	0+105	16	170	25	Subabul	710152	3157587
17	0+107	17	83	10	Sagiyarni	710151	3157587
18	0+114	18	100	15	Sagiyarni	710148	3157588
19	0+118	19	68	7	Sagiyarni	710142	3157585
20	0+117	20	126	20	Pipal	710142	3157584
21	0+116	21	107	15	Sagiyarni	710142	3157583
22	0+120	22	48	8	Neem	710142	3157581
23	0+120	23	50	5	Sagiyarni	710141	3157580
24	0+122	24	28	2	Sagiyarni	710142	3157580
25	0+122	25	184	20	Sagiyarni	710148	3157577
26	0+127	26	120	15	Sagiyarni	710144	3157574
27	0+131	27	125	15	Sagiyarni	710137	3157553
28	0+137	28	130	15	Sagiyarni	710139	3157553
29	0+142	29	82	12	Sagiyarni	710127	3157551
30	0+147	30	186	15	Sagiyarni	710124	3157553
31	0+151	31	47	15	Neem	710120	3157547
32	0+151	32	102	10	Sagiyarni	710119	3157550
33	0+155	33	110	15	Semal	710119	3157551
34	0+157	34	120	15	Sagiyarni	710119	3157540
35	0+161	35	105	12	Sagiyarni	710121	3157546
36	0+161	36	73	7	Ber	710119	3157548
37	0+167	37	100	10	Sagiyarni	710119	3157546
38	0+172	38	75	10	Sagiyarni	710116	3157559
39	0+177	39	40	8	Sagiyarni	710118	3157553
40	0+177	40	75	7	Neem	710117	3157529
41	0+177	41	50	5	Sagiyarni	710111	3157550
42	0+187	42	102	12	Neem	710110	3157520

S.N.	Chainage	Tree Number	DBH/Girth (in Cm)	Tree Height (M)	Tree Name	Easting	Northing
43	0+192	43	130	15	Saptparni	710111	3157518
44	0+197	44	115	15	Saptparni	710106	3157519
45	0+202	45	90	10	Saptparni	710101	3157517
46	0+207	46	90	7	Saptparni	710097	3157507
47	0+222	47	75	5	Neem	710096	3157509
48	0+222	48	90	5	Saptparni	710099	3157509
49	0+222	50	50	5	Neem	710095	3157509
50	0+227	51	110	10	Saptparni	710099	3157505
51	0+231	52	117	15	Saptparni	710091	3157504
52	0+238	53	150	12	Saptparni	710091	3157505
53	0+240	54	97	15	Saptparni	710082	3157495
54	0+240	54A	40	7	Neem	710082	3157498
55	0+246	55	65	10	Saptparni	710080	3157494
56	0+245	56	47	7	Amaltas	710081	3157499
57	0+245	57	44	5	Amaltas	710078	3157501
58	0+246	58	50	7	Amaltas	710079	3157498
59	0+245	59	100	12	Jamun	710078	3157494
60	0+250	60	90	12	Saptparni	710080	3157490
61	0+250	60A	30	5	Amaltas	710080	3157490
62	0+252	61	40	5	Amaltas	710074	3157490
63	0+253	62	117	10	Saptparni	710078	3157488
64	0+253	63	40	5	Amaltas	710078	3157484
65	0+257	64	90	12	Saptparni	710078	3157482
66	0+260	65	180	15	Gular	710074	3157478
67	0+261	66	57	10	Saptparni	710074	3157479
68	0+258	67	45	5	Amaltas	710074	3157484
69	0+258	67A	30	5	Amaltas	710074	3157484
70	0+264	68	45	5	Amaltas	710072	3157479
71	0+265	69	40	4	Amaltas	710073	3157478
72	0+264	70	37	5	Neem	710075	3157477
73	0+265	70A	55	5	Neem	710075	3157470
74	0+271	71	60	5	Saptparni	710067	3157488
75	0+276	72	54	5	Saptparni	710061	3157484
76	0+276	73	54	5	Amaltas	710059	3157485
77	0+282	74	33	5	Amaltas	710058	3157481
78	0+286	75	55	5	Gulmohar	710048	3157459
79	0+295	76	55	5	Ber	710052	3157453
80	0+310	77	49	5	Kachnar	710052	3157444
81	0+314	78	26	5	Neem	710052	3157440
82	0+324	79	27	4	Kachnar	710058	3157429
83	0+338	80	84	7	Jamun	710058	3157423
84	0+343	81	57	5	Kachnar	710058	3157409
85	0+343	81A	55	5	Kachnar	710058	3157409
86	0+347	82	30	5	Kachnar	710059	3157405
87	0+347	82A	30	5	Ber	710059	3157405
88	0+354	84	80	8	Kachnar	710060	3157398
89	0+366	85	125	15	Gulmohar	710059	3157394
90	0+384	86	28	5	Kachnar	710058	3157368

S.N.	Chainage	Tree Number	DBH/Girth (in Cm)	Tree Height (M)	Tree Name	Easting	Northing
91	0+370	88	77	8	Gulmohar	710018	3157561
92	0+375	87	14	5	Kachnar	710050	3157579
93	0+378	88	24	8	Pagri	710038	3157570

Tree Enumeration
Nelson mandela marg

District/Forest Division: West

RHS

S.N.	Chainage	Tree Number	DBH/Girth (in Cm)	Tree Height (m)	Tree Name	Easting	Northing
1	0+005	\140	40	10	Kachar	710171	3157687
2	0+007	\139	370	25	Pipal	710170	3157685
3	0+013	\138	80	8	Kachar	710168	3157680
4	0+016	\137	250	25	Pipal	710160	3157669
5	0+016	\136	56	7	Septparni	710159	3157669
6	0+021	\134	84	7	Jamun	710158	3157662
7	0+024	\133	70	5	Jamun	710156	3157666
8	0+030	\132	260	22	Pipal	710157	3157667
9	0+032	\131	84	8	Ber	710153	3157664
10	0+032	\131A	67	8	Ber	710153	3157664
11	0+036	\130	80	7	Septparni	710154	3157659
12	0+040	\129	250	25	Pipal	710152	3157654
13	0+045	\128	96	7	Neem	710150	3157646
14	0+148	V8	47	8	Septparni	710102	3157577
15	0+148	V8A	50	8	Septparni	710101	3157577
16	0+146	V7	114	10	Neem	710104	3157575
17	0+151	V8	90	18	Septparni	710100	3157582
18	0+156	V5	126	15	Neem	710094	3157581
19	0+156	V5A	40	1	Pagri	710092	3157585
20	0+163	V4	37	10	Pipal	710089	3157558
21	0+163	V3	110	15	Neem	710090	3157559
22	0+166	V2	80	10	Bargad	710078	3157554
23	0+169	V1	78	10	Neem	710077	3157555
24	0+169	317	210	15	Pipal	710075	3157547
25	0+169	316	109	15	Neem	710071	3157541
26	0+169	315	103	28	Subabul	710070	3157535
27	0+169	314	119	10	Subabul	710070	3157535
28	0+170	313	54	3	Jamun	710072	3157531
29	0+170	312	38	4	Palad	710073	3157529
30	0+173	311	114	10	Subabul	710065	3157530
31	0+180	310	104	9	Septparni	710066	3157522
32	0+183	309	88	8	Septparni	710065	3157510
33	0+186	308	110	8	Septparni	710060	3157518
34	0+189	307	110	7	Septparni	710059	3157514
35	0+192	306	90	8	Septparni	710058	3157511
36	0+195	305	85	8	Septparni	710053	3157508
37	0+198	304	113	8	Septparni	710051	3157506
38	0+198	304A	47	10	Subabul	710050	3157505
39	0+200	303	115	8	Septparni	710048	3157505
40	0+202	303A	38	8	Amaltas	710051	3157507
41	0+202	303B	30	8	Amaltas	710051	3157507
42	0+203	302	100	7	Septparni	710049	3157501
43	0+206	301	90	8	Septparni	710048	3157495

S.N.	Chainage	Tree Number	DBH/Girth (in Cm)	Tree Height (m)	Tree Name	Easting	Northing
44	0+109	200	111	10	Septpemi	710048	3157469
45	0+211	199	121	6	Septpemi	710041	3157465
46	0+216	198	88	8	Septpemi	710040	3157464
47	0+218	197	90	8	Septpemi	710040	3157461
48	0+218	197A	58	5	Subabul	710040	3157461
49	0+218	197B	32	8	Septpemi	710040	3157462
50	0+221	196	80	4	Septpemi	710038	3157477
51	0+225	195	77	4	Septpemi	710038	3157475
52	0+230	194	170	10	Neem	710029	3157470
53	0+237	194A	10	3	Pagri	710039	3157475
54	0+260	193	80	5	Septpemi	710027	3157455
55	0+263	192	98	8	Jamun	710028	3157451
56	0+266	191	65	5	Septpemi	710025	3157444
57	0+269	190	32	8	Jamun	710021	3157441
58	0+270	189	80	8	Septpemi	710019	3157440
59	0+273	188	87	5	Septpemi	710016	3157439
60	0+277	187	88	8	Septpemi	710015	3157435
61	0+280	186	88	4	Septpemi	710013	3157435
62	0+284	185	95	5	Septpemi	710011	3157429
63	0+287	184	75	4	Septpemi	710010	3157424
64	0+291	183	80	8	Septpemi	710008	3157424
65	0+294	182	110	7	Jamun	710007	3157421
66	0+328	181	77	8	Septpemi	709999	3157391
67	0+329	180	93	7	Septpemi	709999	3157388
68	0+332	179	75	5	Septpemi	709999	3157385
69	0+335	178	88	8	Septpemi	709999	3157388
70	0+338	177	93	8	Jamun	709997	3157383
71	0+341	176	51	5	Jamun	709997	3157384
72	0+344	175	80	4	Jamun	709997	3157380

Tree Enumeration
Nelson mandela marg

District/Forest Division: West

Median

S.N.	Chainage	Tree Number	DBH/Girth (in Cm)	Tree Height (M)	Tree Name	Easting	Northing
1	0+015	5	10	1	Sagtgarni	710184	3157849
2	0+019	6	10	1	Sagtgarni	710182	3157842
3	0+022	7	10	1	Sagtgarni	710181	3157838
4	0+025	8	10	1	Sagtgarni	710179	3157836
5	0+028	9	10	1	Sagtgarni	710178	3157833
6	0+031	10	10	1	Sagtgarni	710176	3157830
7	0+035	11	10	1	Sagtgarni	710173	3157825
8	0+045	12	10	1	Sagtgarni	710167	3157818
9	0+050	13	10	1	Sagtgarni	710163	3157814
10	0+053	14	10	1	Sagtgarni	710161	3157810
11	0+056	15	10	1	Sagtgarni	710144	3157807
12	0+059	16	10	1	Sagtgarni	710141	3157804
13	0+064	17	10	1	Sagtgarni	710138	3157799
14	0+070	18	10	1	Sagtgarni	710139	3157796
15	0+073	19	10	1	Sagtgarni	710134	3157793
16	0+080	20	10	1	Sagtgarni	710131	3157788
17	0+088	21	10	1	Semal	710123	3157778
18	0+100	22	45	8	Neem	710118	3157773
19	0+107	23	10	1	Sagtgarni	710116	3157766
20	0+110	24	25	1	Sagtgarni	710114	3157761
21	0+113	25	10	1	Sagtgarni	710113	3157759
22	0+116	26	22	1	Sagtgarni	710111	3157755
23	0+119	27	20	1	Sagtgarni	710109	3157753
24	0+122	28	10	1	Sagtgarni	710107	3157751
25	0+125	29	10	1	Sagtgarni	710105	3157748
26	0+128	30	10	1	Sagtgarni	710103	3157746
27	0+131	31	10	1	Sagtgarni	710101	3157743
28	0+154	32	10	1	Sagtgarni	710097	3157743
29	0+170	36	10	1	Sagtgarni	710083	3157716
30	0+173	37	25	1	Sagtgarni	710081	3157713
31	0+176	38	10	1	Sagtgarni	710079	3157711
32	0+179	39	10	1	Sagtgarni	710077	3157708
33	0+183	40	10	1	Sagtgarni	710074	3157706
34	0+188	41	10	1	Sagtgarni	710071	3157703
35	0+189	42	10	1	Sagtgarni	710069	3157700
36	0+192	43	10	1	Sagtgarni	710067	3157496
37	0+195	44	10	1	Sagtgarni	710066	3157495
38	0+198	45	10	1	Sagtgarni	710063	3157491
39	0+215	46	50	5	Neem	710058	3157482
40	0+220	47	75	8	Neem	710056	3157478
41	0+223	48	10	1	Sagtgarni	710047	3157486
42	0+226	49	10	1	Sagtgarni	710045	3157483
43	0+229	50	10	1	Sagtgarni	710044	3157480

S.N.	Chainage	Tree Number	DBH/Girth (in Cm)	Tree Height (M)	Tree Name	Easting	Northing
44	0+225	51	108	1	Neem	710056	3157480
45	0+235	52	55	1	Neem	710057	3157447
46	0+235	52A	10	2	Sagtgarni	710053	3157455
47	0+235	52B	10	2	Jamun	710056	3157427
48	0+235	52C	10	1	Sagtgarni	710027	3157424
49	0+235	52D	10	1	Sagtgarni	710028	3157435
50	0+235	53	10	1	Sagtgarni	710019	3157421
51	0+241	54	10	1	Sagtgarni	710024	3157416
52	0+248	55	10	1	Sagtgarni	710024	3157414
53	0+250	56	65	5	Neem	710014	3157411
54	0+251	56A	10	2	Sagtgarni	710013	3157413
55	0+255	56B	10	2	Sagtgarni	710013	3157407
56	0+255	56C	10	2	Sagtgarni	710012	3157404
57	0+257	56D	10	2	Sagtgarni	710010	3157400
58	0+255	56E	10	2	Sagtgarni	710019	3157397
59	0+260	57	80	3	Neem	710021	3157396
60	0+270	57A	10	2	Sagtgarni	710018	3157388
61	0+283	57B	12	2	Sagtgarni	710017	3157380
62	0+288	57C	30	4	Ficus	710017	3157376
63	0+290	58	80	4	Neem	710017	3157374
64	0+290	59	25	1	Neem	710016	3157374
65	0+300	60	10	1	Sagtgarni	710014	3157365
66	0+305	60A	10	1	Sagtgarni	710013	3157360
67	0+306	60B	10	2	Sagtgarni	710015	3157355
68	0+310	61	55	4	Neem	710013	3157355
69	0+320	61A	25	3	Ficus	710010	3157343
70	0+323	61B	60	3	Ficus	710009	3157339
71	0+323	61C	10	1	Sagtgarni	710011	3157351
72	0+330	62	10	1	Ficus	710009	3157338
73	0+330	63	65	4	Neem	710009	3157336
74	0+333	63A	15	5	Ficus	710005	3157331
75	0+335	64	10	1	Ficus	710005	3157330
76	0+335	65	100	2	Neem	710006	3157330
77	0+335	66	55	1	Neem	710005	3157318
78	0+337	66A	10	1	Sagtgarni	710004	3157312
79	0+339	66B	10	1	Sagtgarni	710005	3157310
80	0+371	66C	10	1	Sagtgarni	710001	3157308
81	0+378	66D	10	1	Sagtgarni	710001	3157306
82	0+377	66E	10	1	Sagtgarni	710000	3157296
83	0+379	66F	10	1	Sagtgarni	709998	3157295
84	0+379	67	55	4	Neem	709998	3157283
85	0+390	67A	10	2	Sagtgarni	709994	3157276
86	0+405	78	45	3	Neem	709984	3157283
87	0+400	78	45	3	Neem	709981	3157288
88	0+410	77	50	5	Neem	709983	3157314
89	0+410	76	40	2	Ficus	709983	3157314
90	0+415	79	10	2	Ficus	709981	3157309
91	0+425	80	75	5	Neem	709951	3157307

S.N.	Chainage	Tree Number	DBH/Girth (in Cm)	Tree Height (M)	Tree Name	Easting	Northing
92	0+330	51	80	3	Neem	709961	3157205
93	0+330	51A	30	3	Ficus	709961	3157205
94	0+335	53	35	2	Ficus	709963	3157205
95	0+336	53	30	2	Ficus	709963	3157201
96	0+342	54	90	5	Neem	709963	3157199
97	0+340	54A	45	2	Ficus	709963	3157198
98	0+345	55	35	2	Ficus	709961	3157196
99	0+350	56	45	3	Neem	709961	3157194
100	0+360	57	30	2	Ficus	709979	3157188
101	0+360	58	60	3	Shisham	709979	3157185
102	0+370	59	40	3	Neem	709979	3157184
103	0+370	59A	28	2	Ficus	709979	3157184
104	0+380	60	10	3	Neem	709978	3157175
105	0+400	61	90	5	Neem	709974	3157168
106	0+405	62	50	3	Neem	709974	3157167
107	0+407	63	50	3	Neem	709974	3157163
108	0+430	64	20	3	Ber	709973	3157161
109	0+430	64A	30	2	Ber	709973	3157161
110	0+430	64B	34	3	Ber	709972	3157161
111	0+435	65	45	3	Neem	709969	3157149
112	0+445	66	60	3	Neem	709966	3157136
113	0+452	67	65	3	Neem	709966	3157131
114	0+457	68	60	3	Neem	709966	3157126
115	0+460	68A	40	2	Figal	709966	3157126
116	0+460	69	120	5	Neem	709964	3157125
117	0+462	100	55	6	Neem	709963	3157111
118	0+470	101	65	3	Neem	709963	3157105
119	0+470	102	60	5	Neem	709961	3157105
120	0+470	103	50	5	Neem	709960	3157099
121	0+470	103A	30	3	Neem	709960	3157099
122	0+470	104	50	5	Neem	709960	3157099
123	0+470	105	84	5	Neem	709956	3157098

Tree Enumeration
Vasant Kunj to Mehipalpur

District/Forest Division: West

Z[cm] MEDIAN

S.N.	Chainage	Tree No.	DBH/Girth (in Cm)	Tree Height (M)	Tree Name	Easting	Northing
1	04114	V58	100	10	Subabul	710138	3157770
2	04114	V58A	90	10	Subabul	710138	3157770
3	04119	V57	95	10	Subabul	710133	3157766
4	04125	V59	100	10	Subabul	710132	3157778
5	04133	V60	25	5	Neem	710127	3157777
6	04135	24 A	100	10	Kookar	710127	3157780
7	04135	24 B	20	5	Chirchida	710128	3157777
8	04137	V61	90	10	Subabul	710127	3157782
9	04142	V61A	50	5	Subabul	710125	3157788
10	04142	V62	110	10	Kookar	710125	3157788
11	04154	29	300	5	Bahan	710115	3157788
12	04155	30	80	10	Kookar	710121	3157788
13	04160	31	47	5	Neem	710118	3157788
14	04165	32	85	10	Bahan	710119	3157789
15	04170	33	110	15	Subabul	710114	3157792
16	04180	34	70	10	Subabul	710100	3157802
17	04181	35	160	15	Neem	710094	3157806
18	04183	36	60	4	Shahtoot	710094	3157809
19	04183	37	70	5	Ber	710103	3157808
20	04189	38	135	20	Subabul	710089	3157813
21	04193	39	40	10	Subabul	710089	3157813
22	04193	40	70	5	Pagri	710089	3157813
23	04196	41	50	5	Pagri	710093	3157814
24	04197	42	25	5	Pagri	710093	3157814
25	04200	43	30	5	Pagri	710093	3157818
26	04205	44	120	10	Pagri	710095	3157818

Tree Enumeration
Vasant Kunj to Mahipalpur

District/Forest Division: West

3rd MEDIAN

S.N.	Chainage	Tree No.	DBH/Girth (in Cm)	Tree Height (M)	Tree Name	Easting	Northing
1	0+225	1	80	10	Jamun	710080	3157851
2	0+230	2	80	5	Gooler	710078	3157852
3	0+235	3	170	10	Neem	710076	3157854
4	0+238	4	125	10	Pakad	710071	3157854
5	0+240	5	45	5	Kanail	710069	3157842
6	0+245	6	170	10	Pakad	710069	3157841
7	0+250	7	40	5	Kanail	710068	3157848
8	0+255	8	35	5	Kanail	710064	3157847
9	0+258	9	45	5	Kanail	710063	3157845
10	0+261	10	120	10	Cooler	710060	3157849
11	0+261	10 A	70	8	Cooler	710060	3157849
12	0+266	11	45	5	Kanail	710053	3157850
13	0+268	12	70	8	Cooler	710055	3157857
14	0+270	13	35	5	Kanail	710056	3157855
15	0+271	14	30	5	Kanail	710053	3157855
16	0+271	14A	30	4	Cooler	710058	3157858
17	0+272	15	80	8	Cooler	710051	3157857
18	0+274	16	70	7	Gulmohar	710050	3157856
19	0+276	17	65	7	Gulmohar	710048	3157858
20	0+281	18	150	15	Neem	710046	3157859
21	0+291	21	150	5	Cooler	710038	3157866
22	0+291	21A	30	4	Kanail	710041	3157864
23	0+294	22	75	10	Cooler	710036	3157868
24	0+294	23	75	10	Cooler	710038	3157868
25	0+301	27 A	110	8	Pakad	710033	3157875
26	0+310	28	85	10	Pipal	710027	3157875
27	0+310	29	30	7	Pakad	710027	3157875
28	0+310	30	80	10	Cooler	710024	3157885
29	0+310	31	106	10	Cooler	710014	3157885
30	0+310	32	114	10	Cooler	710014	3157885
31	0+310	32 A	80	8	Pakad	710013	3157887
32	0+310	33	155	10	Pakad	710010	3157891
33	0+318	37	80	10	Cooler	710009	3157898

Tree Enumeration

Vasant Kunj to Mahipalpur (U-Turn at Red Light Junction)

District/Forest Division: West

LHS

S.N.	Chainage	Tree No.	DBH/Girth (in Cm)	Tree Height (M)	Tree Name	Easting	Northing
1	[illegible]	22	65	6	Jamun	709655	8156305
2		24	88	8	Kooler	709647	8156307
3		25	90	9	Kooler	709646	8156312
4		26	105	5	Kooler	709651	8156322
5		27	55	6	Kooler	709651	8156322
6		31	90	6	Kooler	709635	8156338
7		32	55	5	Kooler	709619	8156239
8		33	10	3	Kersil	709618	8156234
9		34	50	6	Mahua	709613	8156236
10		36	40	5	Shahtoot	709610	8156239
11		37	118	8	Kooler	709618	8156248
12		38	80	9	Kooler	709615	8156246
13		39	55	5	Kooler	709613	8156248
14		40	48	5	Kooler	709618	8156248
15		41	25	5	Kooler	709615	8156245
16		42	60	8	Chirchida	709612	8156248
17		43	70	8	Chirchida	709608	8156243
18		44	25	4	Pepri	709607	8156245
19		45	55	5	Kooler	709608	8156251
20		46	90	6	Kooler	709606	8156253
21		47	55	6	Chirchida	709604	8156250
22		51	50	8	Chirchida	709600	8156257

Tree Enumeration

Vasant Kunj to Mehipalpur (U-Turn at Red Light Junction)

District/Forest Division: West — Median

S.N.	Chainage	Tree No.	DBH/Girth (In Cm)	Tree Height (M)	Tree Name	Easting	Northing
1	0+000 to 0+150	565	30	3	Kikar	709705	3158197
2		565A	30	3	Kikar	709705	3158157
3		565B	30	3	Kikar	709705	3158157
4		566	80	3	Jamun	709705	3158138
5		565	50	5	Jamun	709700	3158154
6		568	30	4	Neem	709699	3158166
7		567	40	4	Kikar	709681	3158183
8		567A	30	4	Kikar	709681	3158185
9		567B	30	4	Kikar	709681	3158185
10		567C	30	4	Kikar	709681	3158185
11		567D	30	4	Kikar	709681	3158185
12		8	30	3	Kikar	709673	3158192
13		9	30	3	Neem	709673	3158192
14		10	30	4	Gulmohar	709664	3158205
15		565	30	3	Sirs	709645	3158228
16		569	40	4	Neem	709638	3158232
17		570	50	5	Jamun	709656	3158255

Tree Enumeration

Vasant Kunj to Mehipalpur (U-Turn at Red Light Junction)

District/Forest Division: West

S.N.	Chainage	Tree No.	DBH/Girth (in Cm)	Tree Height (M)	Tree Name	Easting	Northing
1		2	74	6	Kikar	709678	3158214
2		3	97	4	Kikar	709678	3158214
3		4	75	5	Kikar	709672	3158219
4		5	108	7	Kikar	709681	3158243
5		8/88	67	6	Kikar	709643	3158251
6		9	48	6	Kikar	709643	3158251
7		9 A	82	6	Kikar	709643	3158251
8		9 B	57	6	Kikar	709643	3158251
9		9 C	40	6	Kikar	709643	3158251
10		10	55	7	Kikar	709639	3158253
11		11	55	7	Kikar	709641	3158255
12		12	75	6	Kikar	709655	3158257
13		13	30	6	Kikar	709657	3158257
14		13 A	23	6	Kikar	709657	3158257
15		8/89	85	7	Neem	709655	3158264
16		20	48	6	Kikar	709651	3158269
17		8/88	60	6	Kikar	709651	3158269
18		22	18	5	Kikar	709654	3158270
19		23	18	6	Kikar	709654	3158270
20		24	15	5	Kikar	709654	3158270
21		25	93	7	Ber	709636	3158280
22		26	94	6	Kikar	709631	3158281
23		29	95	5	Sagigarni	709631	3158281
24		30	37	5	Sagigarni	709633	3158281
25		8/82	83	6	Neem	709635	3158288
26		8/81	65	9	Kikar	709635	3158284
27		8/80	88	9	Sagigarni	709630	3158293
28		8/80	75	9	Sagigarni	709630	3158293
29		8/79	47	9	Neem	709629	3158292
30		8/78	140	9	Sagigarni	709628	3158294
31		8/77	79	9	Pepri	709632	3158295

Annexure – IX
Action Plan

ACTION PLAN ON THE COMPLIANCE OF THE RECOMMENDATIONS OF THE CAG

The Action Plan on the compliance of the recommendations of the CAG as per Ministry's Circular No. J-11013/71/2016-IA.I (M), dated 28th October, 2017 have been presented infollowing **Table**.

Table: Action Plan on the compliance to the recommendations of the CAG

S. No.	Recommendations of the CAG	Compliance to the recommendations of the CAG
(i)	Revalidation of data with respect of grant of TOR / EC to be carried out on regular basis with NIC.	Agreed.
(ii)	While scrutinizing the EIA Reports may ensure that they are as per the TOR, comply with the generic structure, baseline data is accurate and concerns raised during the public hearing are adequately addressed.	The EIA report has been prepared as per the compliance of the ToR with generic structure and detailed public issues have been incorporated.
(iii)	The EIA Reports / EC letters should clearly mention cost of activities under EMP and ESR along with the timelines for their implementation.	The cost of activities under EMP and CER has been mentioned yearly wise in the EIA/EMP report.
(iv)	EMP/EC conditions should be more specific for the area to be developed under Green belt and species to be planted in consultation with Forest / Agriculture Department along with post EC Third Party evaluation.	The green belt development plan has been mentioned in section 9.2 of Chapter 9 in EIA/EMP report.
(v)	Copy of EC letter to these projects should be endorsed to CGWA to ensure monitoring of ground water extraction.	Agreed
(vi)	While appraising the EC application, the name and number of posts to be engaged by the proponent for implementation and monitoring of environmental parameters be specified.	The implementation and monitoring of environmental parameters has to be done by the contractor as per the monitoring programme in EIA/EMP report.
(vii)	While prescribing the conditions of EC please mention installation of monitoring stations and frequency of monitoring of various environment parameters in respect of air, surface water, ground water noise etc.	For Air monitoring: 08 locations(Total 864 samples during construction and operation period). For Ground water monitoring: 08 locations (Total 66 samples during construction and operation period). For surface water monitoring: NO stream is present within the vicinity of 15km radius For Noise monitoring: 08locations (Total 90 samples during

		construction and operation period). For Soil monitoring: 08 locations/Total 36 samples during construction and operation period).
(viii)	While scrutinizing the EC application, should ensure that the EIA Report is prepared by accredited consultant having no conflict of interest with any Committee processing the case.	The EIA report has been prepared by NABET/QCI Accredited Consultant i.e. Ambienta Global Private Limited having its Certificate No. No. NABET/EIA/2225/RA0259 as of April 2023.
(ix)	The conditions of EC should be compatible with the nature and type of project in order to avoid non- uniformity in similar kinds of projects.	Agreed
(x)	The EIA Report should clearly mention activity wise EMP and EBC cost details and should depict clear break-up of the capital and recurring costs along with the timeline for incurring the capital cost. The basis of allocation of EMP and EBC cost should be detailed in the EIA Report to enable the comparison of compliance with the commitment by the Central and State monitoring agencies. The capital and revenue expenditure amount to be spent on EMP and CSR cost should be distinctly specified in the EC letter. It should be ensured that there is a time bound action plant for fulfilling the EMP commitment mentioned in the EIA Report to the EC letter.	The cost of activities under EMP and CSR has been mentioned yearly wise in the EIA/EMP report
(xi)	On maintenance of separate account for EMP and EBC, EC conditions should be more specific like opening a separate bank account and accounting format with specific heads of accounts in order to provide financial accountability by project proponents. This should be made compulsory part of the Annual Environment Statement.	Agreed

Annexure – X
Drainage Design System

Preparation of Detailed Project Report Including Pre-Construction Activities for Construction of a Road Tunnel For NH-148AE with its Approach and Connection to NH-248BB and Existing Delhi Internal Roads in the State of Delhi

Annexure 1 D: Drainage Design Note



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1 INTRODUCTION

1.1 PROJECT BACKGROUND

The National Highways Authority of India has been assigned the work of "Construction of a Road Tunnel for NH-148AE with its approach and connection to NH-248BB and existing Delhi Internal roads in the State of Delhi."

1.2 CONSULTANCY SERVICES

M/s SMEC International Pty. Ltd has been appointed as lead Consultants vide letter no **PIU/DWE/20/03/1524 dated 29th October 2020** to carry out the Detailed Project Report (DPR) from proposed Shiv Murti Interchange (Dwarka Expressway Package-1) to Nelson Mandela Marg.

The project involves study and detailed design of the most feasible alignment with twin tunnel arrangement with approach ramps and surface roads to merge into the planned alignment.

The contract with NHAI was signed on 12th January 2021.The scope and principal objectives of the consultancy services is contained in the Terms of Reference (TOR) of the consultancy services, which is part of the contract agreement. **The services were commenced with effect from 12th January 2021.**

1.3 PROJECT DESCRIPTION

The project road takes off from Proposed Shivmurti Interchange (Dwarka Expressway Package-1) to Nelson Mandela Marg. A Bypass to Rangpuri will connect Dwarka Expressway with Vasant Kunj through Nelson Mandela Marg. It has been proposed to extend the existing Nelson Mandela Marg via a tunnel towards Gurgaon/ Dwarka with an interchange near Shiv Murti to connect NH-8 and Dwarka Expressway. The entire alignment is green field.



Figure 1-1: Start of Project Road at Shiv Murti Interchange



Figure 1-2: End of Project Road near Nelson Mandela Marg



2 OBJECTIVE

2.1 OBJECTIVE

The main objective of the drainage study is to determine the required sizes of the components of a drainage system, to allow for the quick and safe removal of the discharges entering into the tunnel including approach road.

2.2 TUNNEL DRAINAGE

A tunnel drainage system collects and disposes the water that enter the tunnel. The drainage system should be designed to deal with the surface water as well as any ground water infiltration.

The surface water includes tunnel wash water, water from fire hydrants, water entering into the tunnels by various means like from tyres of the vehicles, from approach roads etc. Surface water also includes fuels and other flammable liquids, as they may be collected in the drains in case of emergencies. Hence surface water collected, must go through an oil separator Ecosol 4800 before discharging into the natural water bodies.

Ground water seeps through the tunnel linings which needs to be collected and drained off. However in case of undrained tunnel lining, no seepage of ground water is allowed into the tunnel, therefore required no ground water drainage.

3 DESIGN METHODOLOGY

3.1 DRAINAGE SYSTEMS

A drainage system includes pipes, channels, sump-pumps, oil-water separators and control system for safe and reliable collection, storage, separation and disposal of effluents from the tunnels. Since the drainage system must collect flammable liquids during fire emergencies, the pipes should be non-combustible.

Drainage lines and sump-pumps should be sized to accommodate water intrusions and firefighting requirements. Sump and pumps should be located at low points of a tunnel and at portals. Vertical profile of tunnel shall facilitate self-draining of tunnel, however it may not be possible for the long tunnels hence an arrangement of sump-pumps may be required. The carriageway way shall have suitable camber to facilitate drainage into the side drains.

4 HYDRAULIC DESIGN

4.1 FLOW CALCULATION

Flow in carriageway drain is considered to be open channel flow, hence as per Manning's formula for the uniform flow velocity of flow in drain is given as:

$$V = (R)^{2/3}.S^{1/2}.(1/n)$$

$$Q = A.V$$

Where,

Q: discharge in m^3/s

V: velocity of flow in m/s

n: Manning's roughness coefficient

R: hydraulic radius in meter

S: slope of the channel bed

A: flow area in m^2

Tunnel Drainage

The tunnel drainage design is based on the maximum flows due to:

1. Surface Water Network

All seepage may water from the main tunnel is extracted separate from the ground water and has to be collected in the sump by basin grate nearby drainage in the road park.

(a) Storm Water:

Consider rainfall intensity of duration 7.2 (as per Delhi Drainage Manual) tunnel has three zones namely, tunnel portion in open cut, 7.2 (a has been considered for this purpose).

Q_s = 7.2 l/s

Where,

Q_s = storm water flow rate (l/s)

(b) Wash water / Fire fighting

Fighting flow rate is taken as 45 L/sec as per drainage planning manual and this is independent of tunnel length.

Q_w = 36.0 l/s

2. Groundwater Network

The ground water from the tunnel, collected by the external drainages, the base course drainage and the tunnel main drainage, is already discharged into the open channel.

(a) Seepage (Base course):

$Q_s = K \times P \times i$

Where,

Q_s = Quantity of seepage (liter per second)

K = Seepage factor (L per sec per m) (assumed)

P = Tunnel perimeter (m), 12 m

i = Tunnel length (m)

$Q_s = V_s / (24 \times 60 \times 60)$

Where,

Q_s = Seepage flow rate (l/s), which is same = inflow rate

Table below shows the calculated design drainage flow rate for each tunnel, and the calculated total flow volume.

Tunnel	Length (m)	Qw Clean Water: Flow Rate (l/s)	Qs Seepage: Seepage flow volume (m^3/d)	Qs Seepage: Flow Rate (l/s)	Qs Storm Water: Flow Rate (l/s)	Design Flow Rate for Emergency (l/s)	Design Flow Rate Recommended (l/s)
TUNNEL	2601.7	36.0	0.0	0.00	7.2	43	0.0
TUNNEL	2601.7	36.0	0.0	0.00	7.2	43	0.0

Table below shows the calculated tunnel drainage system capacity for the contaminated drainage.

Drainage	Diameter (m)	Required capacity (cumec)	Slope	Remarks		

Tunnel Drainage

The Tunnel Drainage design is based on the maximum flows due to:

1. Surface Water Network

All storm/spring water from the main tunnel is collected segments from the ground water and the tunnel are taken in the existing beam grain laundry drainage in the segment.

(a) Storm Water:

Q_s = 7.2 l/s

Where

(b) Wash water / Fire fighting

Q_w = 864 l/s

2. Groundwater Network

The ground water from the tunnel, collected in the lateral drainage, the base course drainage and the tunnel main drainage, is already discharged into the segment drainage.

a) Seepage **(Groundwater)**

$Q_s = K i A_s$

Where

$Q_s = \frac{\pi \times 0.2^2}{4} \times 0.05 \times 60$

Table below shows the calculated design discharge flow rate for each tunnel, and the calculated total flow volume.

Tunnel	Length (m)	2a Check Values	2b Design		2c Above Water	Design Flow Rate Discharged (m3/s)	Design Flow Rate Accumulated (m3/s)	Volume (m3)
		Flow Rate (l/s)	Design Flow Volume (m3/s)	Flow Rate (l/s)	Flow Rate (l/s)			
Tunnel 1	approx. m							
Tunnel 2	approx. m							

Table below shows the calculated tunnel discharge system capacity for the emergency discharge.

The inputs used in the calculations:
- One capacity of one trash removal (l/s) depth
- The discharge rate which is calculated from the pipeline and the number of pipe

Discharge	Diameter (m)	Depth of water (m)	Steps	Operating		
				(l)	(l/s)	(m3/s)
1 no. DN 00						
2 DN 00 no. DN 00						
3 DN 00 no. DN 00						

(1) dependent on the environmental impact and needs for restoration.
The data shown here are indicative considering AS/NZS, WP 000 and is given by the vendor.



Annexure – XI
Traffic Study

Dwarka Tunnel Traffic Analysis

1. Background

In response to escalating traffic congestion along Nelson Mandela Marg, a 9 km tunnel connecting Dwarka Expressway to Nelson Mandela Road. Featuring twin tubes, this tunnel aims to alleviate peak-hour bottlenecks, offering a strategic solution with a better connectivity between South Delhi, T3 of Indira Gandhi Airport, and Gurgaon. Figure-1 outlines the tunnel's alignment, emphasizing its integral role in optimizing traffic flow.



Figure-2: Proposed tunnel alignment

This report details the forecasting of the traffic aiming for the tunnel and assesses the peak-hour traffic flow. The traffic analysis only supports the forecast of the traffic and calculates the respective level of service but does not consider the calculation of the tunnel ventilation system.

2. Approach

To forecast the future traffic volume, a traffic count and origin-destination survey was conducted at the Mahipalpur and Dwarka Expressway Junction. Using the forecasted peak-hour traffic data, a cross-check analysis was performed to calculate required lane capacity based on Level of Service categories. This analysis identifies the year where capacity falls short, guiding adjustments to ensure the proposed tunnel meets traffic demands efficiently.

3. Methodology

The methodology employed for this analysis follows a systematic approach to ensure a thorough understanding of the traffic dynamics and capacity considerations for the proposed tunnel. Initial steps involve the identification of major traffic flows and the calculation of diverted traffic percentages based on the travel time ratio. Subsequently, a detailed forecast of tunnel traffic is conducted, considering vehicle type data from traffic count surveys. The analysis then shifts to the evaluation of required lane numbers and the verification of the proposed tunnel's compliance with Level of Service (LOS)B and C capacity standards. The following points provide a succinct breakdown of the key steps taken in this comprehensive methodology.

4. Identification of Traffic Flow:

Utilizing the Origin-Destination (OD) survey, major traffic flows currently using the existing road were identified. This laid the foundation for determining the traffic that would be diverted to the proposed tunnel in the future.

To analyze the OD data, Trip start/end locations are clustered in 4 zones. Notably, Zones 1, 3, and 4 collectively account for 86.3% of the total traffic, underscoring their importance in transportation planning and emphasizing their significance for the proposed tunnel project. Understanding these traffic dynamics is pivotal for effective diversion strategies and optimizing traffic management in these identified zones.

As this OD analysis based on the collected data at Mahipalpur only, 60% is assumed as potential traffic.

5. Calculation of Diverted Traffic:

The percentage of diverted traffic was calculated by analyzing the flow count percentages for the existing road. Traffic diversion curve, based on the travel time ratio of both the existing road and the proposed tunnel, was employed for precise calculations. As per the travel time ratio that is shown in above table, diverted traffic is 70% of the attracted traffic.

Table 2: Traffic at Mahipalpur

Year	PCU Calculations at Mahipalpur											
2023	BIKE	AUTO	CAR/JEEP /VAN/TAXI/PICKUP	MINI BUS	BUS	LCV	2 AXLE TRUCK	3 AXLE TRUCK	MAV	TRACTOR	TRACTOR TROLLY	TOTAL/ Day
ADT	14501	4782	14078	106	889	852	47	111	35	8	31	35014
PCU factor	0.5	1	1	1.5	3	1.5	3	4.5	4.5	1.5	4.5	
Traffic in PCU	7251	4782	14078	204	2007	980	141	500	158	8	140	30011
60% Traffic	11,601	5,802	11,161	109	533	533	56	69	36	2	35	34,169
Diverted Traffic	6,121	2,661	7,853	78	375	366	28	52	20	2	17	18,216

6. Comprehensive Tunnel Traffic Forecast:

A detailed analysis was conducted to forecast future tunnel traffic, utilizing the calculated diverted traffic volume. The traffic count survey data, categorized by vehicle type (omitting NMT vehicles), was instrumental in this forecasting process.

Table 3: Growth rates

	Growth Rate			
Vehicle Type	2017-20	2021-25	2025-30	Beyond 2030
Car	6.21%	5.04%	5.00%	5.00%
LMV (passengers)	5.00%	5.00%	5.00%	5.00%
Two-Wheeler	5.70%	5.00%	5.00%	5.00%
Bus	9.90%	11.00%	7.00%	5.00%
LCV	5.00%	5.00%	5.00%	5.00%
2-Axle Trucks	9.00%	9.00%	9.00%	9.00%
3-Axle Trucks	5.00%	5.00%	5.00%	5.00%
MAV	5.00%	5.00%	5.00%	5.00%
Non-motorised	-2.00%	-2.00%	-2.00%	-2.00%

Individual vehicles categorize wise growth rate is used to forecast the future year traffic along the project road. 2023 year is taken as base year and calculated traffic from the Traffic count survey at Mahipalpur. The projected opening year for the tunnel is considered 2026. Then traffic data is

forecasted to another 20 years to analyze the sustainability of the tunnel based its capacity and requirements.

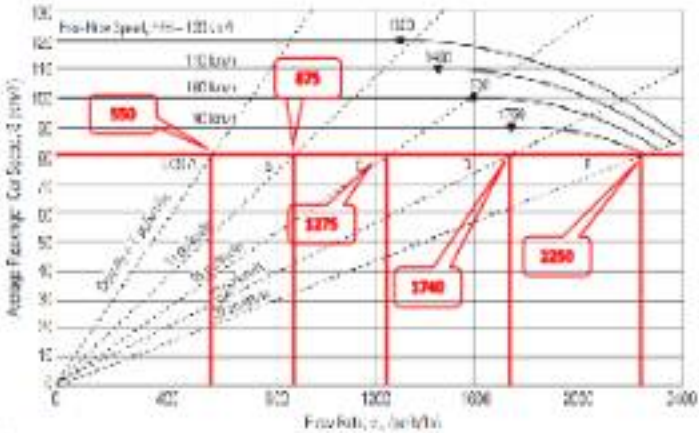
Traffic Forecast

	Year												
Base Year													
Opening Year													
Opening Year + 5													
Opening Year + 10													
Opening Year + 15													

Opening Year + 02														
Opening Year + 05														
Opening Year + 09														

7. Lane Requirement Analysis:

Based on the forecasted volume and the targeted Level of Service (LOS) B and C capacity, an analysis was undertaken to determine the required number of lanes. The proposed tunnel, designed per IRC standards, comprises 6 lanes (3 lanes for each direction). A thorough check was conducted to ensure that this configuration aligns with the required lane numbers. If not, the year of failure was identified.



Source: Exhibit 22-2, Speed-Flow Curves and LOS for Basic Freeway Segments, HCM 2000

Table 2: Lane capacity calculations

	Flow Rate (pc/h/ln)				
	LOS A	LOS B	LOS C	LOS D	LOS E
Capacity/lane	550	875	1,275	1,740	2,250
Road Capacity (Hourly)	3,300	5,250	7,650	10,440	13,500
Road Capacity (Daily)	79,200	126,000	183,600	250,560	324,000

Design speed 80 kmph, lane 6 and peak hour traffic 8%

Table 9: Sample calculation for the tunnel

LOS	A
Design Speed	80 kmph (Source: IRC: SP:84-2019)
Capacity	990 pc/hr/ln
Lane	6 lanes (3 lanes on each direction)
PCU / hour	6*550 = 3300 PCU/ hr
PCU / day	3300*24 = 79200 PCU/ day
LOS	B
Design Speed	80 kmph (Source: IRC: SP:84-2019)
Capacity	875 pc/hr/ln
Lane	6 lanes (3 lanes on each direction)
PCU / hour	6*875 = 5250 PCU/ hr
PCU / day	5250*24 = 126000 PCU/ day
LOS	C
Design Speed	80 kmph (Source: IRC: SP:84-2019)
Capacity	1375 pc/hr/ln
Lane	6 lanes (3 lanes on each direction)
PCU / hour	6*1175 = 7650 PCU/ hr
PCU / day	7650*24 = 183600 PCU/ day

Source: Exhibit 23-2, Speed-Flow Curves and LOS for Basic Freeway Segments, HCM 2000

8. LOS Capacity Check:

Each year's peak-hour volume was compared against different LOS capacity categories, considering a design speed of 80 km/h. This assessment spanned all LOS categories, providing insights into the tunnel's ability to support the projected traffic volume.

	Road Capacity Check on PCU/Hr.											
Year	Peak Volume PCU/hr	LOS A	Check	LOS B	Check	LOS C	Check	LOS D	Check	LOS E	Check
2028	1,958	3300	OK	5250	OK	7650	OK	10600	OK	12000	OK
2034	1,687	3300	OK	5250	OK	7650	OK	10600	OK	12000	OK
2035	1,919	3300	OK	5250	OK	7650	OK	10600	OK	12000	OK

	Road Capacity Check on PCU/Hr.										
Year	Peak Volume PCU/hr	LOS A	Check	LOS B	Check	LOS C	Check	LOS D	Check	LOS E	Check
2016	1,608	3800	OK	5250	OK	7650	OK	10600	OK	13500	OK
2017	1,693	3800	OK	5250	OK	7650	OK	10600	OK	13500	OK
2018	1,779	3800	OK	5250	OK	7650	OK	10600	OK	13500	OK
2019	1,871	3800	OK	5250	OK	7650	OK	10600	OK	13500	OK
2020	1,969	3800	OK	5250	OK	7650	OK	10600	OK	13500	OK
2021	2,068	3800	OK	5250	OK	7650	OK	10600	OK	13500	OK
2022	2,171	3800	OK	5250	OK	7650	OK	10600	OK	13500	OK
2023	2,280	3800	OK	5250	OK	7650	OK	10600	OK	13500	OK
2024	2,394	3800	OK	5250	OK	7650	OK	10600	OK	13500	OK
2025	2,513	3800	OK	5250	OK	7650	OK	10600	OK	13500	OK
2026	2,639	3800	OK	5250	OK	7650	OK	10600	OK	13500	OK
2027	2,771	3800	OK	5250	OK	7650	OK	10600	OK	13500	OK
2028	2,910	3800	OK	5250	OK	7650	OK	10600	OK	13500	OK
2029	3,055	3800	OK	5250	OK	7650	OK	10600	OK	13500	OK
2030	3,208	3800	OK	5250	OK	7650	OK	10600	OK	13500	OK
2031	3,368	3800	Not OK	5250	OK	7650	OK	10600	OK	13500	OK
2032	3,537	3800	Not OK	5250	OK	7650	OK	10600	OK	13500	OK
2033	3,714	3800	Not OK	5250	OK	7650	OK	10600	OK	13500	OK
2034	3,899	3800	Not OK	5250	OK	7650	OK	10600	OK	13500	OK
2035	4,094	3800	Not OK	5250	OK	7650	OK	10600	OK	13500	OK
2036	4,298	3800	Not OK	5250	OK	7650	OK	10600	OK	13500	OK
2037	4,514	3800	Not OK	5250	OK	7650	OK	10600	OK	13500	OK
2038	4,740	3800	Not OK	5250	OK	7650	OK	10600	OK	13500	OK
2039	4,977	3800	Not OK	5250	OK	7650	OK	10600	OK	13500	OK

	Road Capacity Check on PCU/Hr.										
Year	Peak Volume PCU/hr	LOS A	Check	LOS B	Check	LOS C	Check	LOS D	Check	LOS E	Check
2030	5,219	3300	Not OK	5250	OK	7650	OK	10500	OK	13500	OK
2031	5,587	3300	Not OK	5250	Not OK	7650	OK	10500	OK	13500	OK
2032	5,791	3300	Not OK	5250	Not OK	7650	OK	10500	OK	13500	OK
2033	6,018	3300	Not OK	5250	Not OK	7650	OK	10500	OK	13500	OK
2034	6,631	3300	Not OK	5250	Not OK	7650	OK	10500	OK	13500	OK
2035	6,949	3300	Not OK	5250	Not OK	7650	OK	10500	OK	13500	OK
2036	7,002	3300	Not OK	5250	Not OK	7650	OK	10500	OK	13500	OK
2037	7,309	3300	Not OK	5250	Not OK	7650	OK	10500	OK	13500	OK
2038	7,720	3300	Not OK	5250	Not OK	7650	Not OK	10500	OK	13500	OK

Comparing the Capacity (PCU/day) of forecasted traffic value with LOS A, B, C, D, and E Capacity (PCU/day), failing year is identified and marked in the table. This forecasted peak hour value is calculated as per the 6-lane tunnel.

	LOS Category				
	A	B	C	D	E
Failing Year	2031	2251	2038	Not failing in projected 30 years	Not failing in projected 30 years

9. Additional Peak Hour Volume Check:

As a part of scenario test, a 10% increase in peak-hour volume for each year was considered. This analysis aimed to assess the tunnel's resilience to accommodate potential increases in traffic demand to ensure robustness of the analysis.

Table 3 : Analysis scenario with 10% Increased traffic

	10% Extra Traffic considered Road Capacity Check on PCU/Hr											
Year	Peak Volume PCU/Hr	10% Extra Traffic	LOS A	Check	LOS B	Check	LOS C	Check	LOS D	Check	LOS E	Check
2013	1,316	1,188	3900	OK	5250	OK	7650	OK	10440	OK	18900	OK
2014	1,437	1,581	3900	OK	5250	OK	7650	OK	10440	OK	18900	OK
2015	1,519	1,681	3900	OK	5250	OK	7650	OK	10440	OK	18900	OK
2016	1,608	1,769	3900	OK	5250	OK	7650	OK	10440	OK	18900	OK
2017	1,692	1,861	3900	OK	5250	OK	7650	OK	10440	OK	18900	OK
2018	1,779	1,957	3900	OK	5250	OK	7650	OK	10440	OK	18900	OK
2019	1,871	2,058	3900	OK	5250	OK	7650	OK	10440	OK	18900	OK
2020	1,969	2,166	3900	OK	5250	OK	7650	OK	10440	OK	18900	OK
2021	2,068	2,275	3900	OK	5250	OK	7650	OK	10440	OK	18900	OK
2022	2,171	2,388	3900	OK	5250	OK	7650	OK	10440	OK	18900	OK
2023	2,280	2,508	3900	OK	5250	OK	7650	OK	10440	OK	18900	OK
2024	2,394	2,633	3900	OK	5250	OK	7650	OK	10440	OK	18900	OK
2025	2,514	2,765	3900	OK	5250	OK	7650	OK	10440	OK	18900	OK
2026	2,639	2,903	3900	OK	5250	OK	7650	OK	10440	OK	18900	OK
2027	2,771	3,048	3900	OK	5250	OK	7650	OK	10440	OK	18900	OK
2028	2,910	3,201	3900	OK	5250	OK	7650	OK	10440	OK	18900	OK
2029	3,055	3,361	3900	Not OK	5250	OK	7650	OK	10440	OK	18900	OK
2030	3,208	3,529	3900	Not OK	5250	OK	7650	OK	10440	OK	18900	OK
2031	3,368	3,705	3900	Not OK	5250	OK	7650	OK	10440	OK	18900	OK
2032	3,537	3,890	3900	Not OK	5250	OK	7650	OK	10440	OK	18900	OK
2033	3,714	4,085	3900	Not OK	5250	OK	7650	OK	10440	OK	18900	OK
2034	3,899	4,289	3900	Not OK	5250	OK	7650	OK	10440	OK	18900	OK
2035			3900	Not OK	5250	OK	7650	OK	10440	OK	18900	OK

	10% Extra Traffic considered Road Capacity Check on PCU/Hr											
Year	Peak Volume PCU/Hr	10% Extra Traffic	LOS A	Check	LOS B	Check	LOS C	Check	LOS D	Check	LOS E	Check
	4,284	4,804										
2046	4,399	4,739	5900	Not OK	9350	OK	7650	OK	10440	OK	18900	OK
2047	4,514	4,965	5900	Not OK	9350	OK	7650	OK	10440	OK	18900	OK
2048	4,710	5,218	5900	Not OK	9350	OK	7650	OK	10440	OK	18900	OK
2049	4,977	5,474	5900	Not OK	9350	Not OK	7650	OK	10440	OK	18900	OK
2050	5,335	5,748	5900	Not OK	9350	Not OK	7650	OK	10440	OK	18900	OK
2051	5,487	6,036	5900	Not OK	9350	Not OK	7650	OK	10440	OK	18900	OK
2052	5,761	6,337	5900	Not OK	9350	Not OK	7650	OK	10440	OK	18900	OK
2053	6,049	6,654	5900	Not OK	9350	Not OK	7650	OK	10440	OK	18900	OK
2054	6,351	6,987	5900	Not OK	9350	Not OK	7650	OK	10440	OK	18900	OK
2055	6,668	7,336	5900	Not OK	9350	Not OK	7650	OK	10440	OK	18900	OK
2056	7,001	7,703	5900	Not OK	9350	Not OK	7650	Not OK	10440	OK	18900	OK
2057	7,351	8,088	5900	Not OK	9350	Not OK	7650	Not OK	10440	OK	18900	OK
2058	7,719	8,492	5900	Not OK	9350	Not OK	7650	Not OK	10440	OK	18900	OK

	LOS Category				
	A	B	C	D	E
Traffic saturation year	2045	2048	2054	Not falling within projected 30 years	Not falling within projected 30 years

10. Conclusion

The lane requirement analysis finds the proposed 6-lane tunnel configuration with standards and highlights potential points of capacity stress. The Level of Service (LOS) capacity check, considering various categories and an 80 km/h design speed, thoroughly evaluated the tunnel's

capacity. Additionally, assessing a 10% increase in peak-hour volume for each year provided valuable insights into the tunnel's resilience.

Annexure – XII
Typical Cross Section

Preparation of Detailed Project Report including Pre Construction Activities for Construction of a Road Tunnel For NH-148NB with its Approach and Connector to NH-248BB and Existing Delhi Internal Roads in the State of Delhi

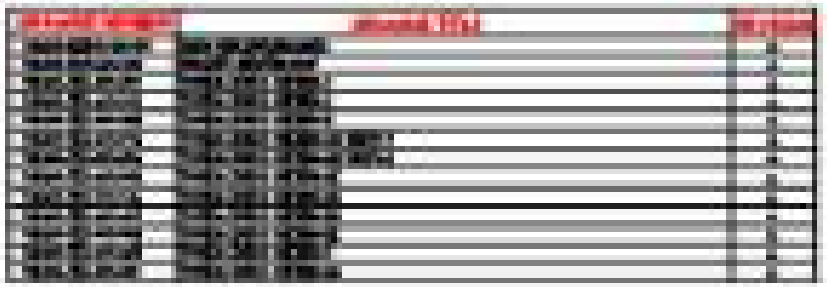
Volume-IV

DPR Bridges

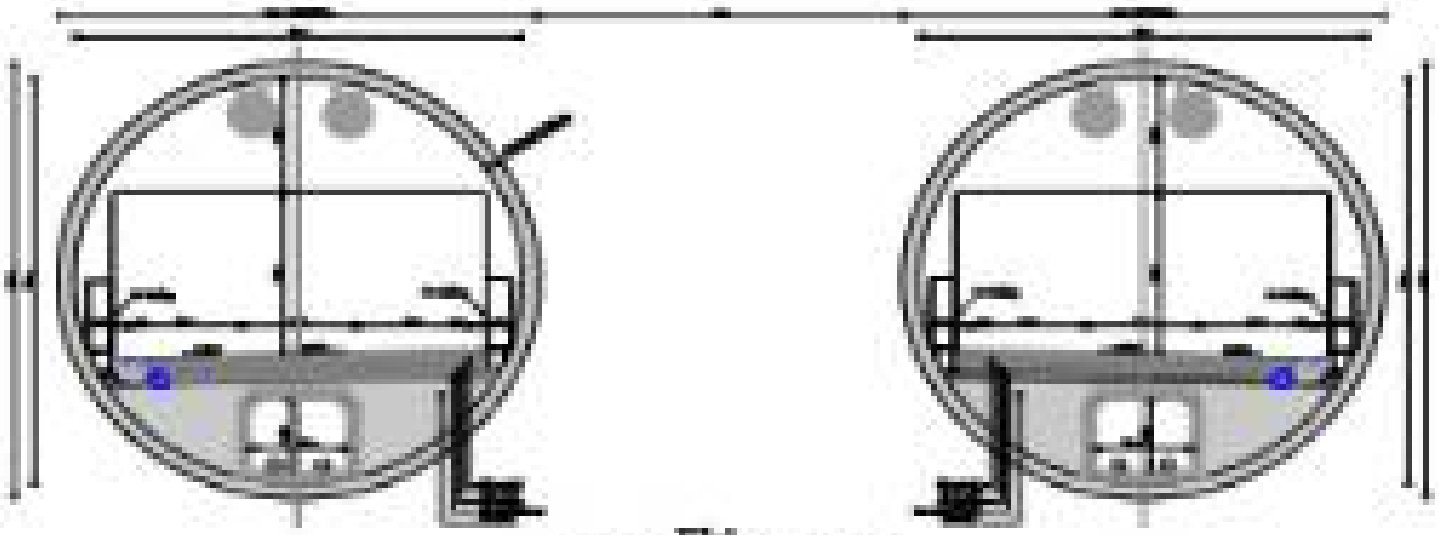


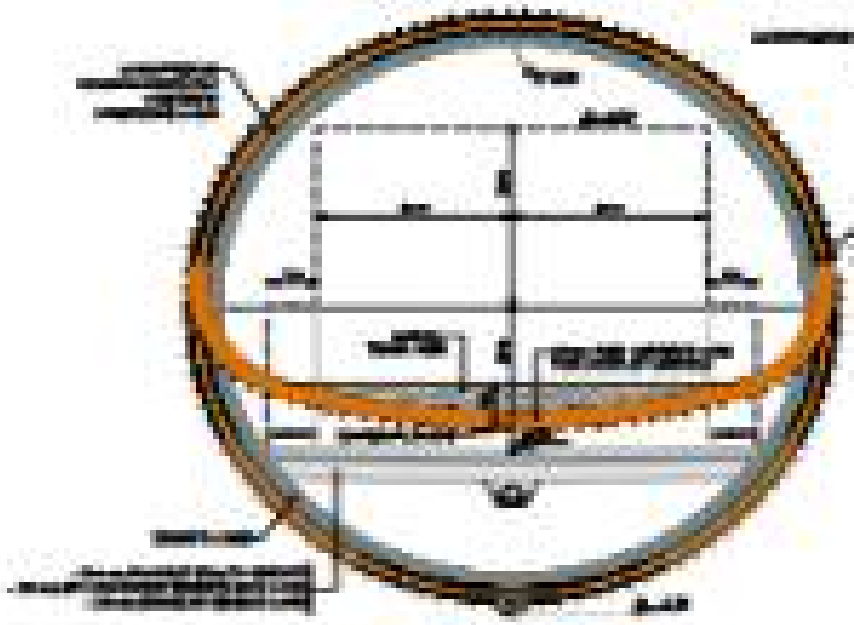
November 2022

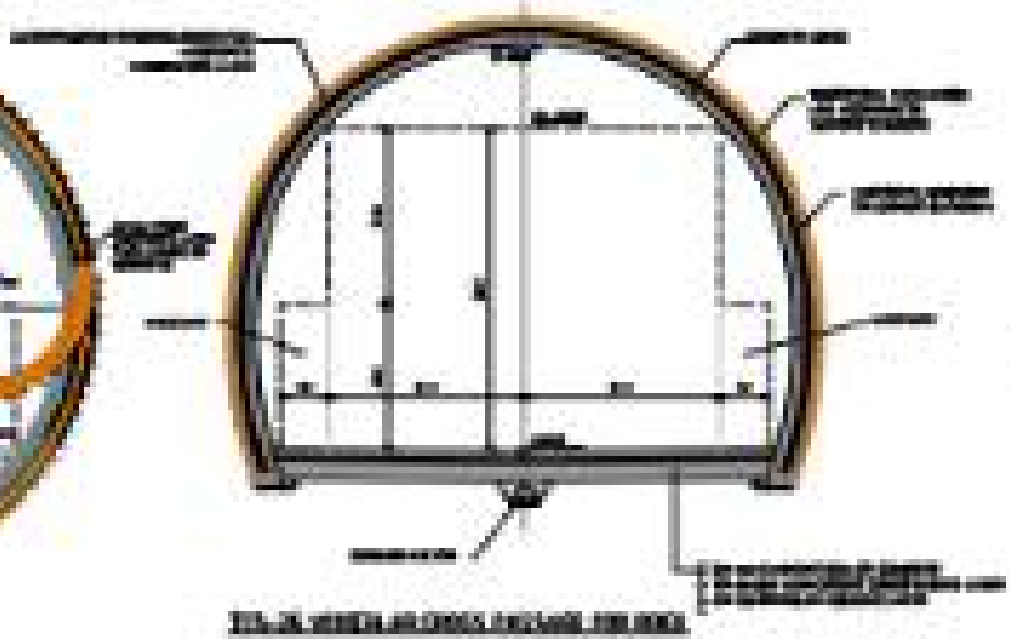


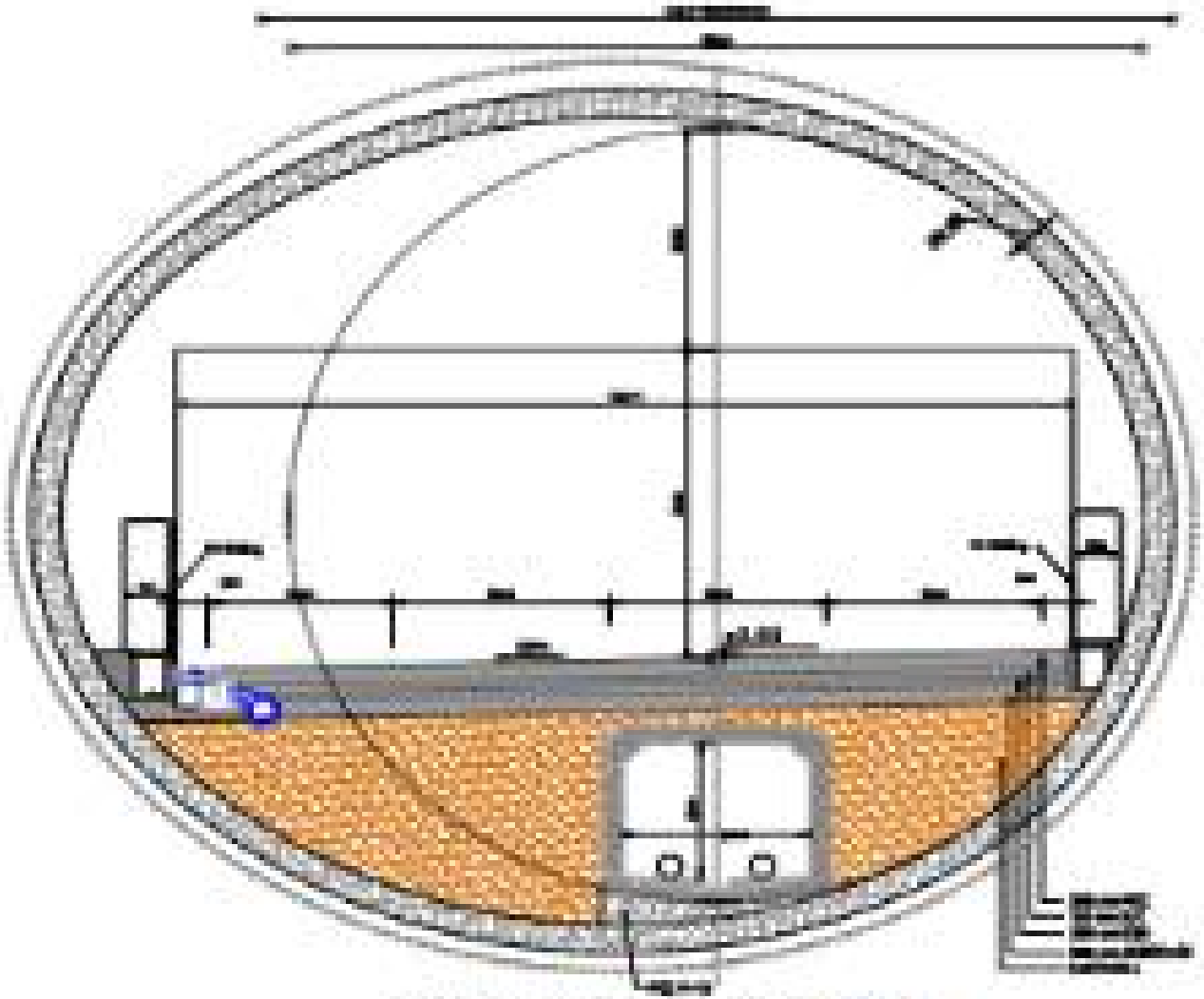


TYPICAL CROSS SECTION

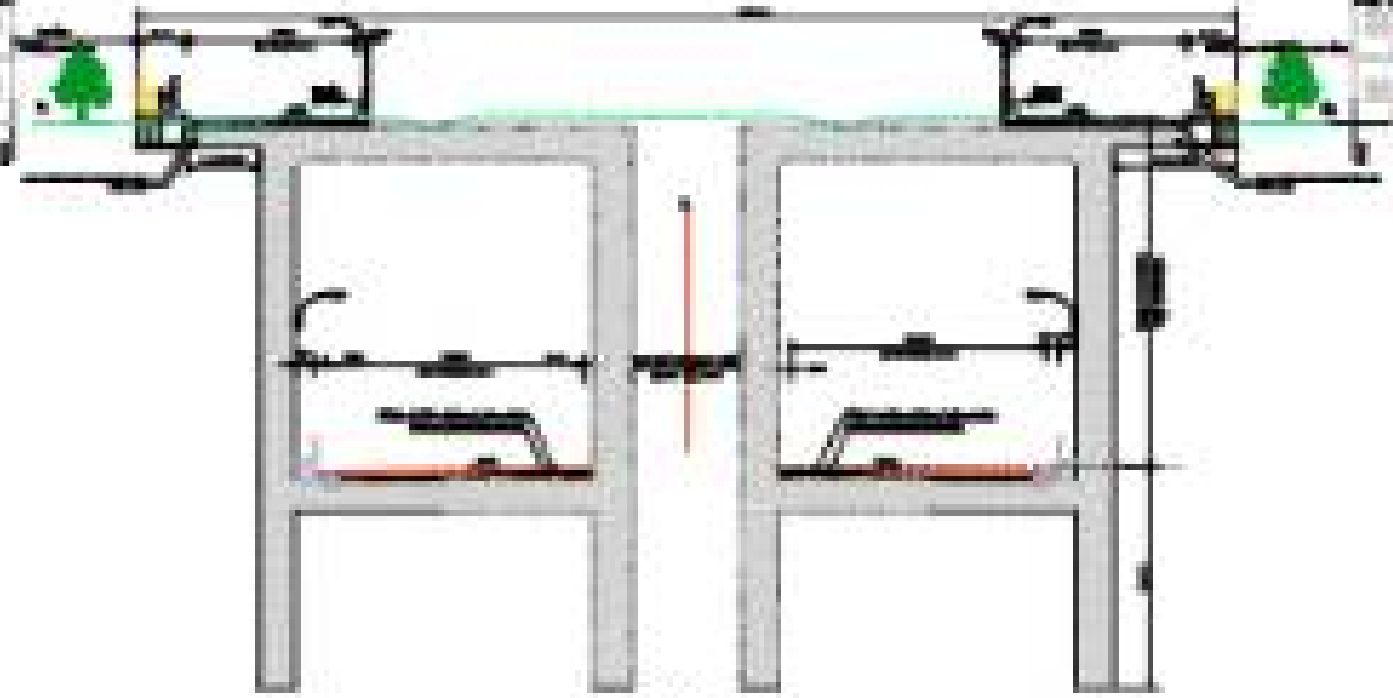


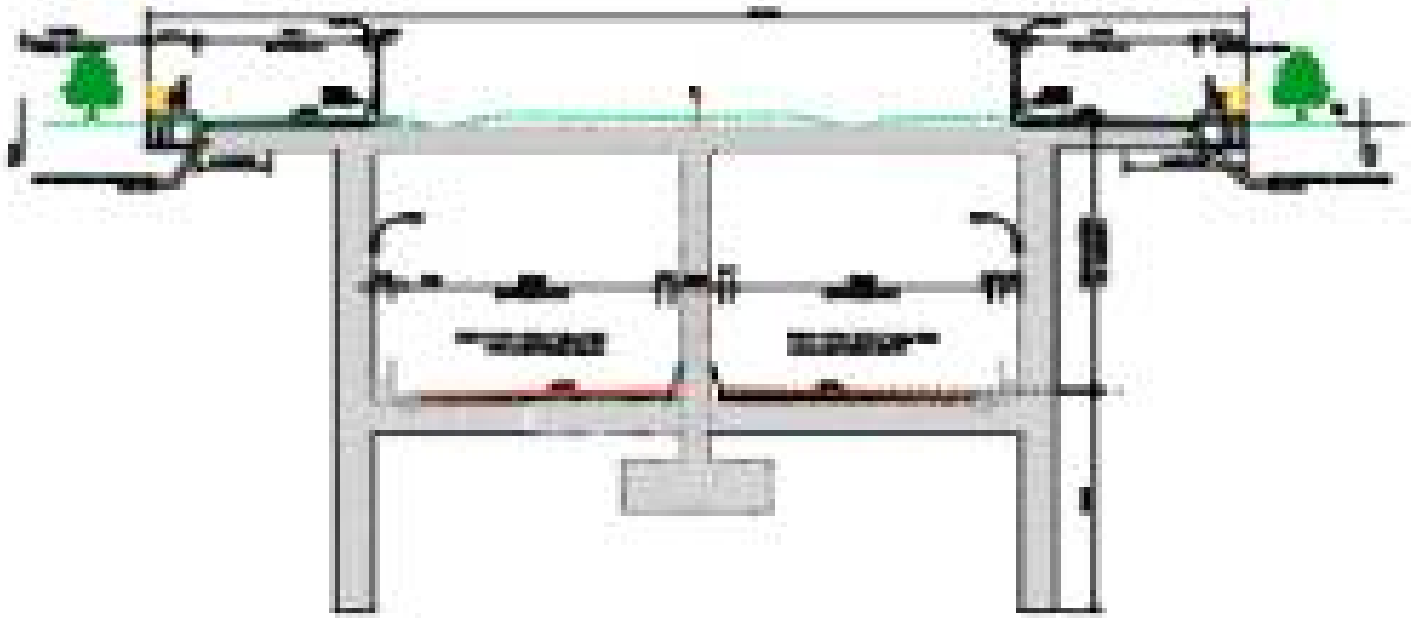


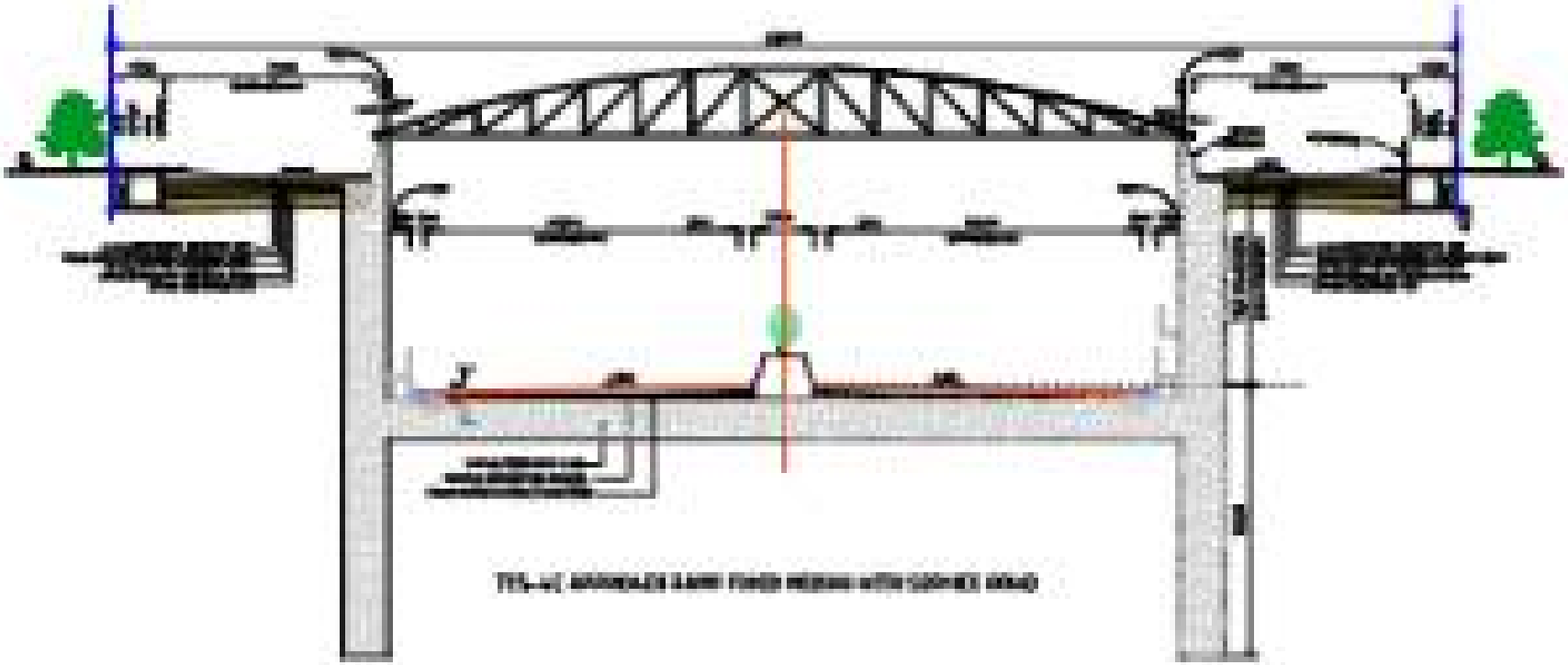


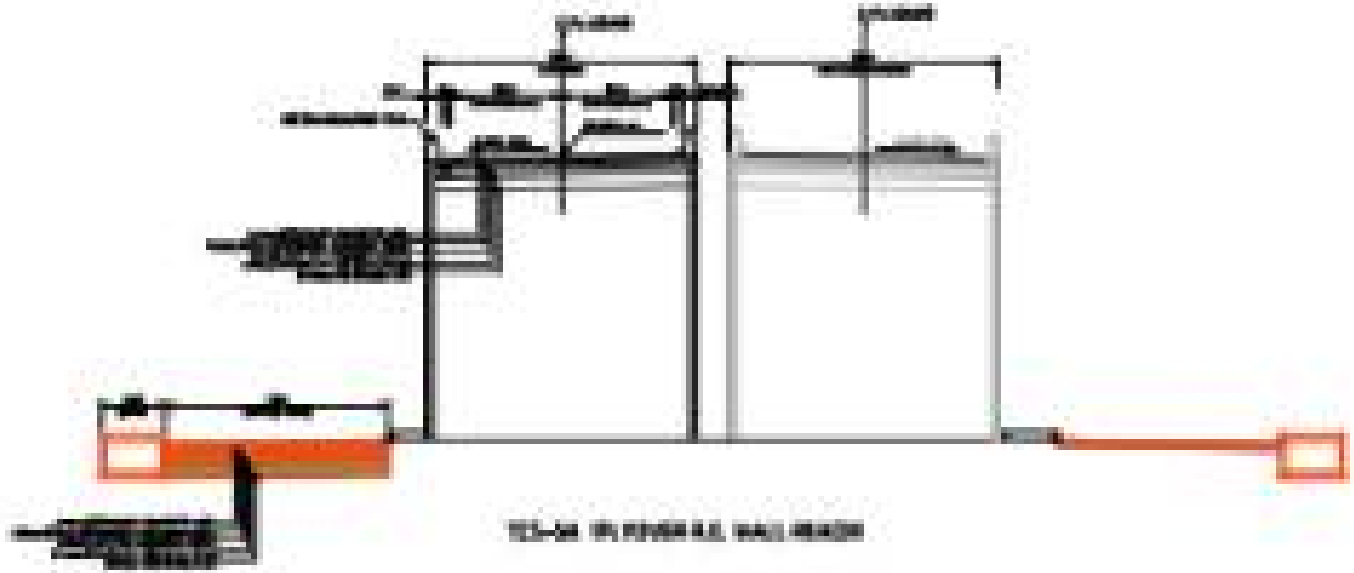


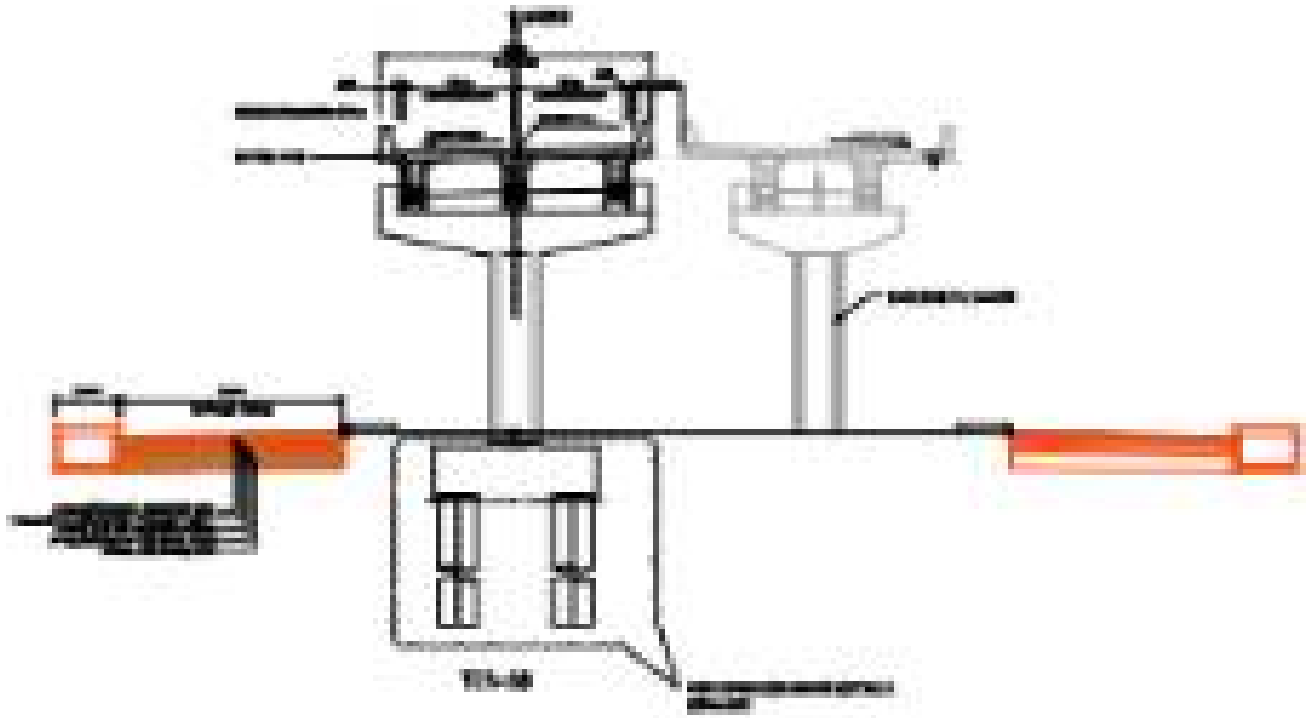
TCS-3 MAIN TUNNEL WITH LAY BYE

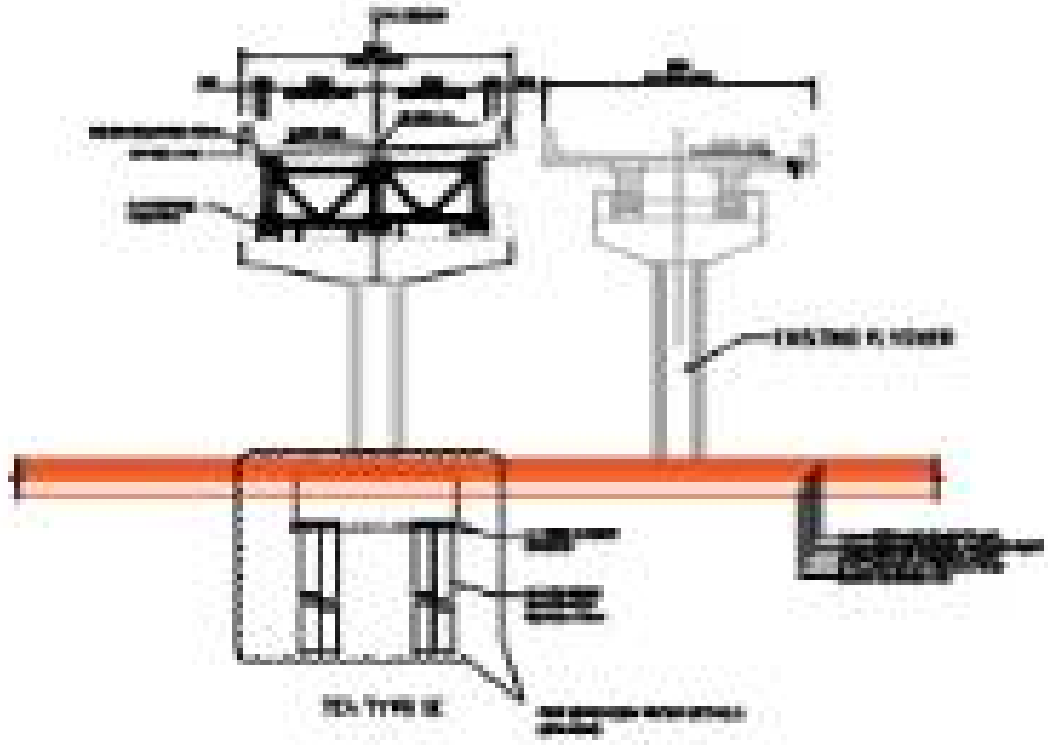


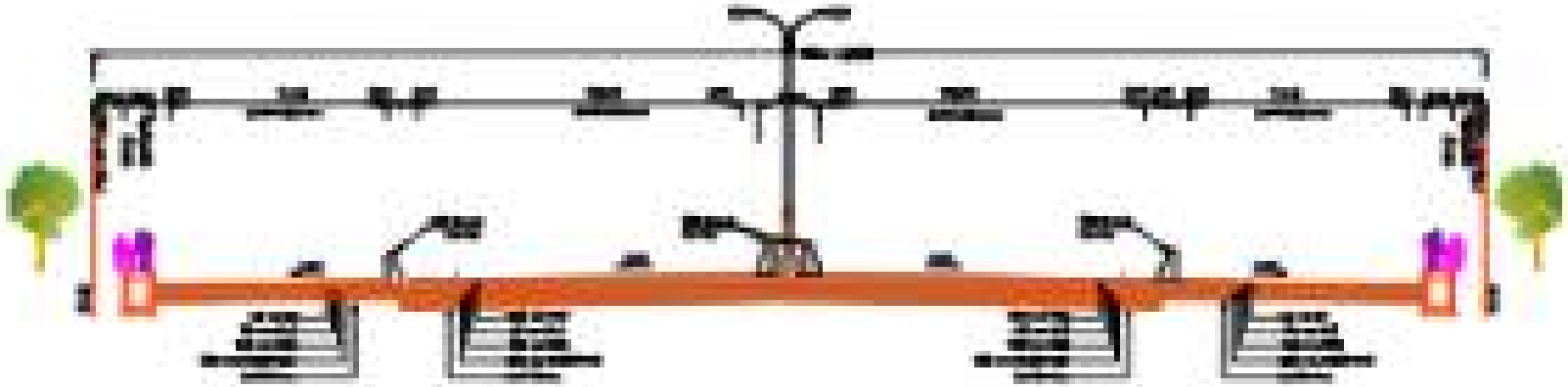


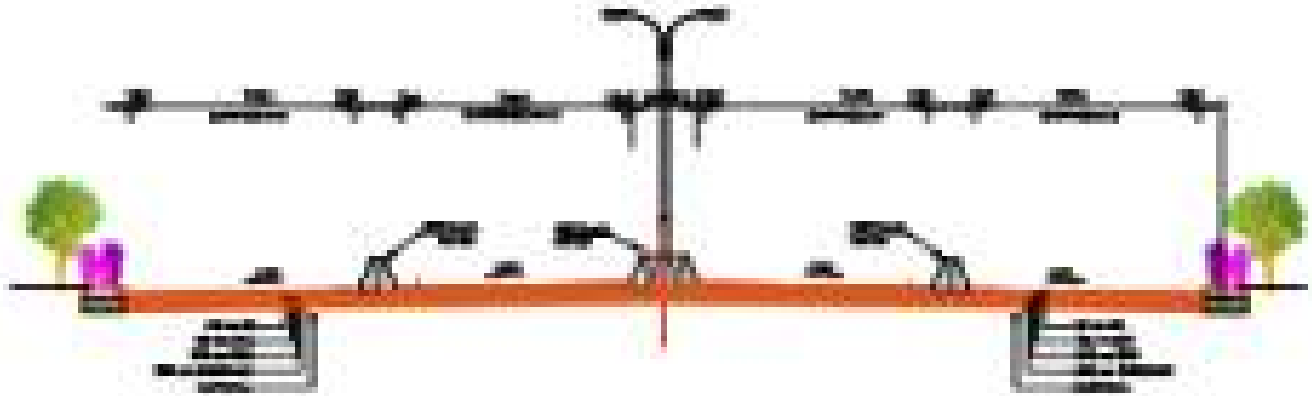












Annexure – XIII
Detail Study about TBM

1 TUNNELING BOARING MACHINES (TBMS)

Tunnel Boring Machines (TBMs) nowadays are full-face, rotational (with cutter heads) excavation machines that can be generally classified into two general categories: Gripper and Segment (refer figure below). There are three general types of TBMs suitable for rock tunnelling including Open Gripper/Main Beam, Closed Gripper/Shield, and Closed Segment Shield, as shown within the dashed box on the Figure.

The closed shield type of TBMs for most rock tunnelling applications are suitable for friable to unstable rocks which cannot provide consistent support to the gripper pressure. The closed shield type of TBMs can either be advanced by pushing against segment, or gripper. Note that although these machines are classified as a closed type of machine, they are not pressurized at the face of the machine thus cannot handle high external groundwater pressure or water inflows. Shielded TBMs for rock tunnelling include Single Shield, Double Shield and Gripper Shield.

Pressurized-face Closed Shield TBMs are predominantly utilized in tunnelling in soft ground and unstable ground or in urban environment where stability of face and ground settlements control are must.

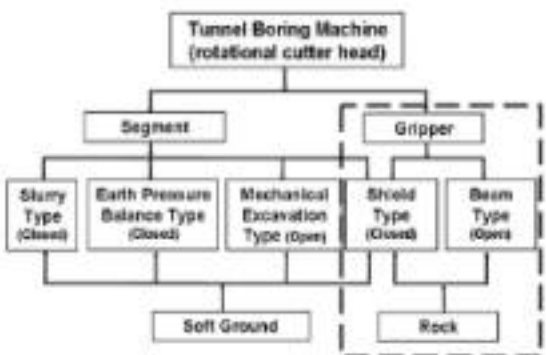


Figure 1: Classification of tunnel boring machines (TBMs) (Source: FHWA)

1.1 CHOICE OF TBM

The choice of the selection of the TBM type is generally depends on many factors, for example:

- The need of excavation in sandy silt/ hard rock ground at shallow depth in urban area
- The requirement to avoid water inflow and ground deformation during tunnelling.

Furthermore, the TBM should assure the following key functions:

- To have power, thrust and torque suitable for excavating the tunnels, assuring high penetrations in the ground; the average speed will be adequate for complying with the contract key dates
- To be equipped with segment erector for installing the pre-cast concrete segment lining necessary to the tunnel stability
- To be outfitted with equipment and devices for probing and investigating the ground characteristics ahead the excavation face
- To record all the excavation parameters in a Data Logging System

The proposed TBM type for Dwarka tunnel can be an Earth Pressure Balanced TBM (EPB) or Slurry TBM or a Mix shield TBM.



Figure 2: Earth Pressure Balanced TBM



Figure 3: Slurry/ Mix Shield TBM

1.2 TBM CONSTRUCTION METHOD STATEMENT

Where sufficient space is available the TBM will be fully commissioned prior to launch with all the backup plant installed. A shove frame will be erected within the launch chamber to provide the reaction to propel the TBM into the ground.

Where necessary ground treatment will be carried out around the tunnel to form a plug of stable ground behind the launch chamber structure to allow the TBM to be buried into the ground safely and the full stabilising effects of the closed faced tunnel machine brought into operation.

Following the launch of the TBM a regular construction cycle of excavation, advance of the TBM and ring erection, immediately after advancement of the shield is complete, will be established.

Excavation will be undertaken one ring at a time. On completion of the excavation cycle, the segments will be erected within the tail-skin of the TBM using a mechanical erector to form a complete ring. The excavation cycle will then be repeated with the TBM propelled forwards by hydraulic jacks shoving off the ends of the previously erected tunnel lining ring.

Grouting of rings will be undertaken as a continuous process through the tail-skin of the TBM to a predetermined pressure to fill the voids between the ring and the excavated surface of the ground. The injection pressure and volume of grout will be automatically recorded. Back grouting will be undertaken on a regular basis to ensure that any voids left behind the lining after excavation and erection are filled.

The delivery of materials (tunnel lining segments, grout etc) to the TBMs will be by a narrow-gauge construction railway or similar system.

Removal of excavated material may be by railway, conveyors or by pumping dependent on the type of tunnelling machine selected and lengths of the tunnel drive.

TBM parameters will be monitored continuously to ensure all voids have been filled to minimise the risk of settlement.

The tunnelling operation will be a continuous operation to ensure a steady state is achieved with the tunnel machine parameters and to enable any adverse trends to be identified and corrective actions taken to minimise ground movements and the risk of damage.

On completion of the tunnel drives the TBMs will be dismantled and removed either underground through the tunnel or lifted to the surface from the tunnel reception chamber.

1.2.1 STEPS INVOLVED IN TBM TUNNELLING

Following are the steps involved in the TBM tunnelling process:

- Lower main body, cutting head, segment erector, screw conveyer, tail shield, thrust frame
- Assemble TBM
- Erection of reaction frame
- Connection of hose and cables
- Installation of temporary segments

- Initial drive
- Completion of initial drive
- Modification of TBM including removal of reaction frame, cradle and temp rings, laying rail
- Main drive
- Break through soft eye (reach receiving shaft)
- Dismantle TBM

2 SEGMENTAL LINING FEATURES

A typical cross section of the proposed tunnel is shown below in the figure.

- Finished Diameter: 13.8 m
- Proposed Grade of concrete: M50 conforming to IS 456
- Proposed minimum thickness of the segments: 450 mm
- Proposed average width of the segments: 2000 mm, considering adequate taper shall be provided in the rings during detailed design to negotiate any horizontal and vertical curves in the alignment.

The configuration of the segmental lining is generally depending on the number of the jacks of the TBM. The segmental lining could be Universal ring of a total nine (9) equal segments placed at 40 degrees each.

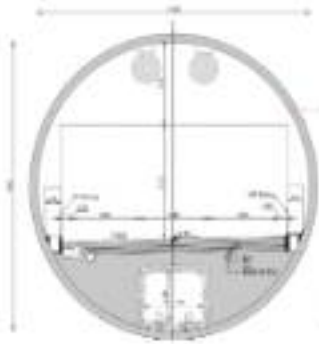


Figure 4: TBM Tunnel Cross Section

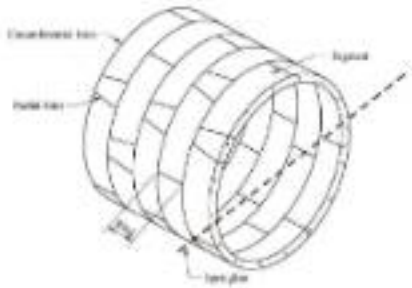


Figure 5: Schematic precast segmental lining



Figure 6: Stacked individual precast segments

3 TIMELINE ESTIMATION FOR TBM

A time period of 20 months is estimated for excavation and lining of 4.3 km, 1 number tunnel with an average of 215 m monthly progress by deploying Tunnel Boring Machine (TBM). The TBM shall be robust with adequate safety margins for the anticipated duty, designed and manufactured to comply with all safety standards. The TBM procured must be capable of efficient excavation and installation of support within the expected site and ground conditions. This includes soil, rock, soil/rock mixture and existing EBS (notably wells) all mainly below the groundwater table.

The TBM shall be designed to maintain a pressure on the excavated ground at all times. This pressure shall at-least balance the in-place soil and hydraulic pressures making up the total overburden pressure and shall be capable of varying the face pressure as the overburden pressure changes. The design shall also take into account the soil type, density, gradation, strength and abrasion.

Based on the progress achieved by the TBM in Delhi/NCR regions for metro and tunnels, progress of 215 m per month is acceptable. Dwarka tunnel have a very large excavated diameter of 15.10 m therefore provision of drainage arrange in running tunnels and requirement of removal of existing foundations of any structure may also be required and shall hamper the progress of Boring rate. Typically, of Delhi tunnelling media is composed of very wet silty clay & sandy soil, so proper condition of soil at TBM face also to be taken care for smooth progress of TBM. Foreseeing all such conditions TBM progress rate is estimated for 215 m per month. However, same shall also depend upon type of TBM and technology proposed by contractor and schedule may be revisited during construction.

Annexure – XIV
Detail Study of Mechanical and Electrical System of Tunnel

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1 INTRODUCTION

The Twin tube road tunnel has been planned for NH-148AE with its approach and connection to NH-24BB and Existing Delhi Internal Roads in the State of Delhi (from Shivmurthi to Vasant Kunj).

In accordance to IRC: SP: 91, the tunnel is classified as long tunnel and therefore require ventilation system and associated MEP systems along with other facilities suitable to all possible tunnel operations modes.

The following section establishes design criteria of mechanical & electrical systems for Tunnel.

2 SCOPE OF WORK

The following system systems have been considered in MEP works.

S.No	Description
1	Service Control Building
2	Ventilation System
3	Power Supply System
4	Emergency Power supply System
5	Fire Fighting system
6	Cabling System
7	Lighting System
8	Earthing System
9	Tunnel control system (SCADA)
10	Operations Management and Controls Systems (OMCS)
11	Plant Management and Control Systems (PMCS)
12	Traffic Management and Controls Systems (TMCS)

This Specification covers MEP Systems divided into sections, as indicated above, with each section aimed at a specific type of work. The various sections of the Works may thus be dealt with in several areas of the Specification.

3 TERMS AND ABBREVIATION

The following are the main terms and abbreviations used in this document.

Abbreviation / Acronym	Description
GUI	Graphic User Interface
HGV	Heavy Goods Vehicle
HV	High Voltage
LV	Low Voltage
IDF	Incident Detection Function
kph	Kilometres per hour
LED	Light Emitting Diode
MMI	Man-Machine Interface
OMC	Operation and Maintenance Centre
PLC	Programmable Logic Controller
PTZ	Pan, Tilt and Zoom camera
SCADA	Supervisory Control and Data Acquisition
SCF	Speed Control Function
TLE	Traffic Logging Equipment
UPS	Uninterruptible Power Supply
VDF	Vehicle Detection Function
VIP	VIDEO over Internet Protocol
VMS	Variable Message Sign
VoIP	VOICE over Internet Protocol
OMC	Operation maintenance centres
ECP	Electrical Cross Passage
VCP	Vehicular Cross Passage
VID	Video Incident Detection
RCU	Remote Control Unit
LAN	Local area Network
RMU	Ring Main Unit

4 CODES AND STANDARDS

The relevant list of Indian standards and International standards for the design of tunnel are as below (Standards produced by Bureau of Indian Standards shall always be considered first, in case the above standards are

silent on the subject other standards shall be considered).Apart from the codes and guidelines corresponding to specifications mentioned below, The Contractor shall/may propose as per latest technology in MEP systems for tunnels and same will finalized during detail engineering based on discussions and approval by Client.

Code	Description
NFPA 502	Standard for Road Tunnel , Bridges and Other Limited Access highways
IRC: SP:91	Guidelines for Road Tunnels
IRC: 99:99	Manuals for Specifications and Standards For Expressways
PIARC 989 05-05-B	Fire and Smoke Control in road tunnels, 1999
PIARC World Road Congress, Road Tunnels	Vehicle Emissions and Air Demand for Ventilation, Report 05.14.B, 2004.
MoRTH	Guidelines for Expressway, Chapter 13 for Tunnel Lighting/ United Kingdom: Highway agency standard BD78/99 design of Road Tunnels
European Directive 2004/IEC/54	safety for road users in tunnels in the trans-European road network
IEC 60034	Rotating electrical machines
IEC 60085	Electrical insulation - Thermal evaluation and designation
IEC 60470	High-Voltage Alternating Current Contactors and Contactor-Based Motor-Starters
IEC 60529	Degrees of protection provided by enclosures (IP code)
IEC 60947	Low-voltage switchgear and control gear
BS 546	Domestic AC power plugs and sockets
IEC 60085	Electrical insulation - Thermal evaluation and designation
IEC 60189	Low-frequency cables and wires with PVC insulation and PVC Sheath
IEC 60287	Electric cables - Calculation of the current rating
IEC 60352	Solderless connections
IEC 60364	Low-voltage electrical installations
IS:3646	Code of practice for interior illumination

Code	Description
IS:732	Code of practice for electrical wiring installations
IS:10322	Luminaries
IS:2149	Luminaries for street lighting
IEC 60076	Power transformers
IEC 60137	Bushings for alternating voltage above 1000 V
IEC 60273	Dimensions of indoor and outdoor post insulators and post insulator units for systems with nominal voltage greater than 1000 V
IEC 60664.1	Insulation coordination for equipment within low-voltage systems
BS 159	Specification for High-voltage busbars and busbar connections
BS 5266	Emergency lighting
BS 5308	Instrumentation Cables
BS 5467	Electric cables. Thermosetting insulated, armoured cables for voltages of 600/1000 V and 1900/3300 V
BS 5489	Code of practice for the design of road lighting
BS 5958	Code of practice for control of undesirable static electricity
BS 6134	Specification for pressure and vacuum switches
BS 6346	Electric cables. PVC insulated, armoured cables for voltages of 600/1000 V and 1900/3300 V
BS 6387	Specification for performance requirements for cables required to maintain circuit integrity under fire conditions
BS 7430	Code of practice for earthing
BS 7671	Requirements for electrical installations
BS EN 12464	Lighting of indoor work places
BS EN 13201	Road lighting
BS EN 50131	Alarm systems - Intrusion and hold-up systems
IEC/BS EN 60439-1:1999	Low-voltage switchgear and control gear assemblies. Type tested and partially type-tested assemblies.
CIE 88	Guide for the Lighting of Road Tunnels and Underpasses
CISPR 14-1	Electromagnetic compatibility - Requirements for household appliances, electric tools and similar apparatus - Part 1: Emission

Code	Description
IEC 60034	Rotating electrical machines
IEC 60044	Instrument transformers
IEC 60051	Direct Acting Indicating Analogue Electrical Measuring Instruments and Their Accessories
IEC 60056	High-voltage alternating-current circuit-breakers
IEC 60071	Insulation Coordination
IEC 60076	Power transformers
IEC 60081	Double-capped fluorescent lamps - Performance specifications
IEC 60085	Electrical insulation - Thermal evaluation and designation
IEC 61000	Electromagnetic compatibility (EMC)
IEC 60127	Miniature fuses
IEC 60129	Specification for alternating current disconnectors and earthing switches
IEC 60137	Bushings for alternating voltage above 1000 V
IEC 60189	Low-frequency cables and wires with PVC insulation and PVC sheath
IEC 60258	Direct acting recording electrical measuring instruments and their accessories
IEC 60265	High voltage switches
IEC 60269	Low-voltage fuses
ICE 60273	Dimensions of indoor and outdoor post insulators and post insulator units for systems with nominal voltage greater than 1000 V
IEC 60287	Electric cables - Calculation of the current rating
ICE 60298	A.C Metal-enclosed Switchgear And Control gear For Voltages Above 1 KV and up to and including 52 kV
IEC 60335	Household and similar electrical appliances - Safety
IEC 60352	Solderless connections
IEC 60364	Low-voltage electrical installations
IEC 60376	Specification of technical grade sulphur hexafluoride (SF6) for use in electrical equipment
IEC 60423	Conduit systems for cable management - Outside diameters of conduits for electrical installations and threads for

Code	Description
	conduits and fittings
IEC 60439	Low-voltage switchgear and control gear assemblies
IEC 60470	High-Voltage Alternating Current Contactors and Contactor-Based Motor - Starters
IEC 60502	Power cables with extruded insulation and their accessories for rated voltages from 1 KV (Um = 1,2 KV) up to 30 KV (Um = 36 KV)
IEC 60529	Degrees of protection provided by enclosures(IP code)
IEC 60598	Luminaires - General Requirements and Testing
IEC 60617	Graphical Symbols for Diagrams
IEC 60623	Secondary Cells and Batteries Containing Alkaline or Other Non- Acid Electrolytes - Vented Nickel-Cadmium Prismatic Rechargeable Single Cells
IEC 60662	High-pressure sodium vapour lamps - Performance specifications
IEC 60664	Insulation coordination for equipment within low-voltage systems
IEC 60669	Switches for household and similar fixed-electrical installations
IEC 60896	Stationary lead-acid batteries - General requirements and methods of test
IEC 60921	Ballasts for tubular fluorescent lamps – Performance requirements
IEC 60947	Low-voltage switchgear and control gear
IEC 61131	Programmable controlers
IEC 61386	Conduit systems for cable management
IEC 61508	Functional safety of electrical/electronic/programmable electronic safety-related systems
IEC 61537	Cable management - Cable tray systems and cable ladder systems
IEC 62271-200	High-voltage switchgear and control gear
IEC 62271-100	HV Circuit breakers
IEC 62305	Protection against lightning
IEEE 80	Guide for Safety in AC Substation Grounding

Code	Description
IEEE 802	Standards for Local and Metropolitan Networks
ISO 128	Technical drawings
ISO 1219	Fluid power systems and components - Graphic symbols and circuit diagrams
ISO 1996	Acoustics- Description, measurement and assessment of environmental noise
ISO 2063	Thermal spraying – Metallic and other inorganic coatings – Zinc, aluminium and their alloys
ISO 3046	Reciprocating internal combustion engines
ISO 10012	Quality assurance requirements for measuring equipment
ISO 11801	Information technology — Generic cabling for customer premises
NEMA ICS 1	General Standards for Industrial Control and Systems
NEMA ICS 2 – 230	Components for Solid-State Logic Systems
NEMA ICS 6	Enclosures for Industrial Controls and Systems
	Supply Authority Wiring Rules
AFBMA	Anti-Friction Bearings Manufacturers Association
AMCA	Air Moving and Control Association
ANSI	American National Standards Institute
AWS	American Welding Society
ASTM	American Society for Testing and Materials
NEMA	National Electrical Manufacturer's Association
SSPC	Steel Structures Painting Council
TT-P-645A	Primer, Paint, Zinc Chromate, Alkyd Type (Federal Specifications)

5 SERVICE CONTROL BUILDING

The service control buildings are proposed at both the portals with normal and emergency control and monitoring system with local and remote monitoring requirements as per NHAI's requirement. The following equipment and installation, contained in the service buildings at portals, has to be provided:

(I) Control Room (Operation Maintenance Centre OMCS and SCADA)

(II) Other facilities/rooms including following :

- Transformer room
- DG Set room and Fuel tank
- Fire Pump room
- HV switchgear room,
- LV switchgear room,
- UPS room,
- Battery room,
- Conference room/Office/Meeting room
- Management incident room
- Training room
- Waiting room / guest room
- Library and data storage

(III) Plant rooms for the tunnel maintenance and future requirements, stores;

(IV) Staff room and toilet facilities (if building is manned)

(V) Emergency Vehicle Parking

6 VENTILATION SYSTEM

6.1 EXTENT OF WORK

The work under tunnel ventilation system shall include the:

- Jet Fans
- Ductwork and Support Steelwork as per requirement.
- In - Tunnel and External Environmental Sensors and Monitoring Equipment

In addition, the extent of work shall include following:

- Interfacing with power supply systems, central monitoring & control system, fire services required for safety and traffic control surveillance system.
- Preparation of technical calculations to demonstrate ventilation system performance to meet environmental criteria and fire scenario.
- Preparation of control specification for jet fans based on traffic flow, traffic speed and pollutant levels.
- Preparation of emergency operation procedures for tunnel ventilation system.

- For each system, a complete commissioned, balanced and tested installation with Shop Drawings, As-built drawings, Operation and Maintenance Manuals, Factory Acceptance Tests and Site Acceptance Tests shall be submitted for owner's approval.
- Provision of terminal Cubical/MCC for connection to the Power Supply System cabling.
- Provision of terminal cubicle/MCC for connection to the Central Monitoring and Control System, Traffic Control and Surveillance System and Fire Services System cabling.
- Provision of emergency stop from remote and local for all exhausts jet fans

6.2 DESIGN CRITERIA

The tunnel ventilation system shall be design to:

(I) To provide Ventilation during normal operating conditions in order to maintain air quality conditions below the maximum allowable emission limits inside tunnel.

(II) Provide a means of smoke control during the event of a fire, in order to help with the safe evacuation of occupants as well as to provide a safe means of approach for firefighting and emergency services.

(III) Maintain acceptable air quality inside the tunnel in accordance with latest PIARC/ pollution control authority recommendations:

(Iv) To ensure that the ventilation system and its associated equipment meet the requirements of IRC SP: 91-2019, BD78/99, PIARC and NFPA guidelines.

(V) To install an effective, versatile and energy efficient ventilation systemas per the latest code and guidelines.

(VI) To reduce the risk of incorrect operation of the ventilation system in an incident involving fire

(VII) To ensure required air quality and visibility levels are maintained.

(VIII) To provide adequate tunnel ventilation during tunnel maintenance closures.

6.3 AIR QUALITY REQUIREMENTS

The PIARC publications are used to outline the recommended in-tunnel pollution limits and accordingly the design and threshold values for CO and visibility extinction are generally considered for design of ventilation system.

Ambient air supplied to the tunnel as fresh air contains CO, NO2 and PM. These levels are normally checked by installed air quality monitors in the tunnel at various locations. Typical values of CO ranges between 1 to 6 ppm.

The design criterion of CO in PIARC current trend of improving the air quality inside tunnel as per 'Road Tunnels: Vehicle Emissions and Air Demand for Ventilation.

6.4 TRAFFIC DESIGN SPEED

Design speed for ventilation; posted speed limit of 80 km/h and 20 km/h is taken as the congested case for ventilation design purposes. Average design speed is considered as 50 km/h

6.5 TUNNEL AIR VELOCITY

For safety purposes, the in-tunnel air velocity is not to exceed 10 m/s during emergency operation, as recommended by PIARC.

6.6 TUNNEL DESIGN FIRE

The design fire size for the tunnel is taken as 50 MW for structure design and ventilation design corresponding to the traffic in the tunnel as per NFPA 502: 2020 Edition and PIARC guide line. Fuel tankers are not expected to run through the tunnels.

A summary of the heat release rates for vehicle fires from some of the guidelines for tunnels is listed below:

Table 1: PIARC & NFPA-502 Fire Release Value for Various Type of Vehicle

PIARC & NFPA-502 Fire Release Value for Various Type of Vehicle		
Type of Vehicle	PIARC	NFPA-502
Passenger Car	2.5-5 MW	5-10 MW
Multiple Passenger Cars (2-4 Vehicles)	8-15 MW	10-20 MW
Bus	10 MW	20 MW
General Goods Truck	20 MW	-
Heavy Goods Truck	50 MW	30 MW

The tunnel ventilation system shall be designed to protect passengers upstream of the fire site and to provide a smoke clear evacuation path for passengers to escape and for rescue personnel to approach the fire site.

The maximum air velocity inside the tunnel due to the ventilation system shall not exceed as mentioned in various codes to permit passengers to safely walk in the tunnel during an emergency event.

The twin tube tunnels (both the tubes included) ventilation equipment is required to handle hot smoke during a fire emergency.

The design life of all mechanical plant in this specification shall be 20 years.

The ventilation system in each tube can be controlled either automatically via the Plant Monitoring and Control System (PMCS) computer located in the Control buildings, or manually from the relevant Ventilation Control Panel.

Control of the fans is normally initiated automatically in response to increasing carbon Monoxide (co), Oxides of Nitrogen (NOx) or poor visibility. The air Monitoring stations are Located at the ends of the tunnel and mid points.

In a longitudinal ventilation system, the jet fans and/or normal fans are used to create a longitudinal flow to remove the contaminants, heat.

Jet fans are widely used in tunnels with longitudinal ventilation due to relatively low cost and simple installation.

6.7 VENTILATION SYSTEM EQUIPMENT TUNNEL JET FANS

6.7.1 GENERAL

The Work of this attachment consists of furnishing, installing and testing of tunnel ventilation equipment complete with all required accessories, including Jet fan-motor units, sound attenuators, hangers, supports, and associated work, hereinafter specified or otherwise required for a complete and fully operable system.

The following definitions apply to the Work of this Section:

- Forward Flow: Airflow generated by the fan in the direction of the fan impeller to the fan motor.
- Reverse Flow: Airflow generated by the fan in the direction of the fan motor to the fan impeller.
- Pitch: The angle formed by the chord line of a fan blade root cross-section and a line parallel to the direction of rotation.

6.8 GENERAL

- The longitudinal spacing of the Jet fans shall not be less then 100 m and the distance from the portal for the jet fan shall not be more then 50 m.
- In selecting equipment, provide interchangeability of parts.
- In selecting Jet fan assemblies, ensure that the operating weight and axial thrust generated by fan on supports do not exceed the maximum acceptable limit indicated by the Contractors calculations.
- Furnish Jet fan assemblies of a single manufacturer and like components furnished by a single supplier.

6.8.1 FAN TESTS- GENERAL

- Spin Test-Balance each impeller statically and dynamically at the rated operating speed before spin testing. Spin test each impeller at 125 percent of

design rotational speed for a period of not less than three minutes. Examine impellers for loose blades and other damages. Replace defective parts and repeat the spin test before further testing.

- Vibration test - Check each fan for obviously rough operation. Replace defective bearings and recheck fan operation. Test each fan for vibration, measured in two radial planes 90 degrees apart (front and rear), and in the axial direction. Compare the measured vibration levels with the acceptable vibration limits specified. If the measured vibration exceeds the specified limit, determine the cause(s), correct it and then retest the fan.

6.9 INSTALLATION

- Install Jet fan assemblies in the space provided in such a manner as to readily serviceable. Verify existing inserts and other installation provisions prior to fabrication of hangers and supports.

6.10 FIELD TESTS

General Requirements

- Perform all tests in the presence of the Authority.
- Furnish all field test instruments. The Contractor may remove test instruments only after field-testing is completed.
- Provide lab our, materials and appurtenances required to complete the specified field tests.
- Submit all testing standards and procedures for approval prior to proceeding with any of the tests.

6.11 VIBRATION TESTS

- Check fans for obviously rough operation. Replace defective bearings and recheck fan operation.
- Measure amplitude and frequency of radial and axial vibration levels, and check for conformity to the specified acceptable vibration levels. For a Jet fan assembly whose vibration level exceeds the specified limit, balance impeller as required and re-measure vibration level until the specified requirement is met.

6.12 RUN-IN TEST

- Demonstrate that fans are operational in both directions of airflow.
- Operate each fan continuously for one hour in forward direction of airflow, de-energize for 30 seconds and then re-energize to operate in reverse direction of airflow for one hour.
- Measure and record for each motor individually, the motor starting current, running current, starting voltage, full load voltage and power factor for motor rotation in each direction.

- Measure and record running current and full load voltage in each direction with all fans in operation.

6.13 PERFORMANCE TEST

- Test each Jet fan for the actual "In-tunnel" performance.
- Measure the exit jet velocity and air volume generated by the Jet fan assembly in each direction of airflow. Based on the measured value of velocity and volume, calculate the thrust developed by the fan.
- If the calculated thrust is at least 95% of, or more than the specified value, no further testing is required.
- If the calculated thrust is less than 95% of the specified value, adjust the fan blade angle to increase the airflow; and re-measure the exit jet velocity and air volume until the calculated thrust is at least 95% of the specified value.
- In Tunnel and External Environmental Sensors and Monitoring Instruments In- Tunnel Environment Monitoring

6.14 GENERAL

The tunnel environment will be monitored by the following.

a) CO sensors

b) Visibility (haze) sensors

c) Velometers

d) NO sensors

e) NO2 sensors (Provision for future use)

Provision shall be made in the system for the future connection of NO2 measurement to the environmental control to the system by the use of contractor calculation.

In-tunnel air quality monitoring equipment shall be located each km along the tunnel.

The Central Monitoring and Control System (CMCS) shall scan these sensors in configurable regular intervals. Any sensors failure detected will be reported at the Central Control Room (CCR), wherein such failure will logged and an alarm will be raised at CCR. The scanning interval will be set in order to meet the response requirement of this Specification.

Facilities to filter transient signals shall be provided to avoid spurious signals.

The measured levels of CO2, NO/NOx tunnel air velocity and visibility shall be recorded by the Central Monitoring and Control System (CMCS).

The CO and NO/NOx sensors shall generally be in accordance with latest guidelines as applicable.

6.15 AIR MONITORING STATIONS

Air monitoring stations shall be provided in the nearest distribution panel inside the tunnel near the environmental sensors.

The monitoring stations shall collect data from the CO sensor, NO sensor, visibility sensor and air flow monitoring sensor.

Dual processing units shall be provided. Multiplexers and associated circuitry shall be provided for the transmission of data from the sensor elements to the dual processing units.

Dual communication links connecting the dual processing units to the Central Computer System (CCS) at the CCR shall be provided by the CMCS.

6.16 CO SENSORS

The CO sensors shall be of an infra-red absorption type with automatic self-calibration to give outputs in the measuring range of 0-200 ppm. The CO sensors shall adopt a non- sampling technique to measure CO concentration.

The CO sensors shall be provided with self-testing and self-correcting functions. The CO sensor design shall be appropriate for installation in vehicular tunnels.

Support beams, legs, hangers, lifting eyes and anchor bolts required for the proper installation and maintenance of the CO sensor equipment shall be designed and provided by the Contractor.

The supports and all steel components including bolts, nuts, and washers shall be hot- dipped galvanised latest standard.

The CO sensors shall be mounted a high level on the side wall.

The CO sensors shall be installed in accordance with the manufacturer's installation procedure.

An audible and visual alarm signal shall be sent to the CCR in the event of sensor failure.

The equipment shall consist of the following units sealed to IP 65. All cable terminations to sensors shall I have the same IP rating.

6.17 INFRA-RED SOURCE UNIT

Construction Fully sealed cast Aluminum enclosure

Source heated Power Stainless steel cylindrical elements, electrically 230V 50HzAC

Operating Temperature Range -20°C to +40°C Infra-Red Receiver Unit

Construction Fully sealed cast Aluminum enclosure

Infra-Red Detectors Lithium Tantalate pyro electric detectors with pre-amplification Path length 20 meters

Power	230V 50Hz AC
Operating Temperature Range -20°C to +40°C Signal Processor Unit	
Enclosure	Fully sealed cast Aluminum
Span	Adjustable in range 0 to 150 ppm
Accuracy	± 8ppm or ± .8% Time Constant 2 seconds adjustable to 20 seconds
Output	0 to 20mA (or 4 to 20mA) Operating Temperature Range -20°C to +55°C
Power Supply Unit	
Enclosure	Fully sealed cast aluminium
Power	230V, 50Hz AC
Output	4 x Analogue Outputs 0, 2, 4-20mA 8 x Relay Outputs Max 48VDC, 0.5A Max 48VAC, 1A
Operating Temperature Range -20°C to 55°C	

6.18 NO SENSORS

The NO sensors shall be of an infra-red absorption type with automatic calibration to give outputs in the measuring range of 0-50 ppm. The NO sensor shall adopt a non-sampling technique to measure average NO concentration.

The NO sensor shall be designed for application in vehicular tunnels sensors shall not require routine maintenance at intervals shorter than 3 months.

Self-testing and self-correction functions shall be provided with the sensors.

Support beams, legs, hangers, lifting eyes and anchor bolts required for the proper installation and maintenance of the NO sensor equipment shall be designed and provided by the ventilation system subcontractor.

The supports and all steel components including bolts, nuts and washers shall be hot-dipped galvanized to BS EN ISO 10684 or approved equivalent standard.

The NO sensors shall be mounted at a high level on the side wall.

The NO sensors shall be installed in accordance with the manufacturer's installation procedures.

An alarm shall be raised at the CCR in the event of sensor failure.

The equipment shall consist of the following units sealed to IP65. All cable terminations to the NO sensors shall be made to the same IP rating.

Infra-Red Source Unit

Construction Fully sealed cast aluminium enclosure Source Stainless steel cylindrical element electrically heated

Power 230V 50Hz AC

Operating Temperature Range -20°C to +40°C

Infra-Red Receiver Unit

Construction Fully sealed cast aluminium enclosure

Infra-Red Detectors Lithium Tantalate pyro electric detectors with pre-amplification Path length 20 meters

Power 230V50-HzAC

Operating Temperature Range -20°C to +40°C Signal Processor Unit

Enclosure Fully sealed cast aluminium

Span Adjustable in range 0 to 30 ppm.

Output 0 to 20mA for 4 to 20mA) Operating Temperature Range -20°C to 55°C

Power Supply Unit

Enclosure Fully sealed cast aluminum

Power 230V, 50Hz AC

Power 230V, 50Hz AC

Power 230V, 50Hz AC

Operating Temperature Range -20°C to 55°C

6.19 VISIBILITY SENSORS

The visibility sensors shall be designed to measure the extinction coefficient in units of m-1.

Transmissometers shall be mounted at a high level on the side wall to operate as visibility sensors with 100% calibration mirrors and which allow the computer perform automatic calibrations on the light source and receiver.

The Transmissometers shall consist of: 2 off Duplex Transmissometers

A retro-reflector

The transmissometer shall have the following specifications: Dynamic Range 0 to 100% transmission

Accuracy = 2% transmission Calibration: Self-calibration

The equipment enclosure shall be sealed to IP 65. All cable terminations to the sensors shall have the same IP rating.

Any drifting shall be compensated for automatically and taken into account in the measurement output.

The sensor readings shall not be affected by the ambient light.

An alarm signal shall be raised at the CCR in the event of sensor failure.

The sensors shall be equipped with dust protection tubes to minimize dust deposition on the optical surfaces.

Support beams, legs, hangers, lifting eyes and anchor bolts required for the proper installation and maintenance of equipment shall be designed and provided by the ventilation system subcontractor.

The supports and all steel components including all bolts, nuts and washers shall be hot- dipped galvanised to BS EN ISO 10684 or approved equivalent standard.

The sensor shall be installed in accordance with the manufacturer's installation procedures.

6.20 AIR FLOW MONITOR

Air flow monitors shall be designed to operate on the principle of ultrasonic measurement. Each air flow monitor will consist of two transducers and an evaluator.

Air flow monitors shall be installed high on the tunnel walls to measure the airflow speed and direction, which may be in the same or opposite direction to the traffic flow.

The equipment enclosure shall be sealed to IP 65. All cable terminations to the sensors will have the same IP rating.

The air flow monitors shall be designed for application inside vehicular tunnels.

Support beams, legs, hangers, lifting eyes and anchor bolts required for the proper installation and maintenance of equipment shall be designed and provided by the ventilation system subcontractor.

The supports and all steel components including all bolts, nuts and washers shall be hot- dipped galvanised to BS EN ISO 10684 or approved equivalent standard.

The air flow monitors shall be installed in accordance with the manufacturers installation procedures.

An alarm shall be raised at the CCR in the event of sensor failure.

6.20.1 EXTERNAL ENVIRONMENTAL MONITORING GENERAL

The External Environment shall be monitored at both the portal by the following:

a) CO analyser

b) Wind Speed and Direction sensors.

c) NO analyser

d) NOx analyser (Provision for future use).

e) Particulates (PM10& 2.5) (Provision for future use).

f) Dry Bulb Temperature.

g) Barometric pressure.

h) Relative Humidity.

The CO, NO and NOx analyser (future use only) shall be connected digitally to the data acquisition system providing the advantages in remote communication and minimizing analog to digital noise.

The Central Monitoring and Control System (CMCS) shall scan these sensors in configurable regular intervals. Any sensors failure detected will be reported at the Central Control Room (CCR) at the One portal where such failure will be logged and an alarm will be raised at CCR. The scanning interval will be set in order to meet the response requirement of this Specification.

Facilities to filter transient signals shall be provided to avoid spurious signals.

The measured levels of CO2, NO/NOx tunnel air velocity and visibility shall be recorded by the Central Monitoring and Control System (CMCS).

At both outside of portals, external environmental sensors will be fitted in kiosk/shelter to

monitor external gases.

6.21 SPECIFICATION

Voltage regulation:	Input 230/400 VAC +10% -20%, output+/- 3%
8% Overload capacity:	Input 230/400 VAC +/- 40%, output +5% - 200% of rated load for a minimum of 10
seconds Noise attenuation:	Common mode typically 120 dB
Transverse mode typically	80 dB

Distortion:	Less than 3% Total Harmonic Distortion
Efficiency:	88% at full rated

load RU Instrument Rack

The Instrument Rack shall be used to mount the analysers, calibrator, zero air supply and sample pumps as well as any other equipment which is required to be mounted in a rack enclosure.

Specification:

Rack units:	27RU instrument racks
Overall dimensions:	1350mm (H) x 585(W) x 860(D)
Construction:	2 mm steel frame
	1 mm steel panel skins
	Zinc phosphate preparation and powder coating/enamelling. Removable side panels. Rubberized base to absorb vibration

All angle-steel shall be punched to IEC 297 conformity for strength and dimensional accuracy. Side panels lift off for access to equipment. Rack mounted power distribution panels complement the high standard of finish.

6.22 CO ANALYSER

The analyser shall be microprocessor controlled. The analyser shall be of NDIR gas filter correlation technology to measure CO in ambient air (LDL <40 ppb, Range 0-200ppm).

The analyser shall has a removable USS data storage capable of storing in excess of 8 years of

5 minute averages, helps eliminate the need for an external data acquisition system, minimizing air conditioning requirements of the enclosure.

Analyser for the measurement of CO shall has no internal AC line voltages present, only internal DC voltages are to be permitted, ensuring the safety of technicians when performing routine maintenance. The analyser shall has dual particulate filter which shall help reduce scheduled maintenance calls by up to 50%, critical in high pollution applications such as road side monitoring. The analyser shall has at least 3 Analog Input for met sensors 0-5V 160uV resolution, eliminates the need for an external data acquisition system.

Logs of every event with in the analyser stored in the USS memory

Pre and gain values during calibration are recorded on the log file which can be used for data adjustments if required.

3 analogue inputs that can be logged in the USB and downloaded remotely for sensors with analogue outputs. Storage of existing configuration to reload in case of calibration error. Auto backup of configuration file. Dumping of all

parameters for troubleshooting or routine maintenance Easy test functions for analogue inputs and outputs.

Analogue outputs current and voltage can be calibrated from software Firmware upgrade form USB memory no need to connect a computer Single PCB board.

Background ports available on the back of the analyser for easier converter checks and more precise.

Background correction

Easy pressure calibration Interface Front light indicators for any malfunction Specifications

Measurement Ranges:	0-200ppm (Auto ranging)
Concentration Display: ppb, ppt. Noise:	User selectable mg/m3, µg/m3, ppm, < 20 ppb
Lower Detectable Limit:	< 40 ppb
Linearity: scale	< 1% of full
Precision:	20 ppb or 0.1 % of reading whichever is greater)
Zero Drift: 24 hours:	< 0.1ppm
7 days:	< 0.1 ppm
Span drift 24 hours:	<0.1 % of reading
7 days:	<0.5% of reading
Response time	60 seconds to 95%
STP Reference	0°c, 20°c, 25°c at 101.3kPa
Sample Flow Rate	1000cc/min
Temperature Range:	0°- 40 °c
Power:	99-132 VAC, 198-264 VAC 47-63 Hz
Dimensions:	440 x 178x 620 mm (w x h x d), 3.5 RU
Weight:	12.8 kg (in rack)
Communication ports:	USB port (digital communication)
	TCP/IP Ethernet Network connection (optional) RS232 Port 1: Digital communication
	RS232 Port 2: Multi drop port
	25 pin I/0 port (analogue outputs, analogue inputs, digital status inputs, digital status outputs)

Analogue Outputs: Menu selectable current or voltage output 0-20mA, 4-20mA, or 0-5 VDC

Menu selectable offset of 0%, 5% or 10%.

Auto ranging from 0-50 ppb to 0-20ppm (between Two user specified full scale values)

Analogue Inputs: 3 analogue inputs, 0-5v, 160 µV resolution

Digital Status Inputs: 8 logic level inputs Digital Status outputs: 8 open collector outputs

Removable USB flash memory that stores data in the following formats:

- Instantaneous data from: 1, 3, 5, 10, 30, or 60 minute intervals
- Average data from: 1, 3, 5, 10, 15, 30 minutes, 1, 4, 8, 12, or 24 hours.
- Data storage of 8 years of 12 parameters, 1 minute data on 1 gigabyte memory

The CO analyser shall be Ecotech Serinus 30 Carbon Monoxide Analyser (or approved equivalent).

6.23 NOX ANALYSER

The NOx analyser shall be microprocessor controlled and designed as U.S. EPA equivalent method (RFNA-0809-186) and EN approval (Sira MC1001667/00).

The sensor shall be of gas phase chemiluminescence technology to measure NO/NO2/NOX in ambient air (LDL <0.4ppb, Range 0-20ppm).

Generator and be able to turn the Zero Air Generator on and off when a dilution is required.

Gas Dilution Calibration must enable up to 18 separate dilution sequences to be programmed for automatic initiation by a suitable data acquisition system or via an analyser. Single and multipoint calibrations performed using precision mass flow controllers Setup via front panel display and keypad or a computer.

Remote control provided using a data acquisition system or suitable gas analyser Mass flow controller zero stability drift less than 0.6% full scale per year Two years between mass flow controller calibrations.

6.24 SPECIFICATIONS:

Dilution & Span Flows:

Input dilution gases: 1 standard, (2 optional)

Input source gases: 4 standard

Dilution Mass Flow Controller: 0-10 slpm (std) 0-2 or 0-5 slpm (optional) Source Mass Flow Controller: 0-50 sccm (std), 0-20 or 0-100 sccm (optional) Flow Accuracy (constant temp): ± 1.0% of full scale

Flow Repeatability:	±0.15 % of full scale
Linearity:	± 0.15% of full scale.
Operating Gas Pressure:	70-200 Kpa
Zero Drift:	< 0.58% per year
Response time:	< 1 second
Output Manifold:	4 output ports standard, (8 optional)
Dilution Ratio:	Variable 100:1 to 2000:1 (std)

6.25 INTERFACE

Programming:	Via front panel/keypad or computer

Programmable calibrations: 18 separate dilution sequences may be programmed for automatic initiation by digital inputs from a data logger or suitable analyser

Digital Inputs:	8 digital input bits used for start/stop of calibration sequences
Digital input types:	Relay contact closures or TIL logic inputs
Digital Outputs:	8 digital outputs used for sequence indication and/or
Alarm:	Indication (low gas flow)
Display:	four line illuminated display for status and programming
Memory:	Non-volatile protected, automatic startup after power Failure
7 days	< 1% of reading
Response time:	5 seconds to 95%
STP reference:	0°c, 20°c, 25°C at 101.3 kPa
Sample Flow Rate:	340 cc/min (total flow 680 cc/min)
Temperature Range:	0°- 40 °C
Power:	99-132 VAC, 198-264 VAC 47-63 Hz
Dimensions:	440 x 178 x 620 mm (w x h x d) 3.5 RU
Weight:	16.2 kg (in rack)

Communication ports:	USB port (digital communication) TCP/IP Ethernet Network connections (optionnel) RS232 Port 1: Digital communication RS232 Port 2: Multi drop port 25 pin I/0 port (analogue outputs, analogue
Analogue Outputs:	Menu selectable current or voltage output 0- 20mA, 4-20mA, or 0-5 VDC
Menu selectable offset of 0%, 5% or 10%. Auto-ranging from 0-50 ppb to 0-20ppm (between two user specified full scale values)	
Analogue Inputs:	3 analogue inputs, 0-5v, 160pV resolution
Digital Status Inputs:	8 logic level inputs
Digital Status outputs:	8 open collector outputs

Removable USB flash memory that stores data in the following formats:

- Instantaneous data from 1, 3, 5, 10, 30, or 60 minute intervals
- Average data from: 1, 3, 5, 10, 15, 30 minutes, 1, 4, 8, 12, or 24 hours.
- Data storage of 8 years of 12 parameters, 1 minute data on 1 gigabyte memory

The NOx analyser shall be Ecotech Serinus 40 Nitrogen Oxides analyser (or-approved equivalent).

6.26 GAS CALIBRATION SYSTEM

The calibration equipment shall either be installed into each monitoring station or one set simply moved from one site to the next by a trained technician in order to perform calibrations.

6.27 SPECIFICATIONS

Gas dilution calibrator should be of a simple but reliable design and include no more than 5 solenoid values in its design.

Gas dilution calibrator should feature a digital interface with the Zero air

The analyser shall have a removable USB data storage capable of storing in excess of 8 years of 5 minute averages; helps eliminate the need for an external data acquisition system, minimizing air conditioning requirements of the enclosure.

Analyser for the measurement of NOx shall have no internal AC line voltages present, only Internal DC voltages are to be permitted, ensuring the safety of technicians when performing routine maintenance.

The analyser shall have dual particulate filter which shall help reduce scheduled maintenance calls by up to 50%, critical in high pollution applications such as road side monitoring.

The analyser shall have at least 3 Analog Inputs for met sensors 0-5V 150uV resolution, eliminating the need for an external data acquisition system.

Logs of every event with in the analyser stored in the USB memory Pre and post gain values during calibration are recorded on the log file which can be used for data adjustments if required.

3 analogue inputs that can be logged in the USB and downloaded remotely for sensors with analogue outputs Storage of existing configuration to reload in case of calibration error Auto backup of configuration file Dumping of all parameters for troubleshooting or routine maintenance Easy test functions for analogue inputs and outputs.

Analogue outputs current and voltage can be calibrated from software Firmware upgrade form USB memory no need to connect a computer Single PCB board Background ports available on the back of the analyser for easier converter checks and more precise

6.28 BACKGROUND CORRECTION

Easy pressure calibration interface Front light indicators for any malfunction

6.29 SPECIFICATIONS

Measurement Ranges: 0-20ppm (autoranging)

Concentration Display: User selectable mg/m3, pg/m3, ppm, ppb, ppt. Noise: <0.2 ppb

LDL: <0.4 ppb

Linearity: 1% of full scale

Precision: 0.4 ppb or 0.5 % of reading (whichever is greater)

Zero drift: 24 hours:< 0.4 ppb

7 days: < 1 ppb

Span drift: 24 hours: <0.2% of reading System

Operating Temperature: 0°C - 50°C (20°C-35°C for optimum performance)

Input Voltage: 90-260 VAC 50/60 Hz, Selectable 115 VAC or 230 VAC

Dimensions: 19" Rack Mounting (135mmH x 450mmW x 440mmD) Weight: 12 kg

The Gas calibration system shall be Ecotech GasCal 1100 Gas Dilution Calibrator (or approved equivalent).

6.30 ZERO AIR SUPPLY

The Zero Air Generator shall interface digitally with a Gas Dilution Calibrator which is able to start and stop the zero air generator when a dilution calibration is required.

The Zero Air Generator shall 45tilize a membrane dryer for reducing the moisture content in the air.

The Zero Air Generator shall be of a design that doesn't need to 45tilize a surge/ condensate tank.

The Zero Air Generator shall have CO Catalytic Converter for removal of CO from ambient air.

6.31 SPECIFICATIONS

Scrubbers

Hopcalite: Removal of CO (<0.1 ppb)

Purafil: Removal of NO, NO2, NOx (<0.1 ppb)

Charcoal: Removal of S02, H2S, Ozone

(<0.1 ppb) Molecular Sieve: Removal of H2O (

Dew Point -15deg C)

Power: 230 VAC 50 HZ (optional 110 VAC 60 hz)

Pressure: Up to 200 KPA

Flow: 0-9 LPM

The Zero Air Generator shall be Ecotech 8301 LC Zero Air Supply (or approved equivalent)

6.32 WIND SPEED AND DIRECTION SENSOR

The wind speed and direction sensor shall be connected directly to one of the analyser through its along output. The wind speed and direction sensor shall require no maintenance and have no moving parts.

	Specification Wind Speed
Measurement range	0.56 m/s (0.124 mph, 0.107 knots)
Starting threshold	0.1 m/s (0.1 mph, 0.1 knots, 0.1 km/h)
Delay distance	virtually zero
Resolution	virtually zero
Accuracy (range 0.65 m/s)	+/-0.135 m/s (±0.3 mph, ±0.26 knots) or 3% of the
Wind direction	
Measurement range	0-360'
Starting threshold	virtually zero
Delay distance	virtually zero

Resolution	1°
Accuracy (wind speed over	+/-2°

6.33 RELATIVE HUMIDITY/TEMPERATURE SENSOR

- The Relative Humidity and Temperature sensor shall be a combined unit.
- The Relative Humidity and Temperature sensor shall be installed within a solar radiation shield.
- Relative Humidity Specifications

Measuring Range: 0.8 to 100% RH

Accuracy:

Against factory ref.:	+1/-1.0%
Field calib.:	+/- 2.0% (>90% RH) +/-2.0% (0-90% RH)
Response Time:	<15 seconds with membrane filter
Temp. Dependence:	+/-0.05%RH/deg C
Output:	0-1 VDC

Temperature Specifications

Measuring Range:	-40 to 60 deg C
Accuracy:	+/- 0.2 deg C @ 20 deg C
Response time	< 10 seconds
Supply Voltage:	7-35 vdc
Output:	0-1VDC

Naturally Aspirated Radiation Shield

The Naturally Aspirated Radiation Shield shall be designed to eliminate heating effects due to solar radiation.

Barometric Pressure Sensor

Specification Operating Range: in mm Hg Resolution: Infinite

Accuracy: +/- 0.125% whichever is greater

Repeatability: +/- 0.15%

Linearity: +/- 0.4%

Temp. Range: -40 to 50 deg C Temp. Stability: +/-2.0%

Output 0-1 VDC

6.34 DATA ACQUISITION SYSTEM

6.34.1 GENERAL

An Data Acquisition system softwareData Acquisition and Control System shall be provided to interface between the environmental sensors and the Plant Management and Control System (PMCS) system.

The Data Acquisition System shall be specifically designed for use in ambient air and emission monitoring applications.

The Data Acquisition & Control System shall:

- use "Industry Standard" RS232 and USB Communication enabling digital communication with supported monitoring equipment
- Support remote communication from anywhere in the world enabling full control over the pollution monitoring system and direct interfacing with supported analysers.
- Provide remote communication through switched telephone, cellular telephone, ethernet.
- And satellite telephone networks as well as short haul modems.
- Provide Data storage space for over thirty years of 10 minute historical data
- Capture minimum , maximum average values and standard deviations
- have lightning & surge protection facilities
- have full control over calibration cycle periods allow data retrieval via internal DVD/RW in the event communication networks are unavailable.

The use of RS232 and USB links shall allow Data Acquisition system softwareto collect data directly from monitoring instruments in digital format thus eliminating digital to analog conversion errors.

An optional 16 bit termination panel (TPIM) shall provide a high level of accuracy when interfacing with non-digital sensors.

The Data Acquisition system softwareCPU/motherboard shall support the operating program, data storage function, RAM, calendar clock, RS322 and USB ports, parallel printer port and I/0 interface cards.

A lithium battery shall be provided to protect the calendar clock from any power failures.

The Data Acquisition system softwareshall provide supervisory and interactive control of the monitoring station's analysers and gas calibration system from anywhere in the world using a computer running software.

This control capability shall enable calibration to be performed, system setup and diagnostic parameters to be viewed and changed and data to be retrieved at user selectable intervals both from Data Acquisition system software SCADA from all supported analysers.

A variety of communication methods shall be provided including modem, ethernet and satellite networks..

Data shall be stored in an ASCII format with a new data file created each day, data shall be stored in 4 separate data report types with individually configured averaging periods, span, zero and precision reports also stored.

Data Acquisition system softwareSoftware shall Incorporates a comprehensive security function preventing unwanted entry and enabling various levels of access to be configured for different types of users.

Measurement data shall be stored into four separate reports each with a different averaging period, precision and zero calibration. Data shall also stored in separate reports. Span calibration data shall be stored in up to 16 different reports in order to cater for 20%, 40%, 60%, 80% etc. multipoint calibrations

6.35 REMOTE CONTROL

Data Acquisition system softwareData Acquisition System Software shall work on the Client/Server model. Data Acquisition system softwareData Acquisition System (or approved equivalent) shall have both Server and Client Software installed. The Server shall handle all communication with the analysers, calibrator and stores the data into multiple reports. The Client Software shall have the graphic interface enabling the user to setup the server, view both instantaneous and historical data and perform routine operations.

A second or third Client Software can be installed on a central PC, this Client Software shall be able to interrogate the server remotely and perform all the same functions as if the user was at the station. However it shall not be a VNC connection and as such does not change how the client appears at the stations. The system shall allow multiple users to be running the client software one can be viewing historical data while the other user views instantaneous data.

A Data Acquisition system software (or approved equivalent) client software installed at the monitoring station on the Data Acquisition system software (or approved equivalent) Data Acquisition System is also able to remotely view all other Data Acquisition system software (or approved equivalent) Data Acquisition System that are connected onto the same network. This shall enable a user at a station at Location A to have full remote control of the Data Acquisition system software (or approved equivalent) DAS installed at location B, C, D etc.

6.36 CALIBRATION CONTROL

Data Acquisition system software (or approved equivalent) shall be designed to automatically provide calibration and control signals via direct RS232 interface with Ecotech's GasCal 1100 Dilution Calibrator (or approved equivalent).

A Data Acquisition system software (or approved equivalent) Client installed at a central office shall be able to remotely program the GasCal with cylinder concentrations, span and zero sequences and advise when they are to be performed. All calibration data shall be flagged in order to separate it from measurement data. Calibration data shall be flagged and stored in separate data reports which include precision, zero and multiple span reports,

6.37 DATA PUSHER (WEB SITE)

Data Acquisition system software's (or approved equivalent) Data Pusher shall be able to directly FTP data to web servers and other applications without data needing to be downloaded first. This shall be ideal for reporting unvalidated data on websites.

Specification	
CPU:	X86 compatible processor — 3.0 Ghz+

RAM:	2 GB
Hard Drive Config:	RAID (optional 2nd hard drive as backup of 1st hard drive)
DVD-RW:	Used for installation of software and backing up of data/configuration files
Display Driver:	Supporting up to 2048 x 1536 dual screen
Modem:	9600 Baud or grater
Operating System:	Window 7
Data storage:	SATA II; Size 500 GB
Data Storage:	Data Stored in ASCII format
	Up to 4 independent data sets
	Selectable between 1 minute and 7 days
Calibration control:	Automatic span and Zero control, Calibration
Communication ports:	6 x RS232 serial ports standard, (1 used for the
	6x USB2 1 ports
Modem port :	lx RS232 DB9M
Mouse port:	USB Port
Operational Environment:	0-40°
Power :	450 watt power supply
Modem & Phone Lines	

Remove communication with the Data Acquisition system software (or approved equipment shall be possible through the use of a 3G modem.

The necessary Module shall enable remote communication between the DAS (data acquisition system software) and a central computer running software.

Note: All the above systems shall have latest technology.

6.38 TUNNEL VENTILATION SYSTEM CONTROL AND MONITORING REQUIREMENTS

This Section of the Specification also be read in conjunction with the Central Monitoring And Control System (CMCS) of the Electrical Services Technical Specification.

6.39 GENERAL

All necessary instrumentation will be provided to allow for monitoring and control by the CMCS. The instrumentation shall include transducers, limit switches, proximity switches, dual processing units, etc.

All the necessary control equipment will be provided including all relays, transformers, manual switches, controllers, motors, wiring and all accessories necessary to perform the intended function of the system.

A control algorithm, flow charts, operation mode tables, technical calculations and specification to be implemented by the CMCS will also be provided.

The tunnel ventilation system mimic diagram, the status indication requirements, and the control and monitoring requirements to be implemented by the CMCS will also be provided.

6.40 SYSTEM DESCRIPTION

The Tunnel Ventilation system will be controlled and monitored by the Central Monitoring and Control System (CMCS).

The CMCS will comprise a Central Computer System (CCS) which will also control and monitor other electrical and mechanical systems. The CCS will comprise both duty and standby computers. The standby computer will run at -hot standby mode in parallel with the duty computer and will automatically take over all functions of the duty computer in case of duty computer failure or malfunction. A Manual Fail Back Control Panel will be provided next to the COS. This Panel will perform emergency ventilation system control in case of failure of the CCS.

Dual communication links will be provided to connect each field equipment with the CCS. In addition, a dedicated communication link will be provided to connect each ventilation equipment with the Manual Fail Back Control Panel.

The status of the tunnel ventilation system will be displayed graphically in the Central Computer Room located in the Portal Control Building.

The CCS will perform tunnel ventilation system controls in either full automatic control mode, semi-automatic control mode or manual control mode.

Alarm initiation will include, but not be limited to, the following situations:

Malfunction of any piece of equipment, including each component of the system hardware. Level of CO, NO and visibility exceeding the resettable high limits

Abnormally high level of CO, NO, and visibility. In this case, the type of alarm annunciation, display and acknowledgment will be more distinctive when compared to (I) above

Tunnel air velocity exceeding a limit, normally taken as 8 m/s.

Tunnel air velocity exceeding an extreme limit normally taken as 10 m/s.

The CMCS will be able to restart automatically in accordance with a pre-defined sequence when power is resumed after major power failure.

6.41 FULL AUTOMATIC CONTROL CONTROL Using Pollutant Levels

The jet fans will be controlled automatically by the CMCS based on the measured levels of carbon monoxide (CO), nitrous oxide (NO), tunnel air velocity and visibility inside the tunnel. The fans will be operated automatically by the software. An algorithm will be implemented to determine the number of fan groups required to operate in order to keep the tunnel environment within design conditions. The

algorithm will be provided by the Contractor in discussion to ventilation system O E M and submitted for approval.

In addition, the fan groups will be able to be operated by taking historical statistics of CO, NO, air velocity and visibility in lieu of the field sensor readings in the real time feedback control described above.

6.42 CONTROL USING TRAFFIC DATA

The jet fans will be controlled automatically by the CMCS based on traffic statistics which will include traffic speeds, traffic throughput, day and time. A pre-programmed schedule incorporating 24 hours traffic profiles at weekdays, weekends and public holidays will initiate the ventilation system control alarm will be raised if high levels of pollutant concentrations are detected, which will allow the tunnel operator to turn on additional ventilation capacities via the semi-automatic control mode.

6.43 SEMI-AUTOMATIC CONTROL

If required by the tunnel Operator, jet fan groups or individual fans will be capable of being operated manually. The computer software will issue the corresponding command to operate the fans. The access authorization will be able to be defined by the authorized tunnel operator.

The semi-automatic operating modes are expected to apply under the following situations-Emergency conditions such as vehicle fire, accidents etc;

Abnormally high level of CO, NO, haze and tunnel air velocity; Fans isolated for maintenance or overhauling;

6.44 FAN TESTING

Grouping of tunnel fans shall be the same as that for full automatic control mode. The software will generate a graphic display to show all recommended fan groups to be operated based on either pollutant levels or traffic statistics. Measured level of pollutants, traffic speed and traffic throughput per lane will also be displayed.

The software will generate a graphic display to show the total hours of operation of each fan to assist the operator to determine the stopping and operating of the fan.

Smoke Control Mode will be provided under semi-automatic control. The smoke control mode will override all other control modes and will be initiated by the operator upon the detection of a fire inside the tunnel. Upon activation of this mode, all fans will normally be returned to the off state pending operator commands. After that, advisory messages and menu-driven input shall be provided as the man machine interface to guide the operator through the proper procedures to turn on all the relevant fans to deal with a particular fire situation. Operator input will be kept to a minimum, and all relevant fans will be started in the shortest possible time taking account of all necessary safety measures for protecting the fans. Fans will be started within a maximum time limit to prevent smoke filling the tunnel to a dangerous level. Where fan reversal is involved, the ventilation system subcontractor will employ some form of fan braking mechanism to expedite the reversal process if necessary.

Emergency ventilation plans will take into consideration the following minimum fire scenarios: -

Fire near one portal

Fire at ¼ point from one portal

Fire at mid tunnel

Fire at¼ point from another portal

Fire near another portal

6.45 MANUAL CONTROL

Manual Control of individual fans via CMCS will be achieved by typing in special commands by the authorized tunnel operator.

6.46 MANUAL FALL BACK CONTROL PANEL

A separate and independent system will be installed to back up the CMCS to control the fans in pre-defined groups in case of CMCS breakdown or during a fire emergency situation.

To provide more flexibility under some abnormal situations, ventilation control push buttons shall be provided on the Manual Fail Back Control Panel to operate the fans in groups.

Sets of push buttons shall be provided to select the operation of any combination of the fan groups.

The push button shall activate the fan groups through the dedicated communication link to select the fans to operate and to sequence the starting of the fans. Flexibility to allow the rearrangement of fan groups will be provided.

A 'Total system' bush button shall be provided for the tunnel ventilation system. When this button is pushed; all fans shall be turned on as selected.

The sequence of starting of the 'Total System' control shall be done through the dedicated communication link to limit any current surge in the supply line.

An indication lamp marked ready will be provided. The lamp shall be OFF if the dedicated communication link is busy for any one of the fan selections. The system shall only accept a new selection when the 'Ready' lamp is ON.

A key switch shall be provided on the Manual Fail Back Control Panel which acts as the authorization switch for the operation the tunnel jet fans.

6.47 LOCAL CONTROL

The fans will be capable of being individually operated manually at the services switchboard located at portal building and ECPs. Under this operating mode, the selection switch on the I services switchboard shall be set to local. An alarm will be generated when a fan is selected at local.

The contractor will ensure that the changeover from one ventilation control mode to another will be smooth, taking into consideration current fan settings and permitted fan switching sequences.

6.48 FAN BREAKDOWN OPERATION

In the case of a fan breakdown, the defective fan will automatically be put out of service without affecting the operation of the corresponding shall be provided to select the operation of any combination of the fan groups.

The CMCS will log the time of fan breakdown and display it on the VDUs in the central control room. The CMCS will set the fan group which includes the defective fan to a operating priority..

A fan group with one or more fans in the _local' mode will also be assigned a lower operating priority.

6.49 CALCULATION OF OPERATION HOURS OF FAN GROUP

In order to correctly assess the operating hours of a fan group after an incident such as isolation of a fan for maintenance, operation of individual fan or rearrangement of a fan group, the CMCS shall be capable of recording correctly the individual operating hours of each fan.

A subprogram will enable the operator to define the operating hours of a fan group as:• Total operating hours of all the fans in a fan group; or

Average operating hours of all the fans in a fan group.

Once a fan group is defined and the definition of fan group operating hour selected, the software will calculate the fan group operating hours. These values shall then be used in the determination of fan group operation routine.

6.50 EMERGENCY OPERATION PROCEDURE S

The contractor shall provide emergency ventilation operation procedures in conjunction with other tunnel emergency systems. The Tunnel Operator shall coordinate all system requirements.

Sufficient ventilation is required for tunnel emergencies where a vehicle fire occurs inside the tunnel.

The Tunnel Operator shall turn off all running fans by entering a -System Off command.

The location of the fire site shall be confirmed via linear heat detection system, CCTV, incident detection system or emergency communication facility within the tunnel.

The Tunnel Operator shall then operate the emergency ventilation system according to the pre-programmed schedules for smoke control mode.

6.51 ELECTRICAL

All electrical equipment will be designed, supplied, installed and commissioned in accordance with the Electrical Systems Performance Specification.

6.52 CORROSION PROTECTION

Guide to the protection of iron and steel against atmospheric corrosion by the use of protective coatings (or BS EN 13361/ISO 9223-ISO 12944).

Separate dissimilar metals in all moist locations by a 3mm air gap or 1.5mm red rubber, or polythene insertion. Isolating ferrules and washers having an electrical resistance not less than the jointing material will be fitted to all bolts and fasteners.

Fastenings shall have a corrosion resistance equivalent to the parts fastened and shall be of the same or more noble metal or alloy. Surface coatings subject to damage during fastening operations are not acceptable.

Welding of corrosion protected surfaces will not be permitted.

Metal surfaces in contact will be cleaned and primed before assembly except as otherwise specified.

Manufacturer's standard finish will be accepted where this conforms to good trade practice and no other direction is gene elsewhere in this document.

Metal surfaces to be embedded in or in contact with concrete will be degreased and hand cleaned.

Where practicable, metalwork will be painted in the factory before dispatch. Blast cleaned surfaces will be fully primed before delivery to site.

Areas where painting would affect the operation of the plant, such as on machined surfaces, will be given one coat of temporary corrosion inhibitor.

Treated surfaces will be adequately protected against damage during all handling operations. Surfaces inaccessible after installation will be completed painted before installation.

Dry film thickness reading will be checked using Mikrotest gauges to ensure specified film thickness has been applied.

Defective or damaged surface coatings will be cleaned and repaired in accordance with treatment originally specified.

The performance of the paint material used for jet fans, will be similar and will not emit toxic fumes or smoke when exposed to a hot air.

6.53 NOISE AND VIBRATION GENERAL

The systems shall be installed to be quiet in accordance with the design criteria and in accordance with accepted practice and the requirements of local and Statutory Authorities. Acoustic treatment and vibration isolation devices shall be provided to ensure that no discrete frequencies or broad range noise or vibration enters occupied spaces at levels with may cause annoyance.

6.54 STRUCTURE BORNE NOISE AND VIBRATION

The transmission of noise and vibration to the structure shall be minimized with the following requirements being met.

6.55 BALANCING

Fans shall be balanced so that the out of balance does not exceed 0.7mm gram for fans, having wheel diameters less than 750mm or 1.3mm gram for fans 750mm and over, when connected for normal operation.

6.56 EQUIPMENT MOUNTINGS

Mountings shall be located to prevent excessive equipment motion, particularly on start-up. Mountings shall be easily visible and accessible for inspection and maintenance. When the mountings are carrying the static load, there shall be a clearance of not less than 50mm under the base.

6.57 RUBBER IN SHEAR TYPE

Mountings shall be of neoprene bonded to the metal housings or bases. Housings shall be provided with bolt holes for fixing as appropriate.

6.58 PAD TYPE

Pad type mountings shall be ribbed neoprene waffle type minimum thickness 8mm as particularly nominated.

4.7 PAINTING AND LABELING

The jet fans shall be supplied with a shot blast and zinc spray finish, with any painting necessary to be done locally on site.

6.59 GENERAL

Except where otherwise specified herein, the external surfaces of all equipment, and services including supports, ductwork and brackets installed in the works will be painted.

All surfaces to be painted will be properly prepared, prime coated and undercoated and then finished with two finishing coats. Each coating (including priming, undercoating and the first finishing coat) shall be allowed to dry and will be rubbed down and stopped before the next coat is applied. Painting will not be done in unsuitable weather.

Painter's Plant and Equipment: All painter's plant, tools, gear, steps, trestles, scaffolding, dust covers, masking etc. shall be provided as necessary for the completion of work and for the protection of the finished work.

Masking and Protection: Finished surfaces adjacent to work being painted will be masked and/or protected wherever this is necessary to avoid defacement.

6.60 SURFACES NOT TO BE PAINTED

Chrome plated and stainless steel surfaces;

Bearing surfaces, slides, adjusting screws and any surface that is required to be unpainted for the correct operation or adjustment of the equipment;

Flexible rubber mountings;

Proprietary manufactured equipment that has been finish painted in the factory.

6.61 PAINTED MATERIAL

All paint and other preparations will be best quality, non-poisonous, lead-free prepared synthetic products of approved brand, conforming to the relevant Indian Standard, brought onto the site ready mixed in the manufacturer's sealed containers and used to the manufacturer's specification.

6.62 SURFACES PREPARATION AND PRIME COATING

All surfaces will be thoroughly dry, cleaned down, free from weld splatter, burrs, dust, rust, cement and grease and prepared to proper manner to all.

Metal surfaces will be thoroughly wire- brushed to remove loose rust and scale casting will be either ground smooth or alternatively filed with approved filling compound and rubbed to a smooth finish.

Steel plate and all rolled steel section including brackets and support not specified to be galvanised, will be given an application of cold phosphating compound before being prime coated with red zinc chromate primer.

All galvanised or zinc sprayed steel surfaces and all non-ferrous surfaces will be given an application of PVB/Zinc chromate self-etching primer or similar before being prime coated as specified above.

Machinery, apparatus, equipment and fittings delivered to the site already prime or finish painted will be thoroughly cleaned down.

6.63 LABELING

All fans, silencers, instruments, gauges, indicators, control equipment, contactors, circuit breakers, switches, starters, relays and cable terminals on switchboards, etc., installed as part of the works , will be clearly labeled and identified.

Labels, except where otherwise indicated, will be of laminated plastic with neatly engraved upper-case black letters on a white background. Plastic labels shall be attached by screw fixing.

Punch machine type strip lettering and stick-on markings will not be permitted.

Lettering, except where otherwise indicated, will not be less than 12mm high for large plant items. Lettering for items installed in switchboards and on control panels will not be less than 3mm high unless otherwise specified.

All major items of plant will be provided with stainless steel nameplates riveted on each item in a conspicuous place. Nameplate data shall include fan flow m3/s, fan total pressure (Pa), manufacturer's model, manufacturer's serial number, rated voltage, phase, rated motor power (kW), pitch angle, temperature rating, and date of manufacture, design speed, name and address of manufacturer.

7 ELECTRICAL SYSTEM

7.1 INTRODUCTION

7.1.1 EXTENT OF WORK

7.1.1.1 HV EQUIPMENT

HV system consists of the followings:

Design, supply and install and commissioning Switchgear for the project substation location appropriate to the site conditions complete, at facilities area including all metering, disconnectors, circuit breakers, protection and control, main transformer and auxiliary (facilities) transformer at Portal including and at power supplying substation of local authority (as required) all poles/structure, wires, landings, OHL to U/G transitions, trenches and related equipment.

Design, supply and install 11KV switchgear at the portal .

For the redundancy purpose a 11 KV ring connection shall be made from a portal technical building to another portal technical building connecting to all tunnel transformers via 11 KV RMU provided inside the tunnel.

Design, supply and install suitable dry type transformers located at the tunnel portals. Design, supply and install 11KV switchgear at both ends of the tunnel in the portal buildings.

Design, supply, install and termination of 11KV cable connecting above mentioned 11KV switch gear.

Design, supply and install Ring Main Units (RMUs) and 11KV/0.4KV dry type transformers

Design, supply, install and termination of 11KV cables connecting RMU's together and to the 11KV switchgear at portals.

Design, supply and install lightning protection system to outdoor buildings and portal areas.

Design, supply and install earthing system for equipment inside the buildings and tunnel.

7.1.2 LV EQUIPMENT

Design, supply and install Main Switchboards, Ventilation Motor Control Centers, related control system and associated switchboards in the Switchgear Room.

Design, supply and install power factor correction units and related control systems.

Design, supply and install all plant and tunnel distribution boards, related control system and telemetry systems

Design, manufacture, factory test, supply, install and commission the emergency diesel generators and related control system and telemetry systems, these include:

Design, supply and install of Gensets (Diesel Generator Set) alongwith adequate exhaust and supporting structure as per CPCB norms.

Design, supply and install uninterruptible power supply (UPS) units and associated UPS distribution board.

Design, supply and install surge diverters on the main switchboards.

Design and supply Pump-station distribution, motor control and telemetry equipment Design, supply and install surge reduction filters.

Design, supply and install harmonic filters.

Design, supply and install the manual fallback ventilation control panels and related telemetry systems. Additional Cables and Associated Supports

Design supply, install and terminate sub main cables or Bus Bar Trunking from the supply transformers to the main switchboards.

Design, supply, install and terminate sub main cables form switch boards and control panels.

Design, supply, install and terminate power and control cables to/from UPS, surge diverters and surge reduction filters.

Design, supply, install and terminate all sub-circuit cables from UPS, plant and tunnel distribution boards.

Design, supply, install and terminate all power, control, monitoring and instrumentation cables to the tunnel ventilation system equipment from the motor control centers and Remote Control Units (RCU'S).

Design, supply, install and terminate all power and monitoring cables to the services building ventilation system motor control centers from the main switchboards, motor control centres and RCU's.

Design, supply, install and terminate all power and monitoring cables to the hydraulic system motor control centres from the motor control centres, main switchboards and RCU's.

Design, supply, install and terminate all power and monitoring cables to the fire system motor control centres from the motor control centres and RCU's.

Design, supply, install and terminate all power, control and monitoring cables to the Central Control Room located Fire Indicator Panel (FIP) and Emergency Evacuation and Intercommunication System (EVAS) panel.

Design, supply, install and terminate all power cables to the Sub-Fire Indicator panels, Sub- EVAS panels and deluge valves from the motor control centres and tunnel distribution boards.

Design, supply and install all cable support systems to above cables.

Design, supply and install any additional cable systems that may be required for the operation of the tunnel

7.2 IMPORTANT NOTE:

Where LV cables pass through the smoke duct or any part of the smoke duct, LV cables and optic cables will be housed in 120-minute fire rated cable ducts/trunking and include suitable mechanical protection.

Special attention will be made to joining sections of this ducts/trunking, entry into the smoke ducts, and terminations that are made within the smoke ducts that the 120min fire rating is retained.

HV cable will not be permitted in the smoke ducts.

The contractor will supply details of the intended duct/trunking and methods of closure and termination

7.2.1 LIGHTING AND POWER

- Design, supply and install the tunnel lighting.
- Design, supply and install the tunnel lighting control system.
- Design, supply and install the lighting for all buildings areas.
- Pump Stations for twin tube tunnels (both the tubes included).

- Facilities site and related services buildings near portal
- Design, supply and install the lighting for twin tube tunnels (both the tubes included), external lighting, cross passageways, and technical rooms.
- Design, supply and install exit signs and emergency lighting for tunnels, passageways and services buildings.
- Design, supply and install strobe lights at tunnel portals.
- Design, supply, install and street lights on approach of the tunnel portals.
- Design, supply and install miscellaneous power outlets throughout the tunnels and services buildings.
- Design, supply and install dedicated power outlets and permanent power connection to control equipment, monitoring equipment, instruments and alarm devices throughout the tunnels, services buildings and control building all rooms.
- Design, supply and install all equipment support structures

7.3 DIESEL GENERATORS SCOPE

The Contractor shall provide three numbers diesel generating sets of rating 415V, 750KVA each, complete with local control panel, automatic start/stop equipment and fuel supply system alongwith necessary pumps fuel tanks and day tanks.

The generators shall be of specification to be able to cater to the complete load requirement of the tunnels, the relevant portal building, cross passage and the tunnel under emergency conditions and/or a loss of external supply from state electricity board.

7.4 AMBIENT CONDITION

The generators shall comply with the following environmental design criteria: Max Temp: 50.0°C (to be confirmed prior to order)

Min Temp: 0°C (to be confirmed prior to order)

Air density - 1.2 kg/m3

De-rating considerations will be submitted by the contractor (with tender).

7.5 STANDARDS AND CODES

The generator shall comply with the requirements detailed in the latest revisions of the following standards. Where applicable.

IEC 60034 Rotating electrical machines

IEC 60085 Electrical insulation - Thermal evaluation and designation IEC60529 Degrees of protection provided by enclosures (IP code

ISO 1996 Acoustics- Description , measurement and assessment of environmental noise ISO3046 Reciprocating internal combustion engines

7.6 DIESEL ENGINE

The diesel engine shall be of the four-cycle, 1,500 rpm, solid injection,. The engine shall be suitable for operation on light diesel fuel and give satisfactory performance.

The engine shall be coupled to a 433 volt, 50 Hz, three phase, generator. The engine and alternator shall be direct coupled and mounted on a common bed plate and the bed-plate shall be isolated from the concrete floor by elastomeric type bearings.

The engine shall comply with ISO 3046, and the governing shall be Class 1. The governor speed droop setting shall be adjustable down to zero.

The generator water cooling system shall be air cooled. The Contractor shall describe the measures necessary to protect the cooling system from corrosion.

The hot cooling air from the engines and auxiliaries shall be exhausted to the outside of the building via suitable duct work and fans. Exhaust gases shall not enter the Diesel Generator Room. The exhaust system shall be fitted with a gravity closed flap or other means of preventing the entry of rain and vermin and the nesting of birds whilst the generators are not running.

Each engine shall be equipped with the following accessories:

- full flow lubricating oil filter
- fuel filters
- air filter
- fuel spill return
- exhaust piping and silencer
- Temperature high, shutdown switch (adjustable range)
- Lubricating oil pressure, shutdown switch (adjustable range)
- Over speed shutdown device
- automatic lubrication oil priming system (if required)
- gauge panel complete with the following:
- lubricating oil pressure gauge
- lubricating oil temperature gauge
- Tachometer.

The diesel engines shall be suitable for operation on one or more of the grades of fuel and lubricant available from local sources and the Contractor shall nominate the grades required.

7.7 GENERATOR

Each generator shall be of the double bearing, screen protected type, flange mounted, drip proof, and self-regulating, brushless excitation in accordance with IEC 60034.

The temperature rise of the generators shall comply with the requirements of IEC 60034. The insulation of the generator stator windings shall be Class F material, to IEC 60085.

Although the generator output will generally be closely balanced between the three phases, the possibility exists of this balance being upset due to single phase loads. The generator shall operate satisfactorily when supplying unbalanced loads.

The generator winding shall be star-connected and the neutral shall be solidly earthed to the earthing bus bar in the generator distribution board. Each end of the generator winding shall be brought out to separate terminals and they shall be arranged in a terminal box for convenient testing of the separate phases.

The generator shall withstand the mechanical forces at 120% of the rated speed for one minute under the condition of no-load and no-excitation without incurring any damage.

7.8 AUTOMATIC VOLTAGE REGULATOR

Regulation of the generator set with its automatic voltage regulator shall be such that, at all loads from zero to rated load, at any power factor between unity and 0.85 lagging, and at rated speed, the terminal voltage is maintainedas per latest standards.

The regulation shall also be such that with the generator set rotating under the control of the voltage regulator, the terminal voltage change shall be as per Latest guidelines

The automatic voltage regulator shall be of a type not inverting continuous pulsing of contacting devise (other than during periods of change and shall be fitted with an adjusting device which shall permit the regulated voltage level to be adjusted between +10 per cent and

-5 per cent from nominal voltage. This device shall be mounted inside the associated standby generator control cubicle. For a given setting of the voltage adjusting device, the response of the regulator shall be independent of frequency.

7.9 CONTROL, PROTECTION, ALARM AND INDICATION FACILITIES

The diesel generating sets shall be capable of starting automatically and be available for load within 30 seconds of the start signal being given. And also the control of the generators shall always be possible from local control panel. The automatic starting operation shall be initiated by the supply monitoring systems of the PMCS.

Manual operation of a generator shall be made locally at the front of the generator control cubicle. The generators will be run at least once a month in this mode to check starting and operation.

The Contractor shall provide and install the floor mounted, metal enclosed, generator control cubicles in the associated Generator Rooms. The cubicle shall contain all control, operation, alarm and indication facilities necessary for the satisfactory operation of the diesel generating set, including the following:

Excitation and voltage regulation equipment.
Manual and automatic control equipment.

Protection and alarm equipment indicating lights and instruments; and starting equipment.

All indicating instruments and control facilities (excluding voltage control) shall be mounted on the front panel. Controls for the voltage regulator and excitation equipment shall be located inside the cubicle. The generator control cubicles shall comply with IEC 60529 and IP54 and the general requirements.

All generator alarms and abnormalities shall be annunciated locally and shall input to the respective control rooms as part of the OMCS and PMCS systems.

Protection and alarm relays shall be mounted on withdrawable modules within flush- mounted cases located on the front panel of the cubicle. All fuses and terminal blocks shall be located on the side panels within the cubicle and shall be accessible from the rear door of the cubicle.

In the event of heavy fault on the engine or on a generator during operation, the diesel engine generator shall be shut down automatically and locked out to prevent re-start.

7.10 ACOUSTIC TREATMENT

The supply air and exhaust air system shall be acoustically treated to confirm with the acoustic requirements. The acoustic treatment shall be accommodated within the room envelope.

Suitable silencers shall be installed at the inlet point and within the air discharge ducting. The silencers shall be a weatherproof type, if exposed to the external environment.

Only proven and tested acoustic corrosion resistant enclosures shall be provided. Refurbished container type enclosures are not acceptable.

The Contractor shall submit a curve giving the calculated sound pressure levels in the vicinity of each standby generator, as a function of frequency (octave bands), and also weighted noise level according to ISO 1996. Actual noise level compliance shall be achieved by the Contractor during the commissioning period.

7.11 ELECTRICAL STARTING SYSTEM

A complete set of heavy-duty long-life batteries and battery chargers shall be provided for starting of the generators.

The starter batteries shall be a sealed lead acid type, voltage and minimum ampere-hour capacity as recommended by the generator manufacturer and suitable for the range of ambient temperatures.

The contractor will propose suitable methods of in-situ battery testing, under load conditions.

The batteries shall be mounted on or next to the generator set in a suitable galvanized metal cradle with vibration isolation. The batteries shall enable the generator set to be cranked continuously for a minimum period of 3 minutes.

The battery charger shall be mounted within the control cubicle. The battery charger input voltage shall be 230 volt 50Hz single phase fed from the

nominated switchboard and the output voltage shall be matched to the battery voltage.

The unit shall provide a constant potential D.C. output and shall compensate for load current and supply voltage fluctuations. The D.C. output stability shall be within ±1%.

The charger unit shall be capable of carrying the load and shall be matched to the recommended charging rate of the battery. The charger output shall automatically regulate the trickle (float) and fast (boost) rate depending on the charged state of the battery. The charger shall be self- protecting against overload and short-circuiting of the output.

7.12 FUEL SUPPLY SYSTEM

The fuel supply systems shall comply with relevant Standards and shall include the following:

Day tanks with one underground tank of adequate capacity and automatic replenishing system with redundancy for each generator to be provided by the Contractor. The tank shall be complete with a level indicator, pump motor start/stop level switch and fuel level high/low alarm level switch and gauges. The tank shall be sized to provide a minimum of 24 hours fuel to the generator based on continuous operation at full load.

Fuel supply lines between the day tank and the engine and Fuel spill return between the engine and the daily service tank shall be provided.

All embedded piping work shall be of SS and exposed piping of carbon steel as per relevant standards.

The Contractor shall provide the first fill of diesel fuel for the day tank plus any fuel required for commissioning tests.

Bulk diesel fuel storage tanks and associated pumping equipment and connections to the day tank is be specified by the Contractor .

7.13 ANCILLARY EQUIPMENT

In addition to any ancillary equipment the Contractor may recommend, the following shall be provided for each standby generator:

Protective guards around exposed rotating parts.

A monorail, fixed to the roof, passing over the engine and generator and a manual hoist of sufficient capacity for handling engine & generator parts for maintenance.

7.14 POWER CONNECTIONS

All connections between the generator and the associated portal building switchboard shall be supplied and installed by the Contractor. The design shall allow for parallel operation of the two generators.

A main earth copper bar shall be installed in the diesel generator room. All earthing and bonding connections between the diesel generator, its auxiliary equipment and the earthing bar shall be supplied and installed by the contractor

Control & Indication Connections

The Contractor shall supply suitable transducers and connections for interfacing of the control function, indications and measurement of electrical quantities, temperature, etc. necessary to monitor operation of the diesel generators with the PMCS (Plant Management Control System).

7.15 TESTS

Tests and Inspections at the Place of Manufacture:

Tests of the complete generating set shall be performed in accordance with the relevant Standards and shall include tests under actual load to demonstrate compliance with the Specification. The tests shall include a temperature rise test at rated load.

7.16 TESTS & INSPECTIONS AT SITE

- Tests and inspections on Site shall include:
- Check of mounting, connections, etc.
- Check of fuel lines, pumps, valves, exhaust system
- Insulation resistance of generator windings and circuits
- Operation and setting of control and protection devices
- Power circuit phasing and rotation
- Operation sequences and times for simulated supply failures and restorations
- Proof of AVR operation by switching on and off of available loads
- Temperature rise test at rated load, with the generator synchronized to the 433 V system
- Full load rejection test

Load acceptance test by switching a load equal to the full load of the relevant portal building and nearest cavern transformer onto the unloaded diesel generator.

7.17 UPS AND BATTERIES

7.17.1 GENERAL

Uninterruptible Power Supply (UPS) system shall maintain uninterrupted power to equipment continuously and during power failure. Dedicated UPS shall be provided for emergency lighting, exit signs and all essential services in the tunnel, escape culvert lighting.

UPS shall be provided to supply the following equipment:

- Emergency tunnel lighting, exit signs and strobe

lights Computer system including:

- Both control centres
- All Remote Control Units

- All sensors and associated control

equipment All traffic control equipment, including:

- Variable message signs
- CCTV and surveillance system
- Advisory signs
- Loop detectors and vehicle height detectors
- All traffic lights
- Motorist emergency telephones
- Public address system
- Radio rebroadcast system
- Diesel generator control interfaces to other switchboards
- Fire detection and alarm
- Building access control

UPS shall be installed at Portal Control building, , ElectricalElectrical cross passages The rating of the different UPS shall be sufficient to supply the connected loads for the specified backup period. The UPS for the emergency and exit sign lighting shall ensure uninterrupted power supply for a minimum period of 2 hours. The essential services UPS shall ensure uninterrupted power supply for a minimum period of 90 minutes.

The UPS system shall consist of (1W+1S) module for redundancy purpose. The UPS modules shall be located within a fully enclosed, free standing, system cabinet which shall contain automatic parallel output power terminals and an integral wrap around maintenance by pass switch.

For a parallel configurations single points of failure shall be eliminated where by each UPS module is autonomous, incorporating individual active components such as Power Units, Static Bypass Switches, CPU's, Control Panels and Separate Battery Sets. All UPS modules shall operate simultaneously and equally share the load without utilizing a centralized static bypass switch or system control module.

The static type UPS shall consist of the following components:

- 6 pulse rectifier/charger
- Static inverter
- Internal automatic bypass
- Microprocessor controlled logic and control panel with status indicators
- Digital metering display
- RS232/485 interface port UPS cabinet
- Input and battery circuit breaker

- Sealed maintenance free batteries Battery cabinet or stands
- DC cabling between UPS and batteries
- DC isolator
- External maintenance bypass switch, wall mounted enclosure
- AC cabling between UPS output and maintenance bypass switch
- Control cable to maintenance bypass switch (status indication)

7.18 STANDARDS AND CODES

The UPS and batteries shall comply with the requirements detailed in the latest revisions of the following standards, where applicable.

60950-1 Information technology equipment - Safety- Part 1: General requirements IEC 62040-1 Uninterruptible power systems (UPS) - Part1: General and safety

requirements for UPS

IEC 62040-2 Uninterruptible power systems (UPS) - Part2: Electromagnetic Compatibility (EMC) Requirements.

IEC 62040-3 Uninterruptible power systems (UPS) - Part 3: Method of specifying the performance and test requirements.

EN 61000 Electromagnetic Compatibility Standard (EMC)

BS 6290-2 Lead-acid stationary cells and batteries. Specification for the high- performance positive type

7.19 UPS RATINGS

The full connected load shall be a maximum of 80% of overall UPS rating at a power factor of 0.9. UPS shall be capable of starting up the connected load solely on the supply from the Inverter. This is to allow for peak inrush currents associated with the switching of certain types of lamps from cold start.

The ratings of the UPS system shall be suitable to the system requirements, however tentrative rating are as follows: :

- 200KVA with 120 minutes backup for both portal buildings and ECPs
- control rooms 150KVA with 90 minute backup

7.20 UPS SYSTEM INPUT

Nominal input voltage shall be 433V ac, 50 Hz, three phase, 4-wire plus earth. Operating input voltage range shall be +10% continuously to -20% of average nominal input voltage. Frequency range shall be ±1 Hz.

UPS module shall have a minimum power factor of 0.9 lagging at full load and nominal input voltage and frequency. UPS module input and output current total harmonic distortion (THO) shall be no greater than 5% at full load and nominal input voltage and frequency. Magnetizing inrush current of the UPS module shall be limited to no more than 80% of the full load rectifier input current.

7.21 UPS SYSTEM OUTPUT

Nominal output voltage shall be 433V ac, 50Hz, three-phase, 4-wire plus earth. Steady state voltage regulation shall be within ±1% of the average of the nominal output voltage.

Manual output voltage adjustment shall be ± 5% of the nominal output voltage. Transient voltage response of the UPS output shall be within ±3% of the nominal output voltage for a 100% load step, full load retransfers and full load transfer to battery supply.

The transient voltage recovery time for the UPS module shall be no more than 5mS to within

+2% of the nominal output voltage.

UPS output shall remain synchronized with the input voltage over an input frequency range of± 1.0 hertz.

The free running frequency regulation shall be ±1.0% hertz

The frequency slew rate of the inverter shall be no more than 0.1 hertz/second.

UPS shall have an output voltage harmonic distortion of less than 5% THO (2% for any single harmonic) for 100% linear load, typically 10% THO at 100% nonlinear load.

While maintaining voltage regulation the UPS shall have an overload current capacity of 150% for battery duration specified with normal input voltage and fully charged battery.

UPS module shall have a fault clearing capacity of 200% for 10 cycles.

UPS module shall have a make before break static switch transfer completed in less than 2 m/sec.

UPS shall be capable of supplying full rated load power into a linear and nonlinear load. Protection shall be provided against:

- Over current
- Over voltage
- Over heating

7.22 UPS BATTERIES

The battery type shall be maintenance-free vent regulated sealed suitable to the heavy discharge requirements of a UPS system. Batteries shall have a guaranteed life expectancy of at least 5 years. The final minimum discharge cell voltage at full UPS-load shall be limited to

1.66 V. Nominal battery float voltage shall be 2.25 V per cell. All necessary battery mounting corrosion resist frames or corrosion resist cubicles to accommodate the batteries shall be provided.

For single UPS modules the battery system shall consist of a minimum of 2 parallel strings of multiple cells. Each individual parallel string shall have its own dedicated

means of electrical protection. For multiple UPS module connected in parallel the battery system shall comprise of a separate battery set for each individual UPS module. Each separate battery set may consist of one protected string of multiple cells. If two or more parallel strings are used then each individual string shall have its own dedicated means of electrical circuit protection.

The battery shall have adequate capacity to allow the UPS module to operate at full road unity power factor for a minimum period of 2 hours for emergency lighting and 30 minutes for control equipment. Battery charging current shall be limited to prevent battery overcharging. Battery shall be recharged to 90% of capacity within 10 times the actual discharge time. The batters shall be series connected to get the required de voltage and shall be insulated from earth and any supply conductor and shall be protected at its source.

State of batteries including reserve capacity shall be sent out though the fibre optic data cables to the PMCS for monitoring.

Battery housing shall be in accordance with the enclosure specification, free standing.

Battery rooms shall have proper ventilation system installed and shall not have any build- up of hydrogen or acid fumes.

7.23 UPS STATIC BYPASS SWITCH

UPS module shall contain a fully rated, high speed solid state transfer device. UPS module shall initiate an automatic uninterrupted transfer to bypass for the following conditions:

- Output overload period
- Critical bus voltage out of limits
- Over temperature period

Provision for uninterrupted manual transfer from UPS module to bypass supply shall be available from the UPS control panel. UPS module shall be capable of performing an automatic uninterrupted retransfer whenever the inverter is able to assume the load. UPS module shall inhibit automatic uninterrupted retransfers for the following conditions:

When transfer to bypass is activated manually. UPS module failure.

All static bypass switch transfers and retransfers shall be inhibited for the following conditions:

Bypass voltage out of limits (±10% of nominal). Bypass frequency out of limits (±1 Hz). Bypass out of synchronization.

- Bypass phase rotation /installation error
- The bypass shall be manually energized using the control panel or remotely through a building alarm input.

7.24 UPS CONTROL

UPS module shall have full automatic control through the use of microprocessor controlled logic. Start up and transfer functions of the UPS module shall be an automatic function.

UPS module shall include the following status indicators on the panel and shall be extended to the control centre PMCS SCADA for monitoring:

- System Normal (green)
- Alarm (red)
- Low Battery (red)
- Battery Discharge (red)
- Output Overload (red)
- Sync loss (red)
- AC input failure (red)
- Over temperature (red)
- Shutdown Imminent (red)
- On Bypass (red)
- Inverter Failure (red)
- Battery Fault (red)

UPS module shall have a single on/off control and alarm contacts for any abnormal connection detected UPS shall have a serial interface to the SCADA system located at the control center for status and condition monitoring. UPS module shall have digital panel meters capable of displaying the following and a serial communication facility for sending information:

- AC input voltage
- AC input current
- AC input frequency
- DC battery voltage
- DC battery current
- AC inverter output voltage
- AC inverter frequency
- AC load current.

7.25 UPS MECHANICAL DESIGN

UPS shall be housed in freestanding sheet metal cubicles and the batteries shall be housed in freestanding corrosion resist cubicles or stands.

Refer to section of the specification on control panel construction for details of cubicle construction and size. UPS shall be designed with forced air cooling.

UPS and battery cubicle shall have non-removable warning plates indicating that hazardous AC and DC voltages are present. Rating plate(s) shall be permanently attached to the front of the cubicle. All major subassemblies shall be modular and replaceable from the front or the top of the cubicle. Provide sufficient room for cable entry and termination within cubicle.

7.26 AMBIENT CONDITIONS

The UPS system shall be designed to operate continuously at full load without degradation of its reliability, operating characteristics or service life in the following ambient conditions:

- UPS ambient temperature range 0°c to 50°C
- Battery ambient temperature range 20°c to 25°C
- Relative Humidity 5 to 95% non-condensing allowed

The UPS system shall be designed for operation in altitudes up to 300m within the need for de-rating or reduction of the above environmental operating temperatures.

7.27 SURGE DIVERTERS & SURGE REDUCTION FILTERS GENERAL

Surge reduction filters and surge diverters shall design to protect electrical apparatus from high transient voltage and to limit the duration and frequently the amplitude of follow-current. The surge diverters and surge reduction filters also shall comprise coordinated protection against transients caused by lightning strikes, power switching, standby generator switching, capacitor switching and load switching.

7.28 SURGE DIVERTERS

Surge diverters shall be provided for all main switchboards primary protection. The surge diverters shall protect low voltage switchgear, control equipment, and downstream surge reduction filter.

7.29 SURGE REDUCTION FILTERS

Surge reduction filter shall be provided for all control and monitoring system connected distribution boards. The surge reduction filter shall protect electronic apparatus, including computers and communications equipment.

7.30 STANDARDS AND CODES

The surge reduction filters and surge diverters shall comply with the requirements detailed in the latest revisions of the following standards, where applicable.

IEC 61643-1	Surge protection devices connected to low-voltage power distribution
systems.	
IEC 61000	Electromagnetic Compatibility Standard (EMC) IEC 60099 Surge arresters
IEC 62305	Protection against Lightning

Performance Current rating shall be determined by the contractor and characteristics shall be similar to the nominated value.

7.31 DISTRIBUTION PANELS (DP) SCOPE

Distribution Panels (DP) shall be provided in the electrical cross passages and the portal buildings (LV Switchgear rooms). Panels and associated components shall comply with all relevant standards and shall be fully type tested.

Panels shall provide power distribution for tunnel and room lighting, small power, control and monitoring equipment and emergency power.

7.32 STANDARDS AND CODES

The distribution panels shall comply with the requirements detailed in the latest revisions of following standards where applicable

IEC 60085 Electrical insulation - Thermal evaluation and designation IEC60364 Low-voltage electrical installations

IEC 60439 Low-voltage switchgear and control gear assemblies IEC 60529 Degrees of protection provided by enclosures (IP code) IEC 60947 Low-voltage switchgear and control gear

5.1.2 OTHER ELECTRICAL SERVICE REQUIREMENTS STANDARDS AND CODES

IEC 60034 Rotating electrical machines

IEC 60085 Electrical insulation - Thermal evaluation and designation

IEC 60470 High-Voltage Alternating Current Contactors and Contactor-Based Motor Starters

IEC 60529 Degrees of protection provided by enclosures (IP code)

IEC 60947 Low-voltage switchgear and control

BS 546 Domestic AC power plugs and sockets

The electrical services shall comply with the requirements detailed in the latest revisions of the following standards, where applicable.

7.32.1 POWER OUTLETS

7.32.1.1 INTRODUCTION

The following minimum level of Power Outlets shall be provided:

Area	GPO 5A	Single Phase 15A	Three Phase 5A	Supply
Fan Room	-	2	1	Emergency supply
Control Equipment Rooms	-	2	-	Emergency supply

Control Room	-	2	-	Emergency supply
Training and Incident Management	-	2	-	Emergency supply
Archives stores	-	1	-	Normal supply
Offices	-	1	-	Normal supply
Staff Room and kitchen	-	2	-	Normal supply
Sewers / WC	-	2	-	Normal supply
HVACS	-	2	1	Emergency supply
Transformer room	-	2	-	Emergency supply
Switchgear room	-	2	-	Emergency supply
Maintenance Room	-	6	1	Emergency supply
DG Rooms	-	2	-	Emergency supply
DG Store Rooms	-	1	-	Emergency supply
Transfer Rooms	-	2	-	Emergency supply
LV Rooms	-	2	-	Emergency supply
UPS Rooms	-	1	-	Emergency supply
Battery Rooms	-	1	-	Emergency supply
pumps room Equipment Rooms	-	2	1	Emergency supply
WSC	-	2	1	Emergency supply
Tunnel Distribution Boards	1	-	-	Emergency supply
All other room and corridors (every 10m)	1	-	-	Normal supply

Single phase and three phase power socket outlet of 16 Amp rating shall be provided inside the twin tube tunnels (both the tubes included) at every 250 meter and also inside every cross passage.

Power connections to all electrical equipment shall be provided with the appropriate suitably rated power outlets and isolation switch.

All computer, monitoring, alarm control equipment and racks with plug tops shall have a suitably rated dedicated power outlet which is connected .to the UPS emergency supply.

All power outlets shall be IP56 combination type, 5A single phase or 63A three phase.

7.33 GENERAL PURPOSE OUTLETS

Standard general purpose Outlets shall be 5A IA6A3 type D single pole switch, with 3 pin receptacle and the flush combination type for 15A type M. Moldings shall be impact resistant plastic colored differently for normal supply emergency supply and UPS supply in accordance with relevant standards. GPOs will be mounted into a recess wall box or within the escutcheon plate of the DP.

7.34 SINGLE PHASE POWER OUTLETS

Single phase power outlets shall be industrial surface mounted combination switch socket outlet and have a minimum rating of 5A single pole with 3 pin receptacle and flap lid with

safety interlock to prevent lid from being opened if switch is on. Outlet shall be complete with screw ring for holding plug top in position. Moulding shall be high impact polycarbonate IP56.

7.35 THREE PHASE POWER OUTLETS

The three phase power outlet shall be rated to suit the connected equipment rating and shall be a 5 pin high impact polycarbonate weatherproof IP 56, surface mounted with flap lid and safety interlock and shall be complete with screw ring for holding plug top in position.

The connecting equipment shall be fitted with a plug top suitable to the power outlet.

7.36 PERMANENT CONNECTED EQUIPMENT

All Permanent Connected Equipment shall have dedicated isolation switches,- suitably rated for the equipment, location and function, complying with the relevant standards.

The isolation switches shall be of the impact polycarbonate weatherproof, IP56 rated and surface mounted type.

7.37 JUNCTION BOXES

All junction boxes shall have a minimum enclosure rating of IP 56D to IEC60529 and shall be fitted with terminals.

7.37.1 ACCESS CONTROL SYSTEMS GENERAL

A security and access system shall consist of a centralized control system for access and monitoring alarms and shall be provided to the buildings and tunnel equipment locations. Specifically the access control systems shall be provided in following facilities.

- Control rooms – Surveillance systems control, traffic management & control, Ambient air control room
- Electrical rooms
- Ventilation control building
- Fire pump room
- SCADA Control room

The features of the system shall include:

- 10% spare terminal inputs for future access inputs and alarms with a minimum of two inputs
- Programmable system
- Manual and automatic isolation of individual areas and field devices
- Report logging and retrieval facilities
- Setup for prioritized alarm handling
- Online data base Keyboard coding facility
- Integration of alarm single to PMCS
- Inputs shall include:
- Reed switches
- Status indicators, i.e. door locked or unlocked Motion detectors
- Keypad access for external doors
- Tamper switches shall be installed on the following:
- Data gathering panels
- Junction boxes and marshaling cubicles
- Card readers
- Detectors
- Siren enclosures
- Panel enclosures

7.38 ACCESS READER

Access reader shall be interfaced w h electro-magnetic door locks. Security door shall only open when the access reader acknowledges an input or the when the opposite side of the door handle is operated. All external keypad readers shall be

vandal resistant and weatherproof (IP66). Reader shall have fully operational LED indication and buzzer.

7.39 REED SWITCHES

Reed switches shall be concealed or surface arrangement type with the concealed type used on single and double leaf doors. The switches shall be press fitted into recess in the door and door frame. The switch shall be mounted in a box recessed into the door frame head only. The magnet to operate the switch shall be concealed by recessing into the door head. Reed switch and associated conduits shall not be surface mounted.

7.40 MOTION DETECTORS

Motion detectors shall be a dual technology installed on walls or ceilings. Wall mounted type shall be a Wormald Dualtec motion sensor DT-4405 with swivel mount or similar. Ceiling mounted detectors shall be a Intel -Sense motion sensor 5030 or similar. Detectors shall be located so as to minimize false alarm generation and shall not be directed or mounted in such a manner as to be affected by air vents, heating equipment etc.

7.41 SIREN AND FLASHING LIGHT

A siren and flashing light shall be located external to the building near main entrance and shall be housed in a vandal resistant and weather proof enclosure. The enclosure shall be located at least 4 meters from ground and in an open area which is not easily accessible.

Internal sirens shall be provided in the main corridor area only and shall have a different pitch compared to other installed fire sirens.

Exit action shall be via a single action free handle on the door. Micro switch in the electric strike shall be utilizes to communicate with the control system and to exit shall not activate the door alarm

7.42 DOOR RELEASE DEVICES

Emergency door release unit shall unlock the door to allow unimpeded electrical from building. The door release shall consist of a pushbutton switch mounted in a recess impact resistant flush plate. The unit shall be monitored by the security alarm system directly to indicate unit has been activated.

Interface- Interface to the DCS shall be provided and all alarm signals shall be transmitted. Electric door strike shall have the following features:

- An electric door strike at each access door which is interfaced with the access system
- It forms part of the door Jocking hardware
- Unlocks on energization and locks on the event of any failure
- Weatherproof and dustproof
- Withstands a pushing force of 2kN in the direction of door opening System Installation

Cabling and conduits to and from alarm and access system shall be concealed and mechanically protected. Security and access system shall have an alternate power supply maintained by batteries integral to the main controller and all security system equipment with a minimum period of 12 hours back-up power supply.

7.43 MOTORS SPECIFICATIONS

All motors shall be in accordance with latest guidelines and suitable for continuous running duty.

The starting current at full voltage shall not exceed six times full load current. Motors larger than 0.37 kW shall be of three-phase type. Motors smaller than 7.5 kW shall be suitable for direct-on-line starting. Motors 7.5 kW and above shall be provided with soft start or VSD facilities unless specified otherwise.

Motor rated outputs shall be at least 10% in excess of the continuous maximum power required by the respective driven equipment.

Materials and workmanship shall be of the highest quality. All motors shall in all respects be suitable for operation in the extreme site conditions.

Motors and auxiliary equipment shall be designed and manufactured such that no abnormal wear and no dangerous vibration can occur which will affect the steady operation of the complete set.

5.2 EARTHING SYSTEM

5.2.1 General

Contractor shall provide an earthing system for the tunnel and other related buildings in two portals complying with IEEE 80:2000 and IEC standard.

Electrical installations of buildings, meeting the required touch and step potential criteria.

- Earthing system shall be provided to the following:
- All exposed metal parts forming part of this installation.
- Metal conduits, frames, cable trays, trunking, metal pipes, steel handrails and ducts.
- Cable sheaths and armouring.
- Jet fan earthing.
- All HV and LV electrical equipment and switchboards.

All body of transformers and diesel generators shall be connected to the main earth electrode. Separate neutral earthing shall be provided for transformers and DG sets.

The tunnel earthing system shall also be interconnected with the earth grids.

5.2.2 MAIN EARTH ELECTRODE

Main earth electrode shall be provided by laying a continuous length of bare, tinned-copper stranded conductor in the base of the tunnel 0.5m below the bituminous

concrete and macadam surface, both side of the road. Both main copper conductors shall be connected each other at 100m intervals by exothermic joints

Size of the earthing conductor shall be finalized as per the actual resistivity of the project location by Contractor and submit for owner's approval.

Main water pipe and cable tray along the tunnel shall be connected to the main earth electrode.

The main earth electrode shall be connected to the reinforcement of the tunnel and escape tunnel.

Copper earth raisers shall be provided at each distribution transformers. The transformer and switchgear shall be connected by these earth raisers to the earthing system along the tunnel.

All joints shall be brazed, cleaned after brazing and bitumen coated after cleaning, to avoid corrosion.

Main earth Electrical shall be embedded in concrete, 0.5m below the finished surface and those electrodes shall be connected to main earthing electrode, run along the tunnel. Earthing rods of the portal earthing systems shall be installed in pre-drilled holes and backfilled with a conducting medium such as Bentonite clay/gypsum.

Earth raisers shall be provided to connect to the main protective earthing conductors.

5.2.3 PROTECTIVE EARTHING DISTRIBUTION

Protective earthing copper conductors shall be provided to the two portals. This protective earthing conductor shall be connected to the main earth copper earth electrode.

- Earthing conductors shall be included in:
- The supply cables to each distribution panel in the tunnel and
- Every outgoing cable from the distribution panels, and
- An earth connection shall be made to the frames of electrical equipment supplied from the panels an earth conductor shall be run with every sub main and sub circuit emanating from all switchboards. Earth conductors shall be run to all plug socket outlets, appliances, lights, cameras and equipment required to be earthed.

Earthing links shall be mounted on insulated non-hygroscopic panels, isolated from metal in the switchboard.

5.2.4 EARTH RESISTANCE MEASUREMENTS

At this stage earth resistivity is unknown, however it is required that resistance of the earthing system shall be below 3.5 ohm before interconnection with the the AUTHORITY substation earthing system.

The final Earthing design shall be subject to review and shall be approved by the Engineer.

5.3 ELECTRICAL SERVICES RETICULATION INSTALLATION SCOPE

The cabling reticulation system in the tunnel comprises LV sub-main power cables, final LV sub-circuit cables, fire detection and activation cables, CCTV cables, Plant Management Control system (PMCS) equipment cables and Traffic Management Control System (TMCS) equipment cables, Operation Management and Control System (OMCS) and other communication cables.

The cabling system shall generally comply with, maintaining circuit integrity after exposure to fire for 2 hours and with a mechanical protection against moderate impact and water spray. All cables shall be Low smoke halogen free to prevent the release of toxic or corrosive fumes under fire conditions.

Generally all essential services cables for sub-circuits, fire detection, activation/systems, communication and all other essential light and power distribution shall be halogen free insulated and 2 hour fire rated.

7.44 ELECTRICAL CABLES

11KV, LV power cables, control cables, optic and communications cables shall all be separated from each other by conduit pipe.

Low voltage service cables shall run from distribution panels to cables trays on both sides of the tunnel to provide power to equipment such as lighting and other equipment mounted towards the tunnel ceiling. The cable trays shall run in the vertical riser to the tunnel cable trench and conduits. Equipment mounted at ground level shall be supplied from the trench under the footpath.

Power for the cross passage lighting shall be distributed from the distribution panels connected to UPS to individual lights by mounting on the ceiling of the tunnel.

Power to External Lighting shall be distributed from the distribution panels in the portal buildings via .conduits in the footpath with access pit, no further apart than every 100m.

7.45 CONTROL AND COMMUNICATION CABLES

Redundant fibre optic cables for the control, monitoring and communication system shall run in conduits within the cable trench providing a connection between the RCUs/ RTDs and the tunnel control centers.

Fibre optic cables and copper multicore cables shall run from the RCU to other equipment through conduits in the cable trench under the footpath, cables trays and fire rated ducts in the smoke duct in a similar fashion to the electrical service cables.

All cables external to tunnel shall be reticulated in underground conduits with cable access pits at a maximum spacing of 100 meters.

For practical reasons overhead cable or possibly trough run cables will be required between the portals and the relative facilities areas for HV Power. The accommodation of communications sharing this overhead facility will be considered

7.46 STANDARDS AND CODES

The services reticulation installation shall comply with the requirements detailed in the latest revisions of the following standards, where applicable.

IEC 60085 Electrical insulation - Thermal evaluation and designation

IEC 60189 Low-frequency cables and wires with PVC insulation and PVC sheath IEC 60287 Electric cables - Calculation of the current rating

IEC 60352 Solderless connections

IEC 60364 Low-voltage electrical installations

IEC 60423 Conduit systems for cable management - Outside diameters of conduits to, electrical installations and threads for conduits and fitting

IEC 60439 Low - voltage switch gear and control gear assemblies IEC 60529 Decrees of protection provided bv enclosures (IP code)

IEC 61386 Conduit systems for cable tray systems and cable ladder systems IEC 61537 Cable management-cable tray systems and cable ladder systems IEC 62271 High- voltage switched and control gear

IEC 5308 Instrumentation cables

BS 6387 Specification for performance requirements for cables required to maintain circuit integrity under fire conditions

BS 6346 Electric cables. PVC insulated, armored cables for voltages of 600/1000 V and 1900/3300 V

7.47 CABLE REQUIREMENTS CABLE INSTALLATION

Cables shall be installed in accordance with latest Regulations and in accordance with the following additional requirements:

All cables used within the tunnel and approaches insulation and accessories will be Low Smoke halogen free.

Cables shall be installed in a neat and workmanlike manner free from kinks and unnecessary bends. The Contractor shall provide all necessary terminals, cable glands, ties, cleats, cable boxes and terminating facilities for the plant to which cables are to be connected and shall supply and install all facilities for the purpose of supporting cables.

Particular care shall be taken that the cable sheath is not damaged during installation. Any cable damaged during installation shall be replaced by the Contractor.

All cables shall generally be installed on cable ladders except where preformed cable trenches or ducts have been provided or cables are buried direct in the ground.

The cables shall be run concealed in conduits within the walls or run in surface mounted cable support system along ceiling, these include cable trays, conduits and galvanized metal ducting. In tunnels all cable supports shall be concealed behind wall panels, surface mounted within service zone of tunnel ceiling and within cable trenches concealed in conduits.

Unless otherwise approved by the Engineer power cables and control cables shall be separated physically.

Cables, cable enclosures and supports shall be located so that they do not obstruct doorways, passages, or any other space required for access through the tunnel, building or to equipment.

Where false ceilings are provided cables shall not be allowed to lie across the ceiling lining, but installed in cable support systems.

The bending radius of cables both during installation and the final set shall not be less than those recommended by the manufacture for the individual cable types and in no case be less than eight times the outside diameter of the cable

A minimum of 300mm clearance shall be maintained between low voltage power cables and extra low voltage cables, instrument cables, data cables and communication cables.

Segregation between non-essential and essential services cables shall be maintained.

7.48 SPECIAL REQUIREMENTS

Cable compounds shall, in addition to complying with the requirements of the Standards, be of the halogen free fire retardant type with reduced flame-spread properties and reduced emission of smoke, corrosive and toxic fumes.

7.49 POWER CABLES

The requirements for power cables shall apply to all cables for 11 KV, 433 V and 230 V ac service, as well as cables for 110 V, 48 V, 24V dc service which are frequently or continuously loaded to more than 20 per cent of the rated capacity of the cable.

Power cables shall be circular cables with copper conductors having not less than seven strands. Auxiliary power cables shall be XLPE insulated, steel wire armored with over sheath. 433 V cables with a nominal conductor area of 95 mm2 and above shall be XLPE insulated with over sheath. Power cables for 433 V or below (ac or dc service) shall be insulated, sheathed, 0.6/1 kV grade cables. Cables for direct burial and in the duct between the Facilities area and portal shall be steel wire armored and sheathed. The sheath colour of power cables shall be "electric orange" except that cables exposed outdoors shall have a black outdoor sheath.

The size of cable conductors for power cables shall be determined in accordance with IEC 60364, Electrical installations of Buildings, except that the minimum conductor size shall be 4mm2.

All power cables shall be spaced apart to avoid de-rating. In some areas it may not be possible to space the cabling to avoid de-rating, where de-rating is applicable cable shall be sized to include for de-rating losses.

Single-core power cables shall be installed in trefoil touching formation and the current rating shall be determined in accordance with IEC 60287.

Where armoring of single cables is required, the armoring shall be of nonmagnetic alloy

7.50 MULTICORE CONTROL CABLES

The requirements for multicore control cables shall apply to all cables for the control, protection, indication, instrumentation and alarm circuits, including cables from dc and ac. distribution boards where such circuits are loaded to less than 20 per cent of the rated capacity of the cable (for loading over 35 per cent continuously, these cables shall be regarded as power cables).

Multicore control cables shall be circular, copper conductor, insulated, sheathed, cables to BS 6346, or approved equivalent. Cables for direct burial shall be steel wire armored and sheathed.

Conductors of multicore control cables shall be adequately rated for the service conditions and shall consist of not less than seven strands. The minimum cross sectional area shall, unless otherwise specified, be 1.5 mm2

Untinned conductors may be used only with crimp-on terminal lugs.

Conductors for current transformer secondary circuits shall have a cross sectional area not less than 2.5 mm2 for transformers with I amp secondaries and 4 mm2 for transformers with 5 amp secondaries. Where the burden of the leads associated with the current transformers requires to be further reduced to ensure correct operation of the equipment under all conditions, a larger cross section shall be used. In these cases the required cross-sectional area of the conductors shall be shown on the circuit diagram.

For connections where screened cables are required the cables shall be bedded, screened over the bedding and served overall. The screen shall comprise a helical wrapping of 0.075 mm thick copper tape with at least 30 per cent overlap. The serving shall be identical to the cable sheath specified for unscreened cables.

The insulation of multi core control cables shall be light grey and each core shall be identified by means of black printed numbers repeated throughout the cable at longitudinal spacing of approximately 40 mm. The sheath shall be colored black.

Mineral-Insulated metal-sheathed (MIMS) cable shall not be used except where specified or approved by the Engineer.

7.51 MULTI PAIR INSTRUMENTATION CABLES

Instrument cables shall be copper conductor, twisted pair, aluminum foil screened, sheathed cables complying with BS 5308, or approved equivalent. If these specifications conflicts in any way with any of the referred standards and codes, British and International standards will take precedence over Indian standards. The sheath shall be colored black.

Applications shall be restricted to low signal and solid state circuits, and pairs shall be individually screened where required by the application.

Conductors shall be adequately rated for the duty and shall have a minimum of seven strands. The minimum cross-sectional area shall be 0.5 mm2.

If untinned conductors are supplied, crimp on terminal lugs shall be used.

7.52 COMMUNICATION TYPE CABLE

Communication-type cables shall be twisted pair, single tinned copper conductors, insulated, bedded, aluminum foil screened, served and overall sheathed cables conforming where appropriate to IEC 60189 and BS 4808. If these specifications conflicts in any way with any of the referred standards and codes, British and International standards will take precedence over Indian standards. Polythene insulation and sheathing may be used subject to the approval of the Employer.

The insulated conductors shall be uniformly twisted together in pairs with a right hand lay.

The direction of stranding shall alternate for successive layers, the first layer being right• hand.

Where fillers are necessary for satisfactory laying up of cable pairs they shall be PVC free and halogen free. The cables shall be made of the following standard numbers of pairs: 2, 6, 10, 20 or 50.

The identification of the manufacturer and the year of manufacture shall be printed on a plastic type tag beneath the sheath at not more than 1 m intervals.

The overall sheath shall be PVC free and halogen free and shall be colored black.

7.53 CABLE IDENTIFICATION TAGS

The Contractor shall provide and firmly attach stainless steel or non-ferrous identification tags 50 mm long x 12 mm wide to each cable. The tag shall be fixed longitudinally along the cable by binding with 1.00 mm or larger diameter copper or approved non-corrodible wire through end holes in the tag.

Each identification tag shall be stamped indelibly with the appropriate cable number in accordance with the cable schedules, the letters and figures being not less than 5 mm high. Cable Terminations

7.54 GENERAL

The termination of each end of each cable shall, unless otherwise specified, include the following:

Fixing the cable by an approved gland (or clamp for bottom entry into floor mounted indoor cubicles);

Fitting an approved Jug to each core (except spare cores);

Fitting an approved phase or polarity identification to each power cable core and identification ferrule to each control, indication, protection and alarm cable core; Connections to equipment terminals (except spare cores); and Fitting two approved cable identification tags to each cable end, one within the equipment enclosure and the other clearly visible outside the enclosure.

7.55 TERMINATION OF POWER CABLES

Where possible, phase identification of multicore power cables shall be self coloured cores. For cables where the cable cores are not self-coloured, the RYB phase identification shall be provided by insulated non-flammable heat shrinkable tubing colored red, yellow, blue and black (neutral), as appropriate. Cables shall be installed in accordance with IEE Regulations latest edition.

The Contractor shall ensure that ac cables are correctly phased and that polarity of dc cables is correct. Incorrect connections of power and control cables shall be rectified by the Contractor.

7.56 TERMINATION OF MULTICORE CONTROL CABLES

At both ends of each control cable all cable cores, except spare cores, shall be terminated on terminals. Each core shall be left sufficiently long and neatly looped to allow a fresh termination to be made should the original termination device break off. Where not enclosed in ducting the unsheathed portion of the cable shall be laced neatly with an approved non-- flammable cabling strapping.

Spare cable cores need not be terminated but shall be left sufficiently long to reach the most remote terminal strip in the enclose. Spare cores shall be loomed together and left neatly in the cable ducting inside the enclosure.

The Contractor shall provide and fit approved non-flammable wire-marking ferrules on each core of all multicore control cables. Spare cores shall be identified with the letter "S" followed by the cable number.

Where a separately mounted device to be connected cannot accommodate the specified cable or is not fitted with compliant terminals, the Contractor shall provide a junction box, complete with an approved type terminal block, adjacent to the device. The connection between the junction box and the device shall be made in PVC sheathed flexible steel conduit or screened flexible cord with a suitable cable gland.

Cable cores in multicore control cables shall be terminated using crimp-on cable lugs of the insulated type.

7.57 TERMINATION OF COMMUNICATION-TYPE CABLES

Where communication-type cables are terminated on stud type terminals the cable cores shall be terminated using crimp-on cable lugs or solder type cable lugs of approved make. Communication type cables terminating on pin type terminals shall be wire wrap terminations complying with IEC 60352.

7.58 TERMINATION OF CABLE SCREENS

Unless otherwise specified, the screens of screened cable shall be earthed at one end only. This shall generally be the end at which the signal originates. Shielded control and instrumentation cable shall be earthed at the end furthest from the main control/instrumentation equipment. For shielded cable using separate electrostatic and electromagnetic shields, the electrostatic shield shall be earthed at the end furthest from the main control/instrumentation equipment and the electromagnetic shield shall be earthed at both ends.

Earthing of copper screens shall be by means of wrapping three or more turns of 1.0 mm2 stranded copper earthing conductor over the exposed screen and making an effective soldered joint with the screen. The earth conductor shall be terminated at the equipment by means of crimp-on terminal lugs. All earthing conductors shall be insulated.

7.59 CABLE JOINTS

Cable joints will not be permitted, unless approved or where the length of the cable exceeds the maximum manufactured cable length, in which case cables shall be joined using the manufacturer's recommended procedure and equipment in accessible areas such as junction boxes or cable pits.

7.60 CABLE GLANDS

Cable glands shall be of the weatherproof compression type, and for outdoor locations shall be of non-ferrous metal. Cable glands for cables with an overall diameter over 20 mm shall be of metal. For single core cable, glands and locknuts shall not be made of ferrous metal.

7.61 UNDERGROUND CABLING

Cables to be laid underground shall be drawn into pipes or ducts where appropriate.

In all other places cables shall be laid direct in the ground at the following minimum depths:

Cables below 1 kV, 600 mm under roadways and 500 mm other locations. Cables above 1 kV rating, 700 mm at all locations.

Before any bedding sand is placed in the trench the excavation shall be submitted to the Engineer for approval. The lowest cables in a trench shall be laid in a 50 mm bed of sand. Sand shall then be added until the top of the uppermost cable is covered to a depth of 50 mm. Particular attention shall be paid to maintaining cable spacing's appropriate to the design cable rating.

Concrete or clay brick protective covering for cables shall be placed on top of the bedding and shall comprise either of the following:

Pre-cast concrete slabs of minimum thickness 38 mm and compressive strength 15 MPa minimum.

Concrete slabs cast on site of 100 mm minimum thickness

Clay bricks laid close together lengthwise for cables rated 1 kV or lower and crosswise for cables rated above 1 kV.

Cable marker posts for direct-laid cables shall be supplied and placed at intervals of 30 m to indicate the position of the buried cables and at every position where the cable changes direction. The marker shall be set in the ground to a depth of approximately 350 mm, directly over the buried cable

7.62 SUPPORT OF CABLES

All cables shall be provided with supports located as close as is practicable to the point of termination of the cables. Cables run on perforated cable trays shall be fixed with profile shaped saddles at spacing's between 150 mm and 300 mm as required to ensure a neat installation without sagging between saddles. Cables leaving cable ladders over the side rail shall be fixed to the ladder at the point from where they start to lift. Where cables drop over a ladder rung, the sharp edge shall be fitted with a smooth radius drop-out fitting.

Expansion of cable ladders and trays will be considered in the design and will be provided with expansion joints where appropriate.

7.63 SEALING OF OPENINGS

Where cables, including cables in ducts, trays or trenches, pass through a concrete wall, floor or ceiling or enter or leave pipes the space between the concrete or pipe and the cables shall be sealed with a fireproof sealing mixture of three-to-one by volume of granulated vermiculite and cement mixed with water to from a stiff mix, or other fireproof sealing approved. By the Engineer. Cabling through concrete floors into bottom entry cubicles is included in this requirement.

Cable pipes and ducts entering buildings and pits shall be first fireproofed with the seal described above then sealed with plastic weatherproof compound.

Cable trenches entering buildings and openings between building interiors and external cable pits shall, at the point of entry, have the fireproof seal overlaid with a weatherproof compound on the external side.

The seals around the cables shall be trimmed as required to give a neat appearance, and match-painted by the Contractor when forming part of painted concrete surfaces.

7.64 REMOVAL AND CUTTING OF TRENCH COVERS

Formed cable trenches for installation of cables shall be fitted with covers. Before commencing installation of cables, Contractor shall mark the covers to show their position on such trenches and where appropriate take those covers into safe keeping.

Immediately after cabling is completed the covers shall be replaced. During periods when installation is temporarily suspended, the trenches shall be made safe by replacing the covers or by other approved means.

Where necessary to permit the passage of cables, the covers shall be cut by the Contractor and lined in an approved way to prevent chafing of the cables.

Cable trenches shall be backfilled with suitable inert material to the approval of the Engineer Pits shall be of suitable box type, and shall form common wall with cable trench ends, complete with penetrations for each conduit/pipe including spares and future. Used and unused penetrations shall be sealed with removable seal prior to backfilling.

7.65 CONDUIT S/PIPES GENERAL

Metallic conduit and fittings shall be hot dipped galvanized to approved zinc weight.

Steel conduit shall be rigid screwed steel conduit with metric thread to IEC 60423. Joining of conduit by means of welding is not permitted.

Steel conduit fittings shall be made of malleable cast iron, except that flush wall boxes may be made of sheet steel.

PVC conduit shall be heavy duty conduit to IEC 60614 and be halogen free low smoke.

In tunnels the PVC conduits are acceptable where such conduits shall be buried in concrete with sufficient cover to attain the required fire rating.

The Contractor shall satisfy the Engineer that all metallic conduits are adequately protected against any corrosion which may arise due to wet conditions or otherwise.

Where wiring is to be concealed from view, the conduits shall be installed above suspended ceilings, embedded in concrete or chased in brick walls. The chasing of concrete walls and floors is not acceptable. Conduit chased in brick walls shall be covered by at least 10 mm of plaster.

The embedded conduits shall be hot dipped galvanized steel screwed conduit, the wall boxes to take switches and wall sockets shall be of a type suitable for the equipment proposed to be installed. Galvanised iron draw wires of 1.6 mm, diameter shall be left in all conduits. The embedded conduits shall be checked and cleared if necessary prior to or immediately after removal of formwork.

Junction boxes and draw-in boxes in concrete walls and ceilings shall be installed with the face of the box flush with the formed surface of the concrete unless otherwise approved by the Engineer.

In brick walls the bricks shall be cut neatly and the junction boxes shall be installed so as not to protrude beyond the finished surface. Each flush wall box shall be installed with its side horizontal and vertical to within two degrees of arc. Where two or more flush boxes are adjacent to each other the distance between them shall be not less than required for the satisfactory installation of the flush plates. Neither plain nor inspection type elbows and tees shall be used in the concealed conduit installation.

Conduits shall be installed to allow safe and easy drawing in of cables. Where conduits are bent, the inside radius of the bend shall not be less than six (6) times the nominal size of the conduit. Where more than the above numbers of bends are required an intermediate flush draw-in box shall be provided. Conduit runs in excess of 10 m shall also be provided with draw-in boxes.

Conduit exposed to view shall run parallel to the structural lines. Where surface mounted conduit crosses an expansion joint approved expansion fitting shall be provided.

Where embedded conduits run across expansion or contraction joints in concrete, a 1 m section of flexible steel conduit complete with connectors, shall be inserted across the joint. In addition the flexible conduit shall be taped with 2 layers of half lapped bitumen impregnated paper tape bedded in a bituminous undercoat. An alternative arrangement using expansion/deflection couplings will also be acceptable subject to the approval of the Engineer.

All screwed joints in embedded conduit shall be made watertight by sealing with a plastic weatherproof compound. Conduits shall be electrically continuous between conduit ends. All ends of conduits shall be reamed with a conical reamer and all burrs and sharp edges shall be

removed to prevent damage to the wire insulation.

All joints in PVC conduit shall be made waterproof by use of suitable adhesive compounds. Suitable moulded thread attachments shall be used for entry into equipment. Flexible expansion couplings shall be used to allow movement due to temperature variations.

The Contractor shall ensure that all embedded conduits and associated fittings are not damaged or displaced during the placing of concrete or the installation of reinforcing bars and embedded metal work and that the embedded conduits are kept clean of the ingress of concrete or mortar. To this end all embedded conduits shall be fitted with temporary caps.

Connections between embedded conduits and exposed conduits or cable troughs shall be made in an approved manner and in such a way that metallic and electric continuity is not impaired.

All surface mounted conduits shall be fixed in position with standoff saddles and screws, spacing the conduit approximately 5 mm off the surface at spacing's not more than 1.20m for steel conduit and 0.80m for PVC conduit.

The ends of conduits shall either terminate in a metal box or be screwed directly into a fitting.

Conduits shall be no smaller than 25 mm in diameter and 50mm within the tunnel cable trench and all external underground installations.

Connections between fixed conduit and electric motors, and other similar equipment shall be made by short runs of flexible steel, protected by a corrosion resistant non-toxic sheath conduit of sufficient length to allow full adjustment of the motor. Conduits shall be run from cable tray to equipment in general. No more than one power circuits shall be enclosed in one conduit.

It will be the responsibility of the E&M contractor to ensure pipes and conduits installed by the civil contractor are correctly installed without damage, kept clear of debris and that appropriate draw ropes sealing/draw clothes are in place.

7.66 FLEXIBLE CONDUIT AND FITTING

Flexible steel with a corrosion resistant non-toxic sheathed conduit shall be installed for all final connections to motors from isolators, to control equipment and where conduits are subject to change due to vibration.

Rigid conduit to control equipment shall be run to a junction box adjacent to the item of equipment, and thence in flexible conduit to the equipment. Flexible conduit connections shall be no less than 250 mm or more than 750 mm in length. Where isolating switches are required, they may take the place of the junction boxes.

7.67 CABLE TRAYS/LADDER GENERAL

Cable ladder systems shall be of an established design, complete with horizontal/verticle bends, tees, inside and outside risers and all the necessary accessories including splices, support brackets, hangers, clamps, etc. Double hanger rods or single centre rail supports are acceptable. If designs other than

standard known commercial types are proposed the Contractor shall show the adequacy of the design strength.

Cable ladders, and accessories shall be preferably manufactured from steel if manufactured from steel they shall be hot-dipped galvanized after forming and shall have rungs at a spacing not greater than 300 mm. Cable ladder rungs shall have slotted holes suitable for fixing cables with cable ties. The side rails of the cable ladders, and all bends, risers, tees and similar fittings shall have a rolled or double return top edge of at least 10 mm diameter (or width).

The loading of cable ladders shall in no case exceed the manufacturer's recommended design load. The span deflection of cable ladders shall not exceed the ratio of 1 in 200.

Provision will be made in the form of expansion joints on the cable trays, suitable to their total length. Each cable ladder will be individually earthed to common earth. Where intrinsically safe circuits or cables rated at different voltage levels are run the same tray they shall be separated by a steel divider strip.

7.68 PERFORATED CABLE TRAYS

Perforated cable trays shall be hot dipped galvanized trays with returned edges not less than 12 mm high, made from not less than 1.5 mm thick sheet steel. Trays shall be installed with the returned edges against the wall or ceiling surface. Cable saddles shall be fixed to the perforated cable trays with screws and nylon type nuts inserted from the cable side into the slotted holes.

7.69 INSTALLATION

Different services, including fire, communication etc, shall be run on different cable tray/ladders. A minimum of 300mm segregation shall be maintained between services cable trays and between cables. Cable from other services shall cross at 90° and a minimum of 150mm segregation on crossover shall be maintained.

Trays/ ladders shall be installed perpendicular/parallel with structural lines, with a minimum number of sets and bends, and fully supported over the entire width at intervals not exceeding 1 m. The maximum deflection occurring between supports shall not exceed 6mm with the tray/ ladder fully loaded with cables.

Trays/ ladder shall not be continuously mounted direct on a flat surface. Sufficient room shall always be allowed for air circulation around and throughout the tray/ ladder, and in any case shall not be less than 25 mm clear of such surfaces.

Air circulation around cables shall be a prime factor in determining the location of cable trays/ladders.

In locations where dirt and other foreign materials are likely to be present in sufficient quantities to foul the tray/ ladder, then the tray/ ladder shall be installed in a vertical plane, and supported on suitable brackets clear of fixed surfaces. These cables shall be cable-tied at intervals not exceeding 300 mm or closer as required to prevent sagging.

Cables run horizontally on cable trays shall be fastened to the tray at intervals not exceeding 1,500 mm using cable ties, where the cables enter or leave and in other locations where the cables may tend to be dislodged, such as at bends.

All fastenings must be a proprietary type made for this purpose.

Cables shall be laid parallel in trays and crossovers shall be avoided as far as possible.

Trays/ladder shall not be cut or deformed to form cable exit points. Cables shall leave the tray/ladder at an end, or over the side, and the end or edge of the tray/ ladder shall be suitably formed or protected to prevent damage to the cables.

Cable trays and ladders will be earthed at joins by means of 10mm min flexible earth cable or tray mounted earth clamp to ensure proper earth continuity.

7.70 SUPPORTING STEEL WORK

All supporting steelwork shall be of adequate strength and hot dipped galvanized

7.71 COVERS

Cables tray/ ladder covers shall be installed to all vertical and horizontal runs that occur:

Below ceiling within the building. Exposed areas outside the building within the tunnel (subject to approval, where no other alternative is available). Covers shall be of the same manufacture, matching the tray/ ladder, and fabricated from non-perforated sheet steel. Any fixing penetrations will be made prior to hot dip galvanizing.

7.72 CABLE DUCTING

Cable ducting for plant areas shall be constructed from minimum 0.8 mm thick for plant areas corrosion resistant mild steel or extruded aluminum. This excludes cable ducting for tunnel distribution boards, which shall comply with the requirements specified in the distribution board section.

The duct shall be flat, true and free from scale, rust, dents and blemishes. The duct shall be electro-galvanized.

Cable ducting shall be installed in horizontal or vertically true and straight runs with a minimum number of sets and bends and shall be provided with covers fixed by blunted corrosion resistant screws.

Cable ducting and support brackets shall be powder coated in the same colour to match the surrounding walls.

7.73 CABLE TRUNKING

Cable trunking shall be hot dipped galvanized steel trunking not less than 1.5 mm thick, complete with removable cover and cable retaining clips.

The cable trunking system shall be an established system complete with fishplates, bends, risers and other associated fittings.

All trunking shall be spaced off the surface using 5 mm PVC spacers, and fixed at least every

1.50 m.

There shall be no sharp projections into the cable trunk, only the heads of mushroom head screws shall be permitted inside the cable trunk.

5.4 TRANSFORMER SPECIFICATION SCOPE

All transformers must be appropriate for the high altitude and temperature range stated below.

7.74 AMBIENT CONDITION

All transformers shall comply with the following ambient design

criteria: Max Temp: 50^{0}C, Min Temp: 2°C

Height above sea level: 300m

Note: Dielectric strength of the air in such a high altitude is less than sea level. Such effect need to be taken in to account when external insulation is designed and tested. De-rating calculation needs to be carried out by manufacturer and approved by the client.

7.75 STANDARDS AND CODES

The transformer shall comply with the requirements detailed in the latest revisions of the following standards, where applicable.

IEC 60076 Power transformers

IEC 60137 Bushings for alternating voltage above 1000 V

IEC 60273 Dimensions of indoor and outdoor post insulators and post insulator units for systems with nominal voltage greater than 1000V

IEC 60664.1 Insulation coordination for equipment within low-voltage systems

Number of transformers shall be decided as per the actual load requirements.

7.76 SPECIFIC TECHNICAL REQUIREMENT

Type of installation	Indoor	Indoor	Indoor
Design Standard	IS-11171/ IS-2026/11	IS-11171/ IS-2026/11	IS-11171/ IS-2026/11
Location	At Portal	At Portal	In ECP
Number of transformers	4	2	6
Number of Phases	3 Phase	3 Phase	3 phase
Voltage Level	11/0.4 kV	33/11 kV	11/0.4 kV
Rated Capacity	1500kVA	6300kVA	800kVA
Vector Group	Dyn11	Dyn11	Dyn11

Frequency(Hz)	50	50	50
Impedance(To be confirmed prior to order)	As per standard	As per Standard	As per Standard
Cooling Type	Air Natural	Air Natural	Air Natural
Grounding	Solidly Grounding	Solidly Grounding	Solidly Grounding
Altitude of installed site	300 m above the sea level	300 m above the sea level	300 m above the sea level
Ambient Temperature	50^0C to 2^0C	50^0C to 2^0C	50^0C to 2^0C
Tapping	OCTC, +5% to -5% in steps of	OCTC, +5% to -5% in steps of	OCTC, +5% to -5% in steps of
Power frequency withstand voltage	As per Standard	As per Standard	As per Standard
Noise level (Acoustic)	Vendor specification	Vendor specification	Vendor specification
Ingress protection	AS PER IP 54	AS PER IP 54	AS PER IP 54

*Rated capacity needs to be de-rated by contractor based on the environmental condition provided in section three. The de-rating calculation shall be reviewed and approved by purchaser)

5.5 RING MAIN UNITS

5.5.1 Scope

This specification covers the design, manufacture and testing of Ring Main Units for a 11kV cable network system.

5.5.2 SYSTEM PARAMETERS

Nominal voltage	-	11KV
System highest voltage	-	12KV
System frequency	-	50 Hz +3%
Number of phases	-	3
Method of earthing	-	Solidly
grounded Short time withstand current (for 1s)		- 25kA

5.5.3 SERVICE CONDITIONS

Annual average ambient	-	27°C
Maximum ambient temperature	-	50°C
Minimum ambient temperature	-	2°C
Maximum relative humidity	-	90%
Operational altitude	-	300 above M.S.L

5.11.5 APPLICABLE STANDARDS

The equipment and the components supplied shall be in accordance with the standards specified below or later edition and/or amendments thereof.

BS 159 Specification for high-voltage busbar and busbar connections BS 6134 Specification for pressure and vacuum switches

IEC 60044-1 Instrument transformers - Part 1: Current transformer IEC 60056 High-voltage alternating-current circuit-breakers IEC 60071 Insulation Coordination

IEC 60071-1 Insulation co-ordination - Part 1: Definitions, principles and rules IEC 60071-2 Insulation co-ordination - Part 2: Application guide

IEC 60129 Specification for alternating current disconnectors and earthing switches IEC 60137 Bushings for alternating voltage above 1000 V

IEC 60265 High voltage switches

IEC 60298 AC. Metal-enclosed Switchgear and Control gear For Rated Voltages above 1 kV and up to And Including 52 Kv

IEC 60376 Specification of technical grade Sulphur hexafluoride (SF6) for use in electrical equipment

IEC 62271-1 High-voltage switchgear and control gear - Part 1:Common specifications IEC 62271-100 High-voltage switchgear and control gear - Part 100: Alternating current

circuit-breakers

IEC 62271-102 High-voltage switchgear and control gear - Part 102: Alternating current disconnectors and earthing switches

IEC 62271-200 High-voltage switchgear and control gear - Part 200: A.C. metal-enclosed switchgear and control gear for rated voltages above 1 kV and up to and including 52 kV

ISO 2063 Thermal spraying – Metallic and other inorganic coatings-Zinc, aluminum and their alloys

7.77 BASIC CONSTRUCTIONAL ASPECTS

The equipment offered shall be metal enclosed free standing for transformer mounted type.

The unit shall be provided with lifting facilities of proven design for easy handling.

The equipment shall be complete with necessary cable termination boxes; earth fault indicating device with current transformers, vacuum circuit breaker and disconnect or earthing switch with necessary safety interlocks and designed for minimum maintenance.

The mechanical design and strength of the unit and components shall be able to bear the mechanical stresses on the switch terminals when installed and in operation.

The equipment shall withstand the electro-dynamic forces without reduction of the switches reliability or current carrying capacity.

The main tank (inner enclosure of circuit breaker and ring main switches assembly) and all switchboard assembly shall be housed in a single compact metal clad suitable for either indoor or outdoor application.

7.78 INNER ENCLOSURE (MAIN TANK)

Main tank which will use for SF6 as insulation and quenching medium (vacuum is however preferred for quenching in CB's) shall be welded stainless steel. The pressure system shall be defined as a sealed for life system with an operating life time exceeding 30 years. The leakage rate of SF6 gas shall maintain less than 0.1 % per year. In order to guarantee a reliable and tight welding, manufacturer shall make sure all welding work is carried out by computer- controlled robots. An absorption material such as activated alumina in the tank shall be provided to absorb the moisture from the SF6 gas to regenerate the SF6 gas following arc interruption. A temperature compensating gas pressure indicator offering a simple indication shall constantly monitor the SF6 insulating medium. The degree of protection of the inner enclosure shall be rated IP 67.

7.79 VACUUM CIRCUIT BREAKER

The 3 pole circuit breaker for the protection of distribution transformers shall be enclosed in the main tank.

The manual operation of the circuit breaker shall not have an effect on the spring charging mechanism.

7.80 BUSHING

All the bushings shall be of same height, parallel, on the equal distances from the ground and protected by a cable cover. It is preferable to have bushings accessible from the rear side of the RMU.

7.81 CABLE BOXES

All cable boxes shall be air insulated suitable for dry type cable terminations. The cable boxes at each of the two load break switches suitable for HV cables up to 300mm2 and circuit breaker cable suitable up to 300mm2. The cable box shall be arc resistant as per IEC62271-

200.

The clearance between phase to phase and phase to earth shall be as per IEC 61243-5.

The cable termination and glad arrangements shall be appropriate for the type and style of cables used at the time. Deration and increased clearances due to altitude will be detailed by the contractor.

7.82 OPERATIONAL SWITCHES

The load break switches (isolator) for incoming and outgoing supply must be provided and must fully insulate by SF6 gas. The operating mechanism shall be spring assisted mechanism with operating handle for ON/OFF. Earth positions with arrangement for padlocking in each position. The earth switch shall be naturally interlocked to prevent the main and earth switch being switched ON at the same time. The selection of the main and earth switch is made by a lever on the face, which is allowed.to move only if the main or earth switch is in the off position. The load break switches should have the facility for future remote operation. Each load break switch shall be of the triple pole, simultaneously operated, non-automatic type with quick break contacts and with integral earthing arrangement.

7.83 EARTH FAULT INDICATORS/ FAULT PASSAGE INDICATORS (EFI/FPI)

These shall facilitate quick detection of faulty section of line. The fault indication may be on the basis of monitoring fault current flow through the device. The unit should be self- contained requiring no auxiliary power supply. The EFI shall be integral part of RMU.

7.84 CONTACTORS AND CONDUCTORS

All the contractors and conductors shall be of high standard and should be able to withstand the cool weather conditions. The cable shall be in accordance to the circuit diagram for the proper functioning of the connected equipment.

7.85 ANTI-CORROSIVE PREVENTION

The housing chamber interiors shall be cleaned of all scaled rust by shot blasting or any other approved chemical method and shall be coated with paint/enamel or suitable medium resistive to the electrical insulating medium adopted.

The exterior of the unit cleaned of all scale and rust by shot blasting or any other approved chemical method and shall be treated with zinc spray.

Every precautionary method should be taken to design and construct the unit for weatherproof against the service conditions indicated.

7.86 FOUNDATIONS

The floor fixing of the equipment shall allow for mounting on a simple rectangular plinth with a flat surface.

7.87 BASIC OPERATIONAL ASPECTS

The operating mechanisms shall be of independent manual type and shall be integral with switches and interlocks. The movement of any operating handle against an interlock shall not by any means originate, store or activate the energy mechanism.

7.88 PADLOCKING ARRANGEMENTS

The circuit breakers and switches can be locked in the open/closed or earth on position by 1 to 3 padlocks .

7.89 TESTING FACILITIES

It shall be possible for each of the functions on the RMU to be equipped with a voltage indication, to indicate voltage in the cables. The capacitive dividers will supply low voltage power to sockets at the front of the unit, an external lamp must be used to indicate active cables. Three outlets can be used to check the synchronization of phases with the use of an external device. This device shall comply with IEC 62271- 200.

7.90 REMOTE CONTROL OF THE RMUS

Remote operation of the RMU's line switches must be possible using motors fitted to the operating mechanism. It shall be possible to fit the motors either directly in manufacturing plant or on site when required. RMU shall fully energized when install on site and manufacturer should provide detailed instructions for installation to the control mechanism. The fitting of the motors to the mechanism must not in any way impede or interfere with the manual operation of the switches or circuit breaker.

7.91 EARTHING

7.91.1 METALLIC PARTS

There shall be continuity between the cast resin earth screen and metallic parts of the switchboard and cables so that there is no electric field pattern in the surrounding air.

7.92 NON-METALLIC PARTS

The cables shall be earthed by an integral earthing switch with short circuit making capacity, in compliance with IEC 60129. The earthing can only be operated when the switch is open. The earthing switch shall be operated through the main circuit mechanism and manual closing shall be driven by a fast-acting mechanism, independent of operator action.

5.11.6 QUALITY ASSURANCE

Quality Assurance system conforming to ISO 9001 shall be followed in the manufacturer of Ring Main Unit and the manufacturer shall furnish ISO 9001 Quality Assurance Certification Document.

7.93 5.12 LIGHTNING PROTECTION

5.12.1 Lightning Protection

This section specifies the minimum requirements for the provision of lightning protection system for the control building, portals and any other external structures such as telecom masts, lighting poles etc. outside the tunnel. The contractor shall design, make calculations, supply, onsite install, test and commission the lighting protection system in accordance with the relevant codes and standards.

7.94 STANDARDS AND CODES

The lighting protection shall comply with the requirements detailed in the latest revisions of the following standards, where applicable.

BS 6651	Protection of Structures against Lighting
IS 2309	Protection of Buildings and Allied Structures Against Lighting

7.95 LIGHTNING PROTECTION MATERIALS

Lightning Protection system shall include but not limited to air terminal; down conductors, earth terminations, joints, bonds, test joints etc.

8 LIGHTING

Tunnel Lighting shall be as per the MoRT&H Guidelines for Expressway, Chapter 13 for Tunnel lighting. Also for designing the lighting of tunnel please follow the IRC: SP:91.

8.1 LIGHTING

The contractor shall design, supply and install a complete lighting system of the Portal building. All luminaries, fittings and accessories shall only be proprietary type. The contractor shall lamps in all luminaries verify correct operation before completion. Emergency supply shall be connected to the lighting in the Portal Buildings.

Contractors shall provide the following:

1. Lighting switches.

2. Dimmers.

The contractor shall mount luminaires on proprietary supports by means of battens, trims, noggins, roses or packing material to suit the location.

The lighting system shall utilize fluorescent lighting with electronic ballasts. The lighting shall be designed to the following maintained lighting levels (lux) for the following areas:

Control room	500
Control equipment room/ Switchgear room	300
Offices/training rooms/ conference room	400
Kitchen	400
Amenities	200
Storage room	100
Plant rooms	200
Common space	100
Parking	100
Transformer room/ DG room/ Pump room	150
Workshop area/ Laboratory	250
Library and data storage	200
Bathroom	50
First aid / waiting room	100
Management Incident room / Tunnel Engineer	300

8.2 EMERGENCY LIGHTING

Design, supply and install a complete operational emergency evacuation lighting system, tested and commissioned in accordance with IEC/ISO standards for emergency lighting for the Portal Buildings and Central command and control Center.

Visual indicator lights: Provide a red indicator, readily visible when the luminaire is in its operating location, which indicates that the battery is being charged.

Inverter system: Provide protection of the inverter system against damage in the event of failure, removal or replacement of the lamp, while in normal operation.

Local test switches: Provide a momentary action test switch, accessible from below the ceiling, on each luminaire to temporarily disconnect the mains supply and connect the battery to the lamp.

Common test switches: Provide a common test switch on the distribution board which disconnects main supply to the luminaries and tests for discharge performance, after testing, this switch must automatically revert to normal operating mode.

Type: Lead-acid or nickel-cadmium batteries capable of operating each lamp at its rated output continuously at least 2 hours during completion tests and 1.5 hours during subsequent tests.

Battery life: At least 3 years when operating under normal conditions at an ambient temperature of 25^{0}C and subjected to charging and discharging at 6 monthly intervals.

Marking: Indelibly mark each battery with its date of manufacture.,

General: Provide an unswitched active supply to each luminaire and exit sign, originating from the test switch control panel.

8.3 POWER OUTLETS

Design, supply and install a complete power system for the Portal Buildings. All power outlets shall be connected to emergency supply.. Outlets shall be fabricated from impact resistant plastic with different colours to identify outlets on normal and emergency circuits. Outlets shall be the recessed flush type in office areas and the weatherproof impact resistant type in plant rooms.

Control room	As required but a minimum of 1 every 5m2.	Plug in type with captive lead for under floor application.
Control equipment	As required but a minimum	Plug in type with captive lead for under floor
Room	of 1 every 5m2.	application.
Offices/training rooms	As required but a minimum of 1 every 5m2.	Recessed flush type
Kitchen	10	Recessed flush type

Amenities	2	Recessed flush type
Store	1	Weatherproof type
Plant rooms	2	Weatherproof type
Circulation space	1	Weatherproof type
Parking	1	Weatherproof type

9 OPERATIONAL MANAGEMENT & CONTROL SYSTEM (OMCS)

Design, supply and install a Central Command and Control Centre, Plant Control and Monitoring System (PCMS), Traffic Control and Monitoring System (TCMS) and Operational Management and Control System (OMCS). The OMCS shall integrate the plant management and traffic management system into one supervised and comprehensive operational system in one Central Command and Control Centre.

This shall include all interfaces to the Fire Alarm Detection and Protection System, Emergency Evacuation and Intercommunication System, Telecommunication Systems, Hydraulic System, Security system, Traffic Control Centre (TCC) equipment, Operational Maintenance System, OMS.

Design, supply and install the Ventilation Control System which forms part of the OMCS.

Design, supply and install remote control units (RCU's) and Remote Terminal Units (RTUs) associated with the above system.

Design, supply and install Control Room desks, seats, terminals, colour printers and display panel, including all other necessary equipment.

Design, supply and install communication links via fibre optic cables to the tunnel and plant Remote Control Units (RCU's) and Remote Terminal Units (RTUs) from the OMCS.

Design, supply, install and terminate all control, monitoring, alarm and instrumentation cables associated with the OMCS, PCMS, TCMS RTUs and RCU's.

Design, supply, install and terminate all control, monitoring, alarm and instrumentation cables associated with the manual tailback ventilation control panels, including optical fibre communication links.

Design, supply and install all cable support systems associated with the above systems. Design supply and install all power supplies connected to UPS systems for the OMCS.

9.1 SYSTEM DESIGN

Tunnel operation shall be controlled from the central command and control Centre. The system shall automatically monitor and control all tunnel functions including ventilation, fire detection and protection, traffic incident management system. Full tunnel control shall be done from the central command and control center. A master and password protected access shall give the operator the rights for interventions to main or sub control center.

Tunnel overall control is subdivided into three systems. They are:

Plant Management Control System (PMCS).

Traffic Management Control System (TMCS)

Operations Management Control System.(OMCS))

These shall be achieved through a Distributed digital Control System (DCS) and PMCS, TMCS and OMCS form the sub control systems of the DCS. The platform used

for the DCS shall be fully compatible with all elements of control namely PMCS, OMCS and TMCS.

PMCS ensures a risk-free environmental for tunnel users, operators, local community and any amenities likely to be affected by the operation of the tunnel. This system shall be responsible for the remote operation and monitoring of all subsystems including ventilation, traffic, lighting; communication, CCTVs, radio broadcast, telephones, fire detection, power supplies, security and access control etc. The design shall be based on the current industry practice and also the choice of most up-to-date technology and equipment. They shall be configured with sufficient resources and computational power to meet the specified performance requirements and with 100% redundancy such that the systems design shall ensure that no single point of failure exists which may significantly degrade the availability of any of the basic critical functions.

TMCS shall consist of traffic control and incident detection system through traffic lights, boom gates, variable message signs, variable speed limit signs, traffic counting using loop detectors, vehicle height detectors, CCTVs, PA and radio broadcast, and motorist emergency telephones

OMCS integrates the plant - management and traffic management system into one supervised and comprehensive operational system. The system shall be supported by local control systems, where if failure occurs in the central or associated control systems, local controls shall be able to go into a manual mode of control causing an alarm. OMCS shall also be the main processing and data storage Centre for the tunnel operations.

The tunnel system communication network shall consist of a dual redundant data bus i.e., the two fibre optic communication cables shall run individually along the length of the tunnel to connect each of the remote equipment. Communication requirements for motorist emergency telephone system shall be by separate dedicated fibre optic or copper cables Fibre optic cables shall be installed in underground ducts of sufficient cover.

9.1.1 REMOTE CONTROL UNITS (RCU)

RCU shall be implemented with control logic in conjunction with the OMCS and TMCS. Each RCU shall consist of dual redundant PLCs (Programmable Logic Controllers) and dedicated control programs, field instruments and required interface, motor control units, lighting circuits, command validation, interlocks, data acquisition, multiplexers and fibre optic interface unit In addition to the intelligent features, RCU shall also serve as a data concentrator processor role.

9.2 THE FUNCTIONS OF RCU

Collect information from various sensors and alarm points.

Perform signal conversions such as analogue to digital and vice versa as required Output signals to various controllers and actuators.

Receive and send data to central control room through fibre optic cables Perform programmed functions and run independently if communication fails

Programmable Logic Controllers (PLC) shall be installed at control Centres and electrical niches to control, operate and monitor all tunnel equipment to the

specified requirements independently as well as from control Centre commands. Main and sub control Centres and all PLCs are linked by a Wide Area network (WAN) through redundant optic fibre cables. They also carry tunnel radio, service telephone and CCTV signals between respective equipment and control Centres. Control Centres shall have their own Local Area Networks (LAN) for data transfer between work stations, PLCs, printers, video displays etc.

All field equipment cabling from RCUs to individual items of plant shall be the fire rated type (minimum of 2hr fire rating). All field equipment cabling shall be either fibre optic cabling or the screened type.

9.2.1 CENTRAL COMMAND AND CONTROL CENTRE

Monitoring, manual and auto control of the entire tunnel operation shall be undertaken from Central command and control Centre. All tunnel equipment shall be able to operate automatically from this control Centre and same can intervene as and when required. Input/output (I/O) signals from PLCs are transferred to control Centre SCADA system (Supervisory Control and Data Acquisition) through the fibre optic cables.

SCADA system forms the nerve Centre of the OMCS. Both main and sub control Centres shall have identical SCADA equipment and configuration. Under normal conditions, only the main control center at one portal shall be manned.

The items provided but not limited to Central command and control Centre are:

- Control Desk with operator terminal
- SCADA
- Workstations, Printers
- Radio Control Panel
- Communication Panel
- Video Displays
- LAN and WAN

The design and specification shall require computer equipment to comply with open system standards. This shall ensure that there is no necessity to replace components with exactly the same make and type should this become necessary and avoid a permanent tie to the original equipment contractor.

This approach shall permit ready equipment upgrades as they become appropriate with the overall system design suitable for use for at least 20 years before complete system replacement is necessary.

The system software shall be designed to meet the requirement of the ultimate capacity of the OMCS SCADA system without further program development. Future additional equipment stations shall be added by defining their parameters interactively with the system generation/configuration software.

The importance of the control Centres requires high degree of system availability. In order to meet this requirement, redundant hot standby hardware and software support systems shall be provided and the system shall be designed to ensure that no

single points of failure exist which may significantly degrade the availability of any of the basic SCADA functions.

All operator functions and actions shall be interchangeable between any and all Workstations independent of which desk they are assigned to.

Both control Centres shall collect their data directly from the RCU/PLC stations. The contractor shall define exactly how the distributed database concept for the project will achieve data collection & synchronization between main and sub control Centres. Care shall be given to the status of the historical data and its source. During normal operation, the tunnel shall be controlled from the main control Centre and there shall be seamless automatic transfer of control to the sub control Centre should the main Centre become incapable of controlling the tunnel. The specifications of the system behavior to cover the different scenarios of a possible disaster shall be explained in detail by the contractor. The system shall be able to recover from the disaster to the normal regime of operation without loss of data or discontinuity of operation. It shall not be possible to control ally equipment from both control Centers simultaneously. Contractor shall state their method of ensuring that only one control Centre has control; and how the control is passed between Centres.

Although the two control Centres will independently collect data from PLC stations, they shall also be linked by the communications network to allow other data to be shared between the systems. This shall include the databases, system configuration arid operator entered parameters.

A plant layout based model shall be provided and be able to use information from the SCADA system. Tunnel remote equipment are located at ECPs and two control Centres and shall largely be implemented for remote control from the main and sub control.

9.3 BASIC SYSTEM ARCHITECTURE

The core SCADA system shall comprise proven non-proprietary hardware and an open software structure and shall require no further development work. Custom software may be appropriate to effectively implement plant management and incident.

SCADA system shall also become a major source of information to the network operator in all aspects of its business operations. SCADA system shall therefore establish a framework for information management. An open, flexible design is required that shall support all processes.

The control Centres perform alarm reporting, data and report logging, trending of measurements and historical archival of data. SCADA I/O requirements shall be estimated and this shall form the basis for sizing the SCADA system prior to making any provision for spare capacity.

The contractor shall carry out investigations, studies, calculations, design and documentation as necessary to execute the tunnel distributed control.

The scope of work shall include:

- Investigations and Studies
- Engineering and detail design calculations

- Preparation of drawings and other documents for manufacture, installation, testing, commissioning and operation/maintenance
- Factory testing
- Procurement and delivery to site
- Preparation of as-built documents including drawings and project records
- Supply of spare parts
- Training of personnel
- Provision of a specified defects liability period

The contractor shall propose a suitable arrangement to suit the equipment being offered provided the required functionality and availability is achieved. The contractor shall submit the SCADA architecture, WAN and LAN design, RCU design, I/O calculations, software, workstation and PLC hardware details to Engineer for approval before procurement. Contractor shall include block diagrams showing the type of equipment and arrangement proposed.

At the portal control Centres, the following equipment shall be provided on the SCADA LAN:

Operator Workstation	Dual screen workstation
SCADA application Services	Dual Servers
Historian server	Single Server
Remote Communications	Dual router/ communication interfaces
Printe server	Single server
Printer	Laser, 2 monochrome, 2 colour
Large display screen interface	Single video driver for large screen display
Time synchronization server	Server to synchronize network PCs

In addition, two desktop computers shall be provided for the control Centre office. Desktop software shall be provided. The desktops shall be connected to the control Centre LAN.

Two notebook PCs shall be provided for use as engineering support and diagnostic tools. They shall be supplied complete with all interfaces and cables to allow them to be plugged into the WAN, as well as directly into the equipment they support. The system shall consist of the south and north control Centres. They shall operate on a master/standby basis, but with distributed functionality so that the One main Control Centre at a portal normally controls the tunnel. The sub control Centre workstations at another portal shall replicate the main control Centre workstations which are on the same communications loop and shall normally be used only for monitoring.

9.3.1 SCADA HARDWARE REQUIREMENTS

The SCADA system shall be configured with sufficient resources and computational power to meet the specified performance requirements. Particular emphasis shall be placed on configuring a system with non-proprietary hardware and an open software structure. Replacement of any hardware with equivalent hardware of different manufacture shall have no effect on the operation of the system.

The system design shall ensure that no single points of failure exist which may significantly degrade the availability of any of the basic critical SCADA functions. That is, the failure of any one major system component shall not impair the ability of the system - to meet its performance objectives.

The system shall be capable of future growth with minimal disruption to existing hardware and software structures, including the database.

9.3.2 LOCAL AREA NETWORK (LAN)

A dual redundant high speed data network operating at speed no less than 100 Mbits/sec shall be provided and Ethernet network standard (IEEE 802.3) shall be used. The network shall be based on an open standard and shall not be proprietary. The access method for the network shall be Carrier Sense Multiple Access/Collision Detect (CSMA/CD) (IEEE 802.3).

All components connected to the network shall be able to access both LANs. However, the SCADA system shall be able to operate with only one LAN available. The interface between the components and the LANs shall be designed such that any failure of the components or its interface circuitry shall not disrupt the operation of the LANs. No single component shall be allowed to continuously access the LAN's for more than a specified time.

The medium used shall be fibre optic cable. Within the same building copper cables may be used. The cable shall be well protected against mechanical stresses, low smoke, halogen free and fire rated by installation underground in ducts. Two separate cable routes shall be sued for running the two LAN cables. The protocol for the network data interchange shall be the

Transmission Control Protocol/Internet Protocol (TCP/IP). No proprietary protocol shall be employed.

The SCADA LAN shall be extended to all RCU stations that are connected by dual redundant fibre optic cable to allow layar 3 routed messages to be sent between all locations over the communications SDH network. LANs and network devices installed at RCU stations shall be of rugged industrial construction, able to operate without error in an electrically noisy environment and able to withstand the tunnel environmental conditions.

9.3.3 WORKSTATIONS

Operator workstations shall: Present information in a clear and well organized manner highlight exceptional data and network states abnormal conditions through alarm and event warnings.

Have logical interactive operating procedures with short response times have a dynamic network coloring system to indicate status of equipment.

The operator workstations shall work independently or each other, but each shall have access to all SCADA facilities.

Be equipped with the latest technology Intel microprocessor, latest technology graphics cards, latest technology Microsoft Windows and office suite, 6G memory and 1TB or more hard drive.

Have 23 inch flat screen technology type display with highest commercially available resolution.

9.3.4 LARGE SCREEN DISPLAY

The contractor shall provide a large screen display as described in the CCTV section. The screen shall be minimum 2m x 2m size.

Comprehensive graphic diagram with different levels of details shall be prepared to show the real time status of any equipment being controlled and monitored. Alarms shall be displayed in an alarm list with time/date tags in chronological order. High and low priority alarms shall be displayed in different manners to attract the operator's attention to more import alarms. All alarms shall require acknowledge by the operator. To minimize operator input, global acknowledge facilities shall be provided. All events such as alarms status changes, operator commands, etc. shall be logged with time and ate tags in chronological order.

9.3.5 SYSTEM CLOCK

A Global Positioning System (GPS) time synchronization system shall be provided for each control Centre. The clock system shall provide Indian local time with a resolution better than 1 millisecond. The two GPS systems shall monitor each other's performance and shall have an alarm signal connected to their local RCU.

Synchronization shall occur through network protocol NTP, and shall have the facility to failover to the standby server upon alarm.

The system clock shall be used in all time tagging operations and synchronizing the time of the RCUs. If a Primary Reference Clock is supplied, it shall be used as the system clock. The system clock shall be battery backed. The battery shall enable the clock to operate for a minimum 24 hours without normal power supply. The computer system of the control Centre shall not drift more than 5 milliseconds relative to the system clock between time synchronizing. The clock system shall ensure that all control stations and RTUs do not drift by more than 5 milliseconds between time synchronizing.

A wall clock showing system time to the nearest second shall be mounted in each control room adjacent to the large screen display. The size of the clock display shall be large enough to be read from any of the operator workstations.

9.3.6 CONTROL CENTRE INPUT/OUTPUT

A local RTU (Remote Terminal Unit) shall be provided for each RCU for local interfaces such as building services, power supply alarms and general alarms.

9.3.7 MAIN MACHINE INTERFACE

The system in general shall provide the following operator functions:

- System shall interpret all operator commands and data inputs as well as acknowledge operator action
- Provide operator displays and messages, and printing
- Provide data recording
- Provide system maintenance and fault reporting facilities
- Provide operator override of automatic system
- Provide incident management in emergencies

All items of plant shall be displayed in a graphical manner. The graphical display shall be display all systems in their entirety. E.g. the ventilation system shall have all fans, sensors etc. displayed with status/control icons beside each item of plant. The Plant equipment shall be controllable via Icons, for e.g., electrical and ventilation equipment can be selected in single or groups and switched on/off or have their operational plans changed.

Menu driven activity selection for all equipment, subsystems or systems Scope of operator interface shall include the following but not limited to: Status reports

System status of:

a. Ventilation
b. All plant equipment
c. Electrical HV equipment
d. Electrical LV Equipment
e. Lighting
f. Fire detection, portable and fire water storage tanks, pumps, valves,
g. Traffic system equipment
h. Radio
i. CCTV
j. Telephones and motorist emergency telephones
k. Control functions for:
l. Ventilation
m. Lighting
n. Signage
o. Emergency evacuation
p. HV equipment
q. LV switchboards
r. Diesel Generator
s. Fire deluge and drainage

t. Traffic equipment

9.3.8 CENTRAL COMMAND AND CONTROL CENTRE FURNITURE AND FLOOR

A control desk shall be provided for each control Centre workstation. They shall be commercially available ergonomically designed furniture for computer workstations applications and shall have facility to adjust the height of keyboards and display screens.

The operator desk shall be fitted with:

- Workstation
- Voice communications facilities
- Office desktop computer

The office desktop computer shall match the equipment provided for the workstation. Gas-lift executive office chairs with side arms and five-way casters shall be provided for each control centre workstations.

A cabinet shall be provided in the control room on which the control Centre printers are installed. The cabinet shall include space for storage of manuals and printer consumables. One fire proof cabinet shall be provided in each control room for storage of software and backup tapes.

A computer access floor shall be provided to allow all cabling to be installed under floor. The floor shall be complete with floor supporting structure, floor tiles and all cable support structures and cable guides under floor. The control equipment room shall also be provided with a computer access floor.

All cabling within computer floor shall be installed on cable tray or in purpose made cable ducts.

9.3.9 REMOTE TERMINAL UNIT (RTU)

The Remote Terminal Unit (RTU) are the interface between the SCADA system and the field equipment at Remote control units. In general, PLC station RTUs shall comprise communications modules on PLC equipment. In some cases, a discrete RTU may be required. In this case, field equipment shall be connected to the RTU through a marshalling cabinet which has isolation facilities on its terminal blocks.

9.4 SCADA SOFTWARE REQUIREMENTS

The computing system architecture shall be structured with the following objectives:

- Open system computing environment
- Reliability and availability
- System performance
- Expandability

The hardware and software system shall be based on industry-accepted generic standards, issued or endorsed by independent international technical standards organizations or on de facto standards that have been adopted by multiple vendors and a large majority of users. Single vendors proprietary standards shall not be accepted.

Preference shall be given to system based on major international standards such a:

UNIX Operating system- conforming to IEEE POSIX Standard 1003.1, the AT&T System V Interface definition and the current revision level standards (SVR4).

Linux Operating System- conforming to Linux Base standard, and Red Hat Enterprise Linux version 3

9.5 MICROSOFT WINDOWS

International Standards Organization (ISO/Open System Interconnection (OSI) standards-7- Layer Computer System Architecture recommendations for Open System Interconnection

Networks Protocols- confirming to IEEE 802.3 and 802.4 or equivalent (Ethernet R and Token Ring R Local area Network Standards)

Transport level protocols: corresponding to TCP/IP transmission standards ISO standards for computer Networks ANSI Standard Sequential Query Language – SQL Interface for database management systems

The system supplied shall be based on modular hardware and software system components ensuring:

- Portability of software across diverse equipment platforms, ensuring hardware vender Independence
- Scalability of all system software to allow operation without alteration or reconfiguration on small scale system (desktop workstations) through to large computers
- Interoperability of hardware from different vendors on the same network as well as compatibility of third-party software packages on various hardware platforms
- Flexibility to easily locate hardware and software units at the point where they can be most effectively used and managed
- Reliability through network redundancy, client-server operations and distributed software
- The key emphasis shall be to ensure that parts of the system can be upgraded without disturbing the Integrity of the remaining items. The system shall have both vertical and horizontal upgrade paths with access to a wide range of third- party software applications

9.6 SYSTEM SECURITY

The system shall be implemented with multiple levels of security to prevent unauthorized access or malicious tampering. The operational SCADA network itself shall be segregated from external networks by a firewall set up with a policy. The historian server shall act as a buffer between the SCADA LAN and external equipment.

System shall be implemented to guard against malicious attack such as computer virusesetc .

All computers that access or log into servers on the SCADA LAN shall operate under a controlled environment whereby the only users permitted to install software are those with system administrator capability.

9.7 IT INFRASTRUCTURE

The SCADA system provided shall include all required IT services and supporting functions. The contractor shall set up and configure all network hardware and software that is provided so that it performs all the required functions. The contractor shall also reconfigure any existing equipment which is integrated into the SCADA network so that they interoperate correctly. The SCADA software shall include the ability to automatically send email to nominated addresses on the occurrence of defined events.

9.8 HISTORIAN SERVERS

A separate data historian server system shall be provided which shall store operational data for at least five years. It shall allow users to access subsets of the stored data on request in a variety of different formats.

The historian servers shall be arranged as a backup of the other such that failure of one server shall be transparent to the system and shall not cause any loss of data. Reinstatement of a failed or offline server shall cause the reinstalled server to be updated with all data missed while it was off line contractor may propose alternative redundancy arrangement for these server.

9.9 SCADA SOFTWARE CONFIGURATION

The system shall provide information storage, retrieval and display facilities. The storage facilities shall be in the form of a real time relational database management system, plus special modules for historical archival and retrieval to graphic screen based presentation displays.

SCADA system database shall preferably be based on the relational model optimized for real time system operation. SCADA system shall include a full graphic display system with a well-defined and consistent graphical user interface. All operator interaction shall occur via this facility. SCADA system shall automatically report abnormal conditions and alarms through a standardized alarm/event annunciation system. SCADA system shall include facilities for even Alarm logging, screen trending, recording and screen copying. SCADA software shall include facilities for power demand and ventilation fan schedule planning. These facilities may be custom modules rather than part of the proprietary software.

9.10 COMMUNICATION REQUIREMENTS

The communication system shall comprise

- SDH Fibre Optic Transmission System
- Network Management System
- SCADA Wide Area Network
- Closed Circuit Television (CCTV) Surveillance System
- Telephone System Facilities

The core communication for the tunnel is the fire detection & alarm fibre optic transmission system, which shall inter connect all ECPs and VCPs and control stations. Other communication media shall be used only where use of the SDH fibre optic transmission system is not practical.

Existing telecommunications system facility to the site shall be investigated and the tunnel communication equipment shall be linked. The contractor shall review the existing communication infrastructure and base the design on the Synchronous Transport Module (STM-16/4/1) telecommunications network.

Contractor shall provide details of the fibre cable (FOC) entry and exit to each control point. Contractor shall complete the FOC termination where necessary.

SCADA data communications network shall be designed according to the following criteria:

Each remote terminal unit (RTU) shall be connected to the control Centres via two independent circuits to ensure maximum reliability: a- main and a-backup circuit via the digital network.

At stations serviced by two or more independent fibre optic circuits, the interface with the RTU or station shall be digital, e.g. two 10 Mbit/s IEEE 802.3.Ethernet ports, with the option of adding a third asynchronous serial port.

9.11 NETWORK MANAGEMENT REQUIREMENTS

A complete telecommunications network management system (NMS) shall be installed at both Centres to provide real time monitoring of communications equipment parameters and alarms and facilities for collecting communication statistics. NMS shall be configured as a master NMS located at one portal and a standby NMS located at the another portal.

The NMS shall be based on workstation computers with graphic user type interface and text- based menu systems. The configuration shall ensure that the NMS is operational at all times. One of the three workstations at the south control Centre shall be designated as the main NMS workstation for this with full privileges at any time. A standby NMS workstation at the another portal shall have monitoring role when the south workstation is the designated master station.

The network management system shall be based on Open System architecture conforming to the ITU-T Recommendations M.3010 and G.784. The individual network elements shall be interconnected as a managed SDH sub-network.

9.12 SYSTEM BACKUP/REDUNDANCY REQUIREMENTS

The system shall be configured to ensure that no single point of failure can cause the loss of a critical function.

Critical functions defined for this system are:

- data acquisition
- data processing
- historical data storage
- supervisory control

- alarm/event processing
- network security subsystem

The system shall be provided with sufficient redundancy to meet the required availability figure and to avoid the loss of any critical function. The system shall use redundant power supplies, which shall be powered from two independent switchboards that are each powered by a separate UPS. Failure of one supply causes no loss of critical functions.

9.13 COMPUTER SYSTEM REDUNDANCY

Computer system redundancy shall be achieved by providing dual server computer configurations for SCADA application servers. Either of the two computers shall be able to sustain all server functions indecently of the other.

The IEEE 802.3 LAN cable and equipment shall be configured for circuit redundancy.

The contractor shall recommend their preferred configuration to meet the system availability specification (e.g. dual cable LAN, ring, linear or star topology).

9.14 COMMUNICATIONS REDUNDANCY

On failure of main communication path the software of the concerned subsystem shall automatically switch to the alternate path. The system shall periodically perform the polling of RTU/PLC on their alternate path in order to confirm the integrity of this path.

If valid data is not received from a data source in response to a scan command, the software shall issue another scan request for data from that source. If an invalid or no response occurs again then the RTU or data link is considered to have failed and this condition shall be alarmed. Additional details of the failure including the particular equipment or line that has failed shall be provided via the communications network management system.

If an entire source or its communication channel fails, individual points shall be marked in the database to indicate communication failure. In the event of communication failure, the SCADA shall retain in the database the last good value or status for any point experiencing such communication failure. For calculated data, the failure of any component data value shall not disrupt the continued processing of the calculated values using the failed point.

Operator shall be provided with the capability to substitute a value in the database for any point that is experiencing commutation failure. When communication returns to normal, the SCADA shall automatically resume updating the database with live data from the data source.

9.15 SCADA FUNCTIONAL REQUIREMENTS SUPERVISORY CONTROL

The system shall provide supervisory control functions via control commands to PLCs and RTUs. The control command shall be issued on a priority basis after the control request by the operator has been checked for validity and authorization. The assignment of a particular control type shall be defined on a point-by-point basis in the SCADA database.

The system shall be capable of issuing set-point commands after verification by the system. Verification to be performed includes comparison with nominated analogue values or digital status points as well as confirmation of control circuit continuity.

If the control action is inhibited, the system shall request revalidation of the action from the operator. If the revalidation is confirmed, the control action shall be executed and treated as system event. If the request is not confirmed, the system shall accept a revised target set- point.

All control operations shall be checked for completion. The system shall verify that the requested control action has occurred within a fixed completion time period. If the expected new status or analogue change is not detected within this period, a -control action failed to completel alarm message shall be annunciated. Each controllable device may have a different completion time period. The system shall accommodate at least 16 different time periods. The status change as a result of a control action shall be immediately initiated on receipt from the outstation.

9.16 OPERATOR/SYSTEM INTERFACE FUNCTIONS

This section describes the human/machine interfaced (HMI) functions required for the system. Typing activities required to execute functions shall be minimized.

The operator interface shall be via functionally identical workstations at each of the Workstations. All functions shall be capable of simultaneous utilization on all workstations. Any display may be presented on any of the system VDUs (Video Display Unit) at any one time.

The operator shall monitor and control the tunnel equipment at all stations through the use of on screen buttons via a cursor pointing device, keys on an alphanumeric keyboard and VDU displays with function activation points.

The Contractor shall provide a consistent graphical user interface (GUI), which maintains identical procedures from one application to another. The GUI shall allow the operator to switch from session to session without affecting the current operation in any session.

9.17 WORKSTATION MODES

Workstations shall be assigned to different modes in accordance with the functional requirements of the users. The workstation modes shall restrict the users to specific functions of the SCADA system.

Workstation modes shall direct alarm information only to those workstations where the alarm are required. The functions of alarm display and alarm control shall be independent and separately assignable to different workstation modes.

The workstation modes system shall be:

- System Operator Mode
- Training Mode
- Maintenance Mode
- Engineer/Programmer Mode

System operator mode shall provide only those functions, alarms and events applicable to the monitoring and control functions required for secure and reliable tunnel operation.

Training mode is generally identical to the on-line mode with the exception that all control functions are blocked for all points in the system. Control functions shall be allowed only to a designated test RTU. No modifications to the on-line database, displays, applications or system configuration shall be allowed in training mode.

Maintenance mode is a special mode used for testing stations or points that have been assigned by the operator to be in maintenance and are tagged

No modifications to the on-line data base, display, applications or system configuration shall be allowed in maintenance mode.

System Engineer/Programmer Mode allows access to all facilities of the system, except control functions..

9.18 ACCESS SECURITY

A password system shall be provided with a unique password for each user Each user shall be given an access privilege from among the 3 security levels which are user (level1), supervisor (level2) and administrator (level 3). For most users, the lower of the user or workstation privileges shall be assigned at logon.

The session —log-off‖ procedure shall cancel the current access privileges of the particular workstation; this is also applicable when during a session there is no input device activity for a set period of time resulting in automatic time out and log-off.

9.19 INFORMATION STORAGE AND RETRIEVAL

It is required that the SCADA system maintain a non-proprietary, open computing environment. Fundamental to this is a flexible, modern database structure capable of operation in a real time distributed computing system and supported by well-proven database management software.

The SCADA system shall include a group of information storage and retrieval functions to collect and store data periodically and on an event-initiated basis, and to provide facilities to retrieve, sort, analyze, display, and report the data. The data to be collected shall consist of measurement and status values that are communicated manually entered and calculated together with their associated quality codes, as well as alarms and messages. The SCADA shall provide data storage and retrieval using auxiliary memory and magnetic tape. Transfer of selected stored data to other computer systems shall be feasible.

The stored data shall be time and date tagged and shall contain sufficient information to enable the retrieval functions to access the data and quality codes. Stored data shall not be affected by any future database changes, computer system failure recovery, or regeneration of the computer system configuration. All stored data shall be accessible from any time period regardless of SCADA changes after storage of data.

9.20 HISTORICAL DATA COLLECTION

The historian facility shall collect SCADA data, store the data without loss of the detail for at least five years and present the data in various formats for clients to use. The stored data shall include values and quality flags.

The historian shall also store static reference data such as equipment ratings, lists of PLCs and RTUs and system documentation for easy access. It shall be possible to designate any SCADA database point for historical archival through a database point attribute.

9.21 SCADA DIAGNOSTICS

System Performance Monitoring Software

Facilities shall be provided to gather on-line statistics at specified time intervals about CPU utilization, CPU idle time, input/output waits, number of input/output transfers and other useful information to enable system loading and performance to be analysed. It is desirable that this gathering process can be initiated by the operator on a single shot or repetitive basis, and for a time interval variable in increments of 1 minute. The resultant statistics shall be suitably formatted on an operator-selected VDU screen, and it shall be possible to obtain a printout of the screen image.

9.22 HARDWARE DIAGNOSTICS

Diagnostic routines shall be provided to enable all hardware components to be thoroughly tested. Diagnostics should as far as possible present a logical and consistent interface to the user so that they are as simple to operate as possible. They shall be comprehensive and shall where possible provide printout of the test performed and the results obtained.

On-line diagnostics or exercisers shall be provided which enable limited testing to be performed on-line. Such diagnostics shall not disrupt the operation of the real-time system, but shall enable devices having a relativity low level of usage to be exercised periodically or on demand.

Off-line diagnostics shall be provided to enable hardware malfunctions detected by the operator or by the on-line system to be pinpointed. In some cases, e.g. for malfunction, the device will be failed either automatically or by operator action and a backup device will be used. In such cases the device may be switched to the backup computer and off-line diagnostics used to find the fault. In other cases, e.g. for main memory or bulk storage malfunctions, system failover may occur either automatically or as a result of operator action. In such cases the diagnostics will be executed in the previously on-line machine.

9.23 ENGINEERING ORDER WIRE

An engineering order wire facility shall be provided which provides communication between all control points on the optical fibre network.

10 TRAFFIC MANAGEMENT CONTROL SYSTEM (TMCS)

TMCS consists of the followings:

Design, supply and install two variable message Signs (VMS), one on each tunnel portal

Design, supply and install pairs of variable Speed Limit Signs (VSLS) every 250m for both traffic directions along full length of the twin tube tunnels (both the tubes included).

Design, supply and install Video Incident Detection System with cameras spaced at 60m staggered interval alternatively on both walls of the tunnel along the full length of the tunnel.

Design, supply and install CCTV surveillance system with PTZ dome cameras located in every electrical/pump niches, Cross passages & Technical building/rooms.

Design, supply and install an Emergency Telephone System along the twin tube tunnels (both the tubes included).

Design, supply and install a Public Address System with loudspeakers installed at a maximum spacing of 30m along the twin tube tunnels (both the tubes included).

Design, supply and install a Break-in to the Radio Rebroadcast Communications System.

Design, supply and install a tunnel closure system comprising traffic signals and boom gates at both tunnel portals

Design and supply and install traffic Management and Control System to monitor and control all the above systems and interface to the PMCS.

Install the Traffic Management and Control System main servers and two workstations in the one portal control room, back-up servers and one workstation in the another portal control room, and workstations at the remote control centre.

Design supply and install a fiber optic communications system to integrate the above systems.

Full documentation, Design Report, As-built drawings, Testing Plans and procedures, operation and maintenance manuals for all supplied equipment.

Testing and commissioning of all the above systems including factory acceptance testing for each component, integration testing, inspection testing, site acceptance testing and commissioning.

Operation and maintenance training for all the above systems

10.1 SCOPE

The OMCS shall include a TMCS to monitor and control traffic movements in the tunnel and on the tunnel approaches. The TMCS shall:

Respond effectively to emergency situation in the tunnel in the shortest possible time frame optimize the traffic flows to prevent flow breakdown that leads to congestion

Manage incidents effectively, through a comprehensive incident response system, to mitigate the impacts of incidents and prevent secondary incidents occuring

Provide creditable and timely drive information about traffic conditions and incident situations use standard internationally recognized protocols (NTCIP, etc.) for communications between the TMCS, PMCS and field devices.

Provide a secure interface for future integration with other control Centres using internationally recognized protocols (NTCIP, etc.) for communications standards.

Operate independently of all other systems including the PMCS and have separate server, RCU's I/O processors and data network throughout the tunnel.

Exchange data between it and the PMCS server to manage the integration of incident response and routine operation (e.g. maintenance closures, etc.)

On failure not adversely affect the operation of the PMCS

Be supported by secondary or manual systems to allow the TMCS to be safely operated in the event of a system failure.

Monitor traffic flows in the tunnel and on the tunnel, approaches using video incident detection (VID) system and alter the TMCS operator on the occurrence of a:

Stopped Vehicle's slow moving vehicle

Automatically select the appropriate camera to monitor an incident and switch the images to the defined monitors in the tunnel control room.

Monitor and control traffic control devices inside and outside the tunnel, including as a minimum:

a. Variable Speed Limit Sings (VSLS)
b. Variable Message Signs (VMS)
c. Automatic video Incident Defection (VID)
d. CCTV system including surveillance cameras
e. Boom gates and traffic signals for closing tunnel entries
f. Tunnel advisory sings
g. Traffic data loops

Control voice communications to motorists in the tunnel over a radio rebroadcast system and public address system

Provide data to a remote control centre workstations located approximately 1km from tunnel

Manage the interface to ad access by the backup system located at the northern portal for operator training purposes by simulating device changes on the workstation without affecting the actual tunnel device or other workstation operations

Provide logging and reporting of all TMCS functions

Contiguously collate operational data for long term traffic planning and operational and maintenance service implantation

Provide a comprehensive computer based control facilities through workstation using Windows 7 and map-based Graphic User Interface (GUI) to monitor, command,

Control and report every functional component of the TMCS and PMCS both locally in the tunnel control rooms and at the remote tunnel control centre.

Have an internationally recognized open system architecture using Ethernet backbone to allowing a plug and play approach to device connection.

Use proven system for both TMCS and PMCS that are operating in at least six tunnels in developed countries and have a track record for reliability and availability

Have an availability of 99.998%

As part of the development process of the system must comply with ISO/IEC 61508 functional safety of electrical/electronic/programmable safety-related systems and all other relevant IT, hardware and network development standards

The following system requirement specification must be produced that include all information on the TMCS and sub-systems including the field devices:

Software requirements hardware
requirements Interface requirements to
external systems

The design documentation for each component must include the following in the form of drawings and written documentation for all TMCS systems, sub-systems and field devices:

- Block diagrams
- Cableway and other signaling cableway route designs
- Data communications network design diagram
- Data communications description including TMCS interface
- Component breakdown description
- Overview and top level description of the incident management system
- Structure of workstation control philosophy
- Computer system software architecture and description
- Description of incident management system
- CCTV description
- Description of Remote control centre interface
- Description of workstation structure, display symbols, conventions controls and menus
  The design documentation shall be provided for the computer systems of follows:
- Functional specification
- TMCS operator interface (workstation GUI)
- Data tables for all databases
- Management information database for all TMCS systems, sub-systems and field devices
- Data sheets or proprietary equipment
- Description of operation
- Descriptive of drawings
- Existing technical specification

Design documentation shall be prepared, reviewed, certified and verified in accordance with the general conditions.

A test plan conforming to IEEE 829-1998 or AS 4006 or equivalent software test documentation or equivalent shall be produced. The test plan shall detail the overall test strategy for verifying and validating all TMCS systems, sub-systems and field devices.

Test specifications shall be produced that conform to IEEE 829-1998 or AS 4006 or equivalent software test documentation and shall be submitted to the client's representative no later than 40 days prior to actual testing of the TMCS systems, sub systems and field devices

All testing shall be witnessed by the Client's Representative

As built documentation for all TMCS, systems, sub-systems and field devices shall include:

Finalized design phase documentation all equipment specifications cableway construction drawings cable schedules

Final test specification with results and disposition of non-conformances.

10.2 STANDARDS AND CODES

The equipment and the components supplied shall be in accordance with the standards specified below or later edition and/ or amendments thereof.

ISO/IEC 12207	Information Technology - Software life cycle processes
ISO 31000	Risk Management - Principles and Guidelines
ISO/IEC 90003	Software Engineering - Guidelines for the application of ISO 9001:2000 to computer software
ISO 14817	Transport Information and Control Systems - Requirements for an ITS/TICS Centre Data Registry and ITS/TICS Data Dictionaries
ISO 9735 Series	Electronic data interchange for administration, commerce and transport (EDIFACT)
ISO/IEC 15846 TR	Information Technology-software life cycle processes-Configuration Management
ISO/IEC 17799	Information Technology- Code of Practice for Information security management systems
ISO 14813	TIC System Architecture
ISO/TR 25102	TICS System Architecture , ITS Use Case Performa Template
ISO 24098	Procedures for Developing ITS Deployment Plans Utilizing ITS System Architecture
ISO 25100	Intelligent Transport Systems - System Architecture – User Guide for Harmonization of Data Concepts

ISO25106	Procedures and formats of ITS Glossaries
ISO 20452	Requirements and a logical data model for PSF and API used in ITS database technologies and logical data
ISO 15662	Wide area communications protocol management information
ISO 21707	Data Quality
	National Transportation Communications for ITS Protocol/ NTCIP
ISO/IEC 61508	Functional Safety of Electrical/Electronic/programmable Safety-Related Systems and all other relevant IT, hardware

10.3 ELECTRONIC SIGNS INSIDE TUNNEL GENERAL

Three types of signs shall be provided inside the tunnel, these being:

- Variable Speed Limit Signs
- Variable Message Signs
- Advisory Signs
- All tunnel equipment suspended from the ceiling or supported from the walls of the tunnel shall comply with the following:
- minimum IP66 degree of protection
- all bolts, nuts, washers, screws and anchors shall be in stainless steel of grade 316 and installed for easily dismantling by tools or specialized tools for maintenance purpose
- all support beams, rods, hangers, lifting eyes and anchor bolts required for the proper installation and maintenance of equipment shall be designed and provided by the contractors

All monitoring instruments and power supplies shall be installed within the RCU enclosure.

Detailed technical data and a sample shall be submitted to the Client for review and approval prior to approval to purchase and install the signs.

All signs will be of a very high standard and quality, from an internationally recognized supplier with proven track record.

All sign controllers shall have an Ethernet connection to the communication network and communicate using an industrially recognized protocol such as NTCIP.

10.4 PHOTOMETRIC PERFORMANCE OF ALL SIGNS

The class designation of photometric parameters from EN 12966-1:2005 are summarized in table below:

Colour	C1, C2	C2 is the most restrictive
Luminance (La)	L1, L2, L3,	L3 has the highest luminance for specific situations
	L1(T), L2(T), L3(T),	These classes are for tunnel use
Luminance ratio (LR)	R1,R2,R3	R3 has the highest luminance ratio
Beam width	B1, B2, B3, B4, B5, B6, B7	B7 has the widest beam

All VSLS and VMS shall conform to the photometric class designations defined in EN 12966-1:2005:

- Colour class C2
- Luminance (La) class L3(T)
- Luminance ratio (LR) R3
- Beam width class B3

The Contractor shall provide evidence that the VSLS and VMS display complies with the optical and photometric performance requirements and shall submit to the Client's Representative evidence from an independent NATA certified testing laboratory.

10.5 VARIABLE SPEED LIMIT SIGN (VSLS)

Variable speed limit signs shall be installed within the tunnel and on the tunnel portals. The entire tunnel shall be able to operate a variable speed control zone. The VSLS shall be double sided providing a speed display for vehicles travelling in both directions along the tunnel. VSLS shall be located at no more than 250m intervals and mounted on both sides of the tunnel above the pedestrian walkway.

The VSLS shall comply with the requirements of EN 12966.

A VSLS shall display the regulatory speed limits that are operational throughout the tunnel, including speed limit variations that are required by the TMCS in response to incidents.

The VSLS shall be able to display the following speed limits and words:

10

20

30

40

50

60

70

80

- STOP

When the Tunnel Operator sets the word STOP to be displayed on the VSLS the red flasher lanterns shall flash. The flash rate and order in which each lantern flashes shall both be configurable.

VSLS shall be controlled by a single VSLS group controller that must synchronize the aspect control of the set of VSLS, ensure the same speed is displayed on both VSLS for any one direction of travel and must also control and monitor the VSLS at each location.

The VSLS shall monitor each pixel to that the actual speed limit displayed on the matrix is provided to the TMCS. The VSLS group controller shall be connected to the Communications Network to provide a highly reliable data communication with the TMCS.

The VSLS shall be remotely controlled through the TMCS. The TMC Operator shall be able to select an individual VSLS for a particular direction of traffic flow and change the speed limit. The TMCS shall have a set of configurable parameters whereby when the operator changes the speed of one VSLS the TMCS automatically change the speed limits on the upstream VSLS to match the new speed conditions.

The VSLS character height of the dot matrix used to construct the uppercase alphabet shall be a minimum of 240mm.

The VSLS red LED flasher lantern shall have a minimum diameter of 125m.
The VSLS annulus shall have:

A minimum of 4 rings of LED pixels An inner radius of no less than 237mm

The overall size of the VSLS casing shall sit over the pedestrian footway and shall not overhang the vehicle envelope.

VSLS shall use LED technology for the display and flashers. LED's shall be selected and graded at the source of manufacture to ensure uniformity of light output across all LEDs in the VSLS sign. LED used for the red flashers and red annulus shall be AlInGaP (aluminum Indium gallium phosphide type or of equivalent performance. LEDs for the white matrix display shall be InGaN (Indium gallium nitride) type or of equivalent performance.

The red flashers flash rate (i.e. on and off cycle time) shall be configurable from the TMCS with a default cycle time of 1 second.

VSLS enclosure shall be constructed from extruded marine grade aluminum and shall be suitably reinforced and/or braced to facilitate the erection and continued operation of the unit. All components including mounting brackets shall be non-corrosive in the tunnel environment. The external metal sections of the complete enclosures shall be painted matt black in a finish that will ensure that deterioration due to tunnel environmental conditions has no detrimental effect on the structural integrity or visual appearance which shall include colour fading of the finished enclosure for the life of the VSLS. The whole enclosure shall be weatherproof to IP65 and vandal resistant. Maintenance access to internal components of the VSLS shall be through the front panel. All components in the sign shall be modular and easily replaceable and quick to replace. AU cables used to connect modules within the VSLS shall be use suitable locking connectors that will not dislodge with the continuous vibration. Security locks shall be provided on the VSLS enclosure doors to prevent illegal access.

The supplier shall submit at least one VSLS enclosure for testing at certified testing laboratory to ensure that it meets the specified IP rating.

All VSLS shall be powered from the Essential Services Switchboards.

10.6 VARIABLE MESSAGE SIGN (VMS)

The VMS shall be a three-line type with a minimum of eighteen alphanumeric characters per line and shall be capable of displaying both Hindi and English messages.

VMS shall be provided at the following locations: Traffic entry point to each tunnel portal.

The VMS shall be centrally mounted between 3m and 6m inside the entrance and angled to provide a viewing distance of 200m from outside the tunnel.

The underside of the VMS shall not be below the minimum tunnel clearance height and shall be protected from being struck by an over-height vehicle.

VMS shall be used to advise motorists of traffic conditions that include, but not limited to, the following:

Tunnel Closure Traffic Congestion Expected Delays Detour requirements Information to discourage vehicles entering the tunnel during major incidents

The VMS shall comply with the requirements of EN 12966 and section 18.2 for photometric performance.

The VMS shall have:

Minimum character height 400mm All Characters proportionally spaced

Character font standard 5 pixels (width) x 7 pixels (height) proportional font 2 pixels between characters with 2 pixels between lines of characters.

All text messages Centered and middle justified Amber Flasher Lanterns size 250mm diameter

All VMS shall be controlled individually, and standard messages shall be displayed instantly, pre-programmed messages shall be displayed automatically for emergency or fire conditions via signal from TMCS or fire detection system. Amber Flasher Lanterns shall be provided on the four corners of the VMS which can be configured to flash for any message.

The VMS shall have a Hot Dipped Galvanised Steel enclosed walkway behind the sign to provide maintenance access to the sign components. A vertical access ladder from the footpath or other suitable method of access shall be offered by the tenderer.

10.7 ADVISORY SIGNS

The advisory signs shall be capable of displaying a limited number of fixed messages and are principally located within the tunnel.

The signs shall be supported on the tunnel side wall in the twin tube tunnels (both the tubes included) at suitable intervals as decided at detailed design on unobstructed support frames.

These signs shall be capable of showing the following messages:
"Switch Off Engines"

"Proceed to Exit with either left or right arrow "Switch on Radio"

The signs shall be capable of showing the above messages in both Hindu and English at both times by switching back and forth between each language.

The signs shall be controlled by the individual and or in groups via the TMCS. Also, local control of signs shall be from the niche points RCU and the local control switch status to shall be transmitted to OMCS.

A test pushbutton on the local RCU shall be provided for testing of signs. The characters shall be sized and spaced so that characters can be read easily at a distance of 120 meters. The messages shall be LED display. The signs shall be easily readable in night and day time conditions. The display and control gear shall be housed within an extruded aluminium enclosure with toughened laminated glass in front of the display. The whole enclosure shall be weatherproof and vandal resistant to IP 66.

10.8 SIGNS FAULTS

For each type of sign, the sign controller shall monitor and detect faults in its controller display, power, supply, luminance sensor and all attached communication devices.

All faults shall be logged in the sign controller and transferred to the TMCS

At any instant in time the sign controller shall have sufficient memory capacity to retain a least the last 10,000 fault logs.

The following information shall be provided for each fault logging event: Time of day (hrminisec)

- Sign ID
- Fault description

The following types of faults shall trigger alarming and fault logging:
CPU fault Display fault Dimming fault Clock fault Power System fault

The sign controller shall check for all specified fault conditions at least once per second.

The sign controller shall log and alarm all faults within 1 second of the fault being detected. On detecting a sign controller CPU failure the sign display shall be automatically blanked. A LED pixel on the sign display shall be deemed to have failed if:

It is commanded OFF by the sign controller and is not OFF It is commanded ON by the sign controller and is not ON

It flickers or exhibits reduced or increased brightness compared to properly functioning pixels

The sign controller shall monitor each LED in the matrix and annulus for failure and if the sign controller detects a LED failure it shall log a fault.

The sign controller shall send an Alarm to the TMCS if more than five (5) LEDs have failed on any one character and it shall be the responsibility of the TMCS operators to decide whether to blank the display or leave on and arrange for repair of the sign.

If the sign controller on the VSLS detects that an incorrect speed is being displayed (that is, that a speed other than the last set by the TMCS) the display shall be automatically blanked and an alarm sent to the TMCS.

10.9 PUBLIC ADDRESS SYSTEM GENERAL

Public address (PA) system shall enable the operator to broadcast evacuation tones and give directions to motorists and maintenance staff in the event that the tunnel needs to be evacuated. The system shall utilize speakers with good directivity that shall be

placed to maximize intelligibility in a reverberant environment with background noise levels in excess of 90dBA in the both tube, and 75dBA in the cross passage.

The loudspeakers shall he mounted on the side walls in the twin tube tunnels (both the tubes included) at maximum spacing of 30m in staggered manner alternatively on both wall of both tunnel, similar arrangement shall be made for the cross passage. The ambient noise shall be monitored and the speaker output shall automatically be adjusted for clear hearing.

Zone control switches shall be built into the TMCS operator's workstation so that the PA announcements can be confined to a selected zone.

The system shall deliver voices clear and audible enough to overcome environmental and emergency conditions within the tunnel. PA system shall be designed to withstand rough tunnel conditions and cleaning techniques used to clean contents of the tunnel.

The distribution amplifiers shall provide and maintain the necessary signal levels for optimum performance. All categories of amplifiers must be dual directional in the frequency bands.

The loudspeaker circuits shall be interleaved and overlapped so that alternate loudspeakers are supplied from separate amplifiers located in two different equipment racks.

A digital signal processing based audio management system shall be provided to assist with audio quality. PA system shall store messages that can be automatically triggered by the TMCS.

10.10 BATTERIES AND CHARGER

A 24-volt two stage battery power supply system complete with charger shall be provided for each PA amplifier. Batteries shall be of the nickel cadmium type have the capacity to maintain the system including capacity for 10% future additions for a minimum of two hours continuously in the event of mains supply failure and for 72 hours in a quiescent condition be mounted in a control cubicle with the battery charger be mounted on fibre glass or other non- deteriorating trays be mounted on shelves terraced for easy maintenance access.

10.11 RADIO REBROADCAST SYSTEM GENERAL

Radio rebroadcast facilities shall be provided to receive and re-transmit AM and FM radio station broadcasts to motorists in the .tunnels. For every radio station rebroadcast in a tunnel, the quality of the radio reception shall be equivalent to the reception outside the tunnel. This requirement excludes radio reception disruption effects due to heterodyning caused by dual signal reception at tunnel entrance and exit transition zones.

The radio rebroadcast facilities shall be able to receive and re-transmit at least twelve AM and twelve FM radio stations broadcasts to motorists in the tunnel. The radio stations that are re- broadcast shall be the twelve most popular stations in each band.

Radio broadcast system shall consist of:

Off air reception of AM/FM radio programs and VHF/UHF emergency services such as fire, ambulance, police and other similar services

In tunnel rebroadcasting of VHF/UHF emergency services such as fire, ambulance, police and other similar services

Break-in facility to allow both automatic and manual insertion of audio messages by TMCS operators into the AM/FM rebroadcast for motorists travelling through the tunnel. The facility shall operate using a leaky feeder inside the tunnel coverage.

All receivers, message interposing equipment, transmitters, signal combiner/splitter, trans- receivers shall provide status information to the PMCS.

Radio and rebroadcasting equipment shall be located within the equipment racks in the control Centres. The components of the system shall comprise of base station equipment, amplifiers and radiating cables. The system shall provide channelized capabilities which allow radio communications for all required frequencies used by the emergency services. FM/AM radio and Break-in capability. The break-in facility enables the operators to provide instructions and advice to motorists in the tunnel by over-riding all the normal radio broadcasts on the vehicle AM/ FM radio receiver. Microphone and control panel equipment shall be provided on the operators control desk. Specifically, the work shall comprise the design, supply, install and commission of the following major items:

Multi carrier combiner located in a floor standing equipment rack in the Tunnel

Control Centres- The combiner shall be a wide band unit supporting CDMA, GSM, 3G ((NTS) and 2400 MHz based Wireless LAN transmission.

Radio Services Distribution Control Centre Cabinets to house equipment.

Radiating low smoke, zero halogen Andrew 50-ohm cabling, generally from each electrical niche inside the tunnel feeding half way distance to the electrical niches on either side, such that the entire tunnel length is covered.

All splitters, couplers and connectors.

All interconnecting flexible leads (between splitters, couplers and antennae components) to form a complete system.

Power supplies

The system shall meet the following specifications for 90% of the building area on each level:

Mobile handsets receive level of -85 dBm or greater. Mobile handsets receive quality of 4 (80%) or greater. Dropped call rate of 2% or less.

Network access failure rate of 2% or less.

Each radiating cable feed shall have 2.5KV RMS Galvanic isolation. The signal level received by an isotropic antenna in the tunnel should be not less than -95dBm, measured at the tunnel floor. Radiating cable shall be supported to the tunnel side wall of the north bound lane of the Tunnel using manufacturer recommended stand-offs and spacing's.

Space allowance shall be made for military radio rebroadcasting equipment and antennas.

10.12 TELECOMMUNICATIONS EARTHING

Earthing systems shall comply with the requirements of Indian Standards. Safety earth cabling shall be coloured green. All earth cabling shall be continuous throughout its length. Earth connections shall be made using machine threaded bolts fitted with spring washers. Cable terminations shall be rigidly bolted to the terminal strips/bars. Soldered connections and spade connectors are not acceptable. All terminal bars/strips shall be clearly labelled. All conductive devices, antenna cables, equipment racks, cable tray, centenary wires and cabinets shall be earthed by connecting a safety earth using 4 mm2 copper cable coloured green/yellow. The contractor shall extend a low impedance earthing system from the main building earth bar, independent of, but bonded to, the general light and power earth system.

10.12.1 MOTORISTS EMERGENCY TELEPHONES GENERAL

Telephone system shall be in accordance with the Indian and International ITU standard telephone requirements and the whole installation shall be carried out by Indian telecom approved contractor. The contractor shall organize and liaise with telecom authorities for installation of the external telecommunication cable to connect to the portal building PABX. Internet Protocol (IP) based phones shall be provided. Telephone outlets shall be mounted at on a flush mounted impact resistant face plate similar in size and colour. Internal telephone cable shall be run in the same method as the power cable, but segregation between services shall be maintained. The telephone receiver shall have the following features:

Wall mounted support bracket Digit keypad

Memory and automatic dial Recall, Pause/hold button Message storage and retrieval Call diversion

Telephones shall be provided but not limited to the following locations Control Centre desks Control rooms

Office rooms

Substations- wall mounted, Equipment rooms- wall mounted Service corridors- wall mounted

10.13 MOTORISTS EMERGENCY TELEPHONES

The contractor shall supply and install an IP emergency telephone system for the tunnel. Emergency phones shall be independent from the normal telephones and shall have separate, electronic circuits/control equipment and power supply including separate cable containment. These phones shall be located along with the fire cabinets at 150m spacing along the full tunnel length for motorists to report emergency traffic incidents. Emergency phones shall be installed the emergency escape culvert for motorist's use during a tunnel evacuation. By lifting the handset, motorist can speak to the tunnel operator at the control room. Telephones shall have the following as a minimum:

Telephone handset and associated electronics

Equipment enclosure-each emergency telephone shall be a free-standing weatherproof structure designed to handle outdoor environment.

Mounting fixtures cabling.

10.14 STATIC SIGNAGE:

When a telephone handset is lifted, it shall be automatically registered at the TMCS which handset has been lifted and CCTV cameras to cover the particular location of the phone. Telephones shall be connected directly to a dedicated PABX to be located within the Tunnel Control Rooms. The TMCS Operator workstation shall show an icon on the tunnel mimic to show the Telephone handset(s) that has been lifted.

Emergency telephones shall be contained in an enclosure rated to IP65 to withstand the conditions during tunnel cleaning operations and those conditions normally expected for outdoor roadside equipment. Emergency telephones shall be built to withstand vandalism and to protect the sensitive components from malicious damage.

Emergency phone system shall provide calling number location reference data to the TMCS. The calling number reference location data shall be linked to the tunnel segment identifiers, CCTV camera number and preset view reference number. The TMCS shall automatically focus the nearest camera on the motorist using the telephone within three second of the handset being lifted of the hook.

Alternatively, a loud speaking intercom in a sealed enclosure with a speaker and microphone system can be within the Fire Cabinet. Pressing the speak button enables the motorist to talk to the operator. The system shall have the following features:

The unique data stored on every telephone allows operator to identify and geographically locate a telephone during a call Time and date logging against each call and conditions requiring operator intervention flagged and reported.

Emergency telephones located inside the tunnel sections shall provide audible clarity for the high ambient noise levels in the order of 95dBA inside the road tunnels. Noise cancelling microphones and other techniques shall be employed in the handsets and speakers shall have sufficient output volume, with minimal distortion, and high clarity to ensure conversation is possible. The telephone audible clarity performance shall achieve an articulation index better when subjected to an objective machine-based test based on ANSI 3.5-1997 with a remote operator and a user in the tunnel with A-weighted background noise level.

Emergency telephones shall be interfaced with the TMCS Incident Management System to raise an incident in the Incident Management System arising from a call on the telephone and to automatically locate the incident.

If all the TMCS operators are busy the TMCS shall alert the operator any queue calls so that operator respond in chronological order.

An IP based telephone system shall be provided by lifting the handset, motorist can speak to the TMCS operator from any of the two portal control rooms and the Remote-Control Centre.

Telephones shall have the following as a minimum: Telephone handset and associated electronics Equipment enclosure-each emergency telephone shall be a free standing IP66 weatherproof structure designed to handle outdoor environment.

Mounting fixtures cabling Static Signage
Emergency lighting near the phones

When a telephone handset is lifted, it shall be automatically registered at the TMCS which handset has been lifter. Telephones shall have dedicated cabling and shall be independent from other phone system. These phones shall be connected directly to a dedicated PABX to be located within the Tunnel Control Rooms.

10.15 TRAFFIC INCIDENT DETECTION SYSTEM GENERAL

The traffic incident detection system shall detect vehicle congestion and incidents and raise alarm to operators and generate data on traffic volumes and speeds. The detection of an incident occurring shall be by the following equipment:

Automatic video incident detection system CCTV surveillance system

Fire detection system (see relevant section) motorist emergency telephone.

For the above systems, the contractor shall supply and install the following equipment:

Communications equipment (converters, switches, etc) necessary for transmission over single mode fibre optic cable, miscellaneous equipment (racks, etc) for mounting equipment in device cabinets, brackets, fixings that are non-corrosive. Non-corrosive cable ladders, cable fastenings, etc. fire rated cables, connectors, cabinets and equipment housings.

10.16 AUTOMATIC VIDEO INCIDENT DETECTION (VID) SYSTEM

An automatic VID system shall be provided to alert operators to possible traffic incidents and unauthorized pedestrian movements throughout the full length of the tunnel including the avalanche galleries.

The system shall have motion detection and vehicle/object presence Software on the CCTV system capable of detecting in the tunnel the following:

Irregular traffic flow in the tunnel, Objects fallen off a vehicle Pedestrian movement Fixed zoom camera shall be supplied and installed at suitable intervals and shall be positioned to optimize the performance of the system but not to the detriment or risk of being struck by a vehicle.

The CCTV system shall be capable of simultaneously processing imagery from up to 250 cameras.

The system shall be capable of initiating an alarm and automatically switching a CCTV monitors to appropriate cameras, under pre-determined conditions.

The performance of the VID system must be equal to or better than the following:
Percentage of incidents and stationary vehicles detected >98%

Percentage of false alarms<2%

Time to detect an incident <2 minutes

The image processing software and hardware shall be proven technology world recognised for this type of application and in current use on a similar road in cooler climates such as Scandinavia and Canada. The camera selected to be used for the

Image processing shall provide the best achievable performance for the extreme temperatures and tunnel environment. The Contractor shall provide comparative testing results between cameras as part of the offer.

10.17 CLOSED CIRCUIT TELEVISION (CCTV) SURVEILLANCE SYSTEM

The CCTV surveillance system shall be used to monitor the following:

Traffic flow and incidents along the length of the tunnel activity in the Cross Passage, in and around the Central command and control Centre monitoring traffic approaching the tunnel portal Digital, Internet Protocol (IP) CCTV Pan Tilt Zoom (PTZ) cameras shall be provided.

All PTZ camera shall be fitted with remote controlled auto-iris focus zoom lens and be capable of full definition display in illumination levels down to 1 lux in direction of viewing.

The PTZ cameras shall be incorporated with the CCTV system such that any PTZ camera could be configured for VID when in a nominated preset position.

Panning and tilting of camera shall be with a pan tilt head, and the head and lens shall be fitted with preposition potentiometers which allow both to be automatically set by the control system to a number of predetermined positions. Camera enclosure shall be corrosion resistant IP66 type. All cameras shall be high definition colour type, capable of 480 line PAL format equivalent utilizing 1/4 Inch CCD.

10.18 DIGITAL VIDEO RECORDING AND MANAGEMENT SYSTEM (DVRMS)

The DVRMS shall be designed and developed as per standards: ISO 9001 ISO/IEC 15504

The DVRMS shall include:

Redundant Database Servers (one in each portal equipment room)

Camera control interface software resident on the OMCS and TMCS workstations IP networked connected cameras

Fibre Optic Communications Network Infrastructure

The Redundant database server shall contain a database of all network connected cameras and their configurations.

The database server shall:
Manage the system database

Manage communications with cameras

Allow alarms/events in the DVRMS to initiate recordings

Report any camera failures or recording failures to the TMCS system

Provide a full log of all system status including camera; encoders and server availability and operator actions

The System database shall include:

Camera configuration and settings Recording configuration and settings Configuration of Quad view and sequences Camera preset settings

Configuration of automatic VID

Configuration of surveillance and alarm monitoring System configuration
Schedules Details of recordings

Security password access details

The redundant server shall be a hot standby with sufficient disk storage media to store 1 years' worth of video and shall have a high-speed video search and access software to enable operators to quickly locate and access past video footage

All devices, monitored and controlled from the PMCS and TMCS, shall be able to be configured to switch a fixed camera to an operator monitor and/or wall monitor either automatically or by the operator in response to an alarm condition. In the case of a PTZ camera, this shall switch the camera to a preset (pre-programmed) position and zoom.

The operator shall be able to change these to reflect how they wish to view the location and shall be able to configure views from at least two cameras (e.g. upstream and downstream cameras).

All fixed and PTZ cameras shall be pre-programmed during testing to store a number of views related to the devices visible by that camera.

10.19 TUNNEL ELECTRICAL INSTALLATION

All TMCS equipment installed in the tunnel, on the tunnel portals shall have non-corrosive IP66 type (ISO/IEC 60529) enclosures.

Conduit, cable fastening and support devices, cubicles, trunking, cable tray boxes, metal work and cabling shall be designed to withstand the tunnel environment, and shall be fire resistant, non-flammable, low smoke and halogen free.

Cabling and other elements such as cabling supports and junction boxes shall have a fire rating of two hours except where the cabling is inside a conduit encased in concrete with sufficient cover to attain a two hour fire rating.

Cabling support structures shall be provided on fixed rigid ladders or otherwise in conduit enclosures for all cable runs in the twin tube tunnels (both the tubes included).

Electrical equipment cabinets located throughout the tunnels shall be finished to a standard which ensures the durability of equipment housed within is not degraded by the environment. Construction of equipment cabinets shall be completed prior to installation of electrical equipment and the installation of cables.

All electrical and communications cable passing through floors shall be protected from mechanical impact.

All electrical installation and wiring shall comply with relevant Indian standards and/or British Standards the higher standard being the benchmark.

All tunnel equipment suspended from the ceiling or supported from the walls of the tunnel shall comply with the following:

- minimum IP65 degree of protection

- all bolts, nuts, washers, screws and anchors shall be in stainless steel of grade 316 and installed for easily dismantling by tools or specialized tools for maintenance purpose
- all support beams, rods, hangers, lifting eyes and anchor bolts required for the proper installation and maintenance of equipment shall be designed and provided by the contractors
- All monitoring instruments and power supplies shall be installed within the RCU enclosure.

10.20 POWER SYSTEMS

All TMCS equipment and systems shall be cabled and connected to the essential services power distribution network.

The TMCS shall alert the TMCS operator of any device power failures.

10.21 FIRE PROTECTION SYSTEM

The extent of work covered by these documents includes the detailed design, manufacture, supply, installation, testing and commissioning and subsequent maintenance of the Fire System for the tunnels as detailed in this Specification.

A detailed design shall be completed for the whole of the works described in this performance specification, together with coordination with other services and compliance with all Authorities having jurisdiction over the works. This performance specification describes the intent and extent of works and standards of work required.

The principal items of the Fire System for the Tunnel shall include:

- Linear heat detection System,
- Smoke Detection for Buildings and electrical niches.
- Emergency Warning and communicating system
- Fire Hydrant pump system,
- Fire Hydrants and Hose Reel System,
- Tank filling arrangement and Pipework System, and
- Gaseous based Fire Suppression System,
- Hydrocarbon Gas detection system

10.22 SCOPE OF WORK

The work shall include the following:

- Fire hydrant system including hydrant booster pumps, jockey pump, pressure vessel, associated pipework, valves hoses and hose reels;
- Fire Brigade booster and suction connections;
- Automatic and manual fire detection and alarm system comprising linear detection to tunnels;

- Emergency control cabinets including 60m hose reel, hydrant, extinguisher, manual call point and warden intercom point;
- Control & Indicating Equipment (CIE);
- Graphic user interface;
- Sound system and intercom system for emergency purposes including interface to public address system. Cabling from public address system to sound system by PMCS

Sub-Contractor;

- Colour graphics system;
- Valve monitoring;
- Fire alarm and control systems;
- Fire alarm line to fire brigade;
- Portable fire extinguishers;
- Excavation, construction, backfilling and finishing of services trenches;
- Tank filling pumps and associated pipework and valves;
- Foam fire-extinguishing systems to tunnel drainage holding and sump tanks;
- Extension of electrical power wiring provided by the Electrical Services Sub contractor, including a local isolator, adjacent the fire services pumps. (Power supplies will be provided by the Electrical Services Sub-Contractor to serve CIEs, Graphic user interface/ colour graphics system);
- Provide a high level interface and control wiring from the main CIE to the local PMCS panel;
- Provision of valve monitors to hydrant valves, as specified;
- Temporary firefighting during construction;
- Tactical fire plans;
- Commissioning and testing of installed equipment and hot smoke tests;
- Joint co-ordination responsibility with the PMCS, Mechanical, Electrical, and Hydraulic Services Subcontractor for commissioning of the interfaces with the Fire Services;
- Corrosion protection to all equipment, support, fixings and components;
- Painting and labelling of the completed installation as specified;
- Tunnel roof slab support pull-out tests as specified;
- Provide pressure relief valve, air relief valves etc. on hydrant mains;
- Provide expansion join to allow ±50 mm contraction or expansion in pipe;
- Supply of sleeves, holding bolts, conduits and any other fittings required to be built in during construction and fixing in formwork prior to pouring of concrete;

- Supply of sleeves required to be built in during construction and provision of drawings showing their accurate location;
- Over flashing of pipes and the like penetrating external walls and roof (under flashing will be by Builder);
- Escutcheon plates around pipework penetrations exposed to view;
- Grid mesh flooring, handrails and hoist beams as required to maintain the plant and equipment;
- Hoisting of equipment;
- Provision of required scaffolding;
- Provision of operating and maintenance instructions including as installed drawings, microfilms, completed test reports, and spare parts and equipment data;
- Provision of defects liability as specified;
- Provision of preventative maintenance of the plant;
- Tunnel Control Building - The Tunnel Control Building will require Mechanical, Electrical, Fire, Hydraulics, PMCS and Communications Services Fit out. For the, purposes of this Tender, include a Provisional Sum as indicated in the Tender Schedule for the Fire Services to include detection to all areas, warning systems, hydrants, hose reels & extinguishers; and
- Wire from fire indicator panel/fire fan control panel and connect to terminal strip in the motor control Centres serving the mechanical equipment).

10.23 GENERAL

The Fire services shall be designed to meet with following key performance indicators as minimum:

- The systems to meet with high altitudes and sub-zero temperatures region;
- Tunnel equipment and operations and harsh environment at project sites;
- Comply with International, national and local standards & by-laws;
- Comply with current publication of the National Building Code of India; and
- Comply with operational and maintenance requirement of the tunnel operator

The Fire system within tunnel structure shall be designed in accordance with relevant International standards such as PIARC, NFPA and Indian standards-JS (JS applicable only to achieve the compatibility of equipment). Where Indian standards are not available, reputed International standards shall be used with prior approval from Consultant.

The system shall be designed to meet with the following objectives summarized by PIARC to:

- save lives by making evacuation possible
- make rescue and firefighting possible

- avoid explosions
- limit damage to tunnel structure, equipment and surrounding

buildings. Following design criteria shall be complied with as minimum:

- At the hydraulically remotest hydrant landing valve minimum available pressure should be 7 bar when discharging minimum flow of 63 L/sec.
- Hydrant system to be capable to operate 3 hydrant points simultaneously with conditions
- Maximum pressure at hydrant point shall not exceed limit restrictions required by local fire brigade.
- The hydrant system shall be automatic and remain in pressurized conditions all the time.
- Fire detection system shall be provided throughout the tunnel roadways. Any fire conditions on roadways must be detected quickly and the location of fire point shall be pin pointed by the detection system and displayed on main Fire Indication and Control Panels (MFIP) and colour GUI (Graphic User Interface). The location of fire point displayed on MFIP shall be in the range of 0 to 15m from the actual fire point.
- The emergency warning system shall be intelligible with speech clarity. The warning instructions should be clear audible enough to tunnel users in all conditions. Supplementary visual alarms shall be provided in tunnel.
- The Sub-Contractor must submit evidence that:
- Requirements of the relevant authorities relating to the work under the contract have been ascertained prior to the commencement of the hydraulic services installation
- Fees to relevant authorities, if any, have been paid and all types of approvals obtained.
- Certificates of compliance with regard to the extent of the installation. Such certificates have to be obtained on completion of the installation.
- All fittings, pipes, accessories and the like used in the works must bear approval marks where and as required by the relevant Authorities.
- Test certificates for all essential service fittings. Be provided prior to completion.

10.24 FIXING AND SUPPORTING OF PIPES

All service pipes must be positioned in locations as approved before installation commences. All pipes must be adequately supported and secured to adjacent root. Pipework must not come into contact with any other service pipes or part of the building structure unless insulated with 25mm thick sectional mineral wool lagging.

All pipework must be free to move without causing stresses in the pipework or in the pipe joints.

Support must be galvanised mild steel channel complete with purpose made galvanised spring nuts, framings, fittings and pipe clamps for each pipe. 'U' clamps must not be used with PVC pipes. Fixings for PVC must completely circumvent the pipe without distorting the cross-sectional profile of the pipe. Alternative methods of fixings may be used provided the proposed method is detailed, discussed and approved prior to the

commencement of any work dependent upon such an approval. Approved fabricated mild steel brackets must have ground off neat square ends drilled holes.

Mild steel brackets must be hot dipped galvanised after fabrication. Vertical frames where used to support suspended horizontal runs must allow for complete adjustment of clamp support to suit pipe grading as required. Channels must be galvanised steel bolt fixed direct or with purpose made clips to walls or underside slab. On completion of work remove all cement droppings, dirt etc. from pipe supports, pipework and fittings.

Explosive power fastening tools must only be used where specifically approved. Appropriate screws must be used for fastening supports to timber.

All bolts and screws must be sized to suit the load but in no case must the diameter be less than 6 mm for fastening to timber, steel masonry or concrete; smaller bolt sizes may be approved.

10.25 WATER SUPPLY FOR HYDRANT SYSTEM

The fire services water shall be supplied from tank fill points provided on each portal ends and near fire water tank. Only potable water shall be used for fire hydrant systems.

Each water supply connection serves a set of pumps to achieve design flow and pressures for the hydrant systems

Design Life

Design life for fire systems and water supply equipment and components are summarized below:

Tank Filling Pumps	20 years
Hydrant pumps	20 years
Water storage tanks	20 years
Pipework and valves	20 years
Gas Suppression systems	20 years
Control and Indicating Equipment panels, Graphic user interface, detection and alarm systems	20 years
Instrumentation and controls	20 years
Supports, brackets and fixings	20 years

Manufacturers of the fire systems, water storage and reticulation systems and controls shall have been engaged for a minimum of 10 years in the manufacture of robust industrial quality equipment of the type and duty specified for this contract. In addition, the manufacturer's products offered for this contract shall have a minimum of 5 years proven record of successful application and service in equivalent applications to those specified for this contract.

Manufacturers shall submit documentation in support of the specification conformity and quality of the product offered which shall include,

- Drawings and documentation specified to be supplied
- Supplementary documentation considered to be relevant
- Synopses of design, calculation, manufacturing, testing, installation and commissioning processes
- Schedule of projects where equivalent equipment has been installed, together with relevant installation and commissioning dates, technical details, citing of failures and corrective action, current status and condition of equipment, reference contact details.

10.26 TACTICAL FIRE PLAN

Provide a colour coded drawing indicating the fire services systems installed and features of the building.

The drawing shall be of approved scale and incorporate the following features:

- plan drawings of each floor level
- locations of all hydrants
- locations of all hose reels
- location and content of each emergency control cabinet
- locations of booster connections
- locations of valve assemblies
- locations of indicator panel
- location of hazardous areas
- colour coded areas covered by each alarm zone schematic detail of hydrant piping system
- location of special hazard fire extinguishing system protected areas fans, ducts and shafts
- fuel oil storage tanks
- town gas meters, boosters and controls and piping
- emergency control Centre(s) stand-by power plant fire walls and compartments emergency exit lights

The drawing/s shall be of approved scale, colour fast and mounted in a glazed frame in a location as directed on site.

10.27 STANDARDS

Work not covered by the requirements of Regulatory Authorities or this specification shall comply with the appropriate publication of the International and Indian Standards.

Wherever a Standard or Code of Practice is referred in this specification, it will imply the latest issue and/or revision applicable at the time of tender.

BS 4683/BS EN 60079:	Electrical Apparatus for Explosive Atmospheres
BS 5445:	Components of Automatic Fire Detection Systems
BS 5839:	Fire Detection and Alarm Systems for Buildings
BS 6387:	Performance Requirements for Cables required to Maintain Circuit Integrity Under Fire Conditions
BS EN 54-1:	Fire Detection and Fire Alarm Systems
BS EN 55104:	Electromagnetic Compatibility
BS EN ISO 9000:	Quality Management and Quality Assurance Standards
BS EN ISO 9001:	Quality Systems Model for Quality Assurance in Design, Development, Production, Installation and Servicing
BS EN ISO 9002:	Quality Systems Model for Quality Assurance in Production, Installation and Servicing
BS EN ISO 9003:	Quality Systems Model for Quality Assurance in Final Inspection and Test
BS EN ISO 9004:	Quality Management and Quality Assurance Standards
BS 7846/BS EN 60702-2: IS 2189:	Code for Fire Survival Cables. 2008 Selection, Installation and Maintenance of Automatic Fire Detection and alarm

10.28 ELECTRICAL SUPPLY

All electrical equipment will be designed, supplied, installed and commissioned in accordance with the Electrical Systems Performance Specification.

10.29 FIRE DETECTION AND ALARM SYSTEM GENERAL

A fully addressable fire detection system complying with Indian standards shall be provided comprising a network of main Fire Indication and Control Panels (MFIP) in the main control Centres. Each FIP shall provide emergency fire protection of the tunnel in the event of a fire incident in the tunnel.

At 150m intervals, fire cabinets shall be located on the northbound side wall of the tunnel and these cabinets shall be installed with emergency push button, emergency phone and two portable fire extinguishers.

Tunnel fire detection system shall include a linear heat detection system for the entire length of the tunnel and additional detector loop to serve ancillary equipment and areas such as the Central command and control Centre, electrical cupboards and the like.

Smoke detection shall be provided to all electrical panels within the ECPs and portal rooms such as switch rooms, communications rooms, UPS room, substation, store room, office rooms, toilets, maintenance room and garage. Fire detection system shall have instrumentation and control interface with PMCS through MFIP.

The system shall fully comply with the requirements pertaining to design, installation and commissioning with Indian Standards and in the absence of such standards, shall comply with relevant international standards. The Subcontractor shall examine all architectural and services drawings to ensure that the type and location of detectors comply with the requirements of the relevant Authorities, and be responsible for the coordination and installation of detectors with regard to type, suitability and the location of walls, openings, ducts, pipes, cable trays and other services.

The system architecture shall include remote data gathering from each fire cabinets located inside the tunnel. Fire services alarms, controls, communications and status reporting and ventilation system controls shall be accessible from both the control Centres.

The fire detection and alarm system shall automatically initiate various systems, devices and signals via the fire indicator panel. All necessary equipment and devices shall be provided to ensure that the operation of the fire detection and alarm system is maintained and installed in accordance with Codes and standards and shall operate in an acceptable manner.

10.30 DETECTORS

All detectors shall:

- be designed and installed in locations to minimize the detrimental effects of air turbulence, moisture, dust, insects and other foreign materials
- be installed in accordance with the Manufacturer's recommendations

- be listed by the Scientific Services Laboratories or similar
- be plug in twist lock units to facilitate easy connection into the mounting base
- be manufactured from top quality materials. Components shall be either inherently resistant to corrosion, plated, or otherwise treated to afford adequate protection against corrosion
- utilize plastics of the appropriate class
- be designed to operate within the site conditions and temperature range
- If they contain radioactive isotopes be suitably marked to comply with the Radioactive Substances Act
- have an integral LED which shall operate continuously to give a visual signal during an alarm condition. This LED may be located on the detector base such that it is clearly visible from the direction of approach
- be photo optical type if installed within air ducts, and shall be provided with an approved sampling device
- have a detector base designed to prevent contact with the wiring terminals from the concealed space side of the base
- be installed with remote indicating LED's where detectors are located in concealed spaces
- Smoke detectors shall be analogue addressable type. The system shall accept interchanging of individual detector type with software modification of device parameters.

Smoke detectors, supply and return air ducts shall be photo optical type, complete with air sampling device and shall actuate when the smoke laden air passing the detector has reached an obscuration level in accordance with relevant standards. The detectors for the supply and stair pressurization system shall be, non-latching type when in alarm and shall stop the fan from running. The final location of the detectors in air ducts shall be determined on site during commissioning.

10.31 LINEAR DETECTION SYSTEM

The system shall consist of linear heat detection fibre optic sensor cable and a controller with related software. The system shall provide an exact location of a fire or hot spot anywhere along the sensor cable length. Temperatures shall be recorded as a continuous profile. When configured using software, the system shall be capable of providing graphical representation of the fire size and direction of fire spread. The system shall have at least the following features:

- Unique zoning capabilities
- Multiple alarm initiating feature by zone
- Programmable custom operating logic
- Capable of temperature monitoring

- Graphic display of zones, temperature profile, fire size, spread using visualized on software
- Ethernet Interface (TCP/IP) available

10.32 CONFIGURATION

The linear detector controller shall be designed for 19 inch rack mounting in control rooms, E C P s and shall have:

- Modular design,
- Operating system software,
- Transmitter module for generating laser light by a semiconductor laser diode and its control operation,
- Receiver module including optical coupler,
- Power supply module available in 24 VDC or 230 VAC,
- Digital module for the overall control operation of the system and the temperature measurement process. Based upon the data it receives, the unit calculates the temperature profile along the sensor cable, controls alarm processing based upon stored zone definitions and communicates over the serial interface or Ethernet,
- Visual Indicators, Controls and keypads to provide status indications and alarms on the front panel, and
- Communication Interface with RS232 and Ethernet.

The number of controllers and their physical location shall be decided during the detailed design of the linear detection system. Linear detection fibre optic cable shall be installed along the tunnel Centre line above the road way and under the ceiling within 50mm clearance to the manufacturer's specifications. All controllers shall be linked with the PMCS and MFIP either via the tunnel fibre optics data bus or separate cables.

10.33 ADDRESSABLE FIELD DEVICES

All field devices shall:

- Be designed and installed in locations with a view to minimize the detrimental effects of moisture, dust, insects and other foreign materials,
- Be installed in accordance with the Manufacturer's recommendations, and
- Be manufactured from top quality materials. Components shall be either inherently resistant to corrosion or plated or otherwise treated to afford adequate protection against corrosion.

10.34 ADDRESSABLE INPUT/OUTPUT INTERFACE DEVICE

The devices shall collect and transmit status information from or to MFIP/SCIP and PMCS equipment. Each device shall be designated its own unique address and contain a minimum of one fully floating relay changeover contact. Also Input devices shall be capable of initiating either fire alarm control functions or plant control

functions by means of software programming. The device shall have a monitoring facility such that if the cable from the device is compromised, then a fault condition will be registered at the FIP.

10.35 ADDRESSABLE ZONE MONITORING DEVICE

The devices shall provide the power for a mixed zone of up to forty conventional fire/smoke detectors wired in the form of a continuous spur from an addressable loop. Each device shall be designated its own unique address and the zone of conventional detectors shall be fully monitored for both alarm and fault conditions. The device should incorporate a monitoring facility such that if the cable from the device to the output is compromised, then a fault condition will be registered at the FIP.

10.36 SHORT CIRCUIT ISOLATOR

The devices shall be installed to provide protection against wire to wire short circuits on the addressable loop. They may be independent self-contained devices, or may be contained within other devices on the addressable loop. In their normal quiescent condition these devices shall pass both data and power as required for normal system operation. However, should the detection loop be short circuited the isolators fitted either side of the short circuit shall recognize the line voltage collapse and effectively disconnect that section of the loop.

Short circuit isolation shall be provided between fire detection zones. Isolators shall automatically reset when the wiring short circuit has been repaired. Activation of the short circuit isolators shall not affect operation of alarm functionality, e.g., emergency warning, mechanical plant fire mode, etc.

10.37 DESIGN OF ADDRESSABLE DETECTOR AND ALARM SYSTEM

The number of devices connected to each fire detection and alarm loop shall not exceed 85% of its total capacity. All detection and alarm circuit wiring between addressable devices shall take the form of a continuous closed loop. Under no circumstances must tee joints be used at any device. The use of multi core cables containing both outward and return circuits is not acceptable. The return path of the addressable loop shall be installed in a different route from the forward path.

Where wiring between addressable interface devices and plant or equipment such as flow and pressure switches, etc., is not fully supervised, it shall be two hour fire rated and suitably protected against mechanical damage. Where remote field alarm zone facilities or input output modules or the like are installed, all cabling to the modules are to be fire rated. The communications and power cabling shall incorporate a redundant return path to ensure a single break in wiring does not affect the system. Communications cabling shall utilize fire rated screened, twisted pair cabling. Both communications and power cabling shall be installed such that the return path is physically different from the forward path.

Control and indicating equipment panel shall form the basis of the Fire Detection and Alarm system. Central command and control Centre shall perform as the single point for fire monitoring, control, indication and alarm.

FIP shall be an addressable system capable of connecting at least 125 devices to the detection loop. FIP shall comply with the requirements of Indian and International standards. Each detection loop shall be either 2 or 4 wire and be capable of being supervised for multiple open circuit conditions.

A hard copy of the system configuration shall be provided with the panel documentation such that in the event of total system failure a new panel may be programmed by an approved manufacturer's representative from the information provided. A volatile memory, including that used for a history log, shall battery backed so that it is not lost on power failure.

FIP shall provide manual over-ride control for Fire Brigade intervention.

10.38 CONSTRUCTION

The FIP shall be enclosed in an IP54 for internally mounted and IP54for externally mounted metal cabinet suitable for floor standing, securely fastened to the wall with all indicators and control functions arranged for front access. All controls and indicators shall be mounted on a swing frame inner door to permit easy access to equipment located within the panel. The cabinet shall be constructed from not less than 1.6 mm furniture grade steel. All welds to be ground finish and smooth. The cabinet shall be fitted with a transparent panel door secured by a 003 code lock to prevent unauthorized access. Cabinet finish shall be baked epoxy and the colour shall be standard manufacture or as per the Architects or Engineer's requirements and:

- Be of folded sheet metal construction so that all edges of the sheet are concealed
- Have all joints welded with continuous seam welds which have been ground flush after fabrication. Spot welds are unacceptable
- Be provided with a suitable means of securing the complete assembly to walls and/or floors
- Be fitted with an approved means of supporting all cabling with bushed holes between compartments
- Have 100 mm, minimum, wiring space on each side and 150 mm, minimum, wiring space at top and bottom for each compartment, the wiring space being increased to suit the quantities and types of cables entering and leaving the panel. Ducting shall be provided to accommodate the wiring in a neat fashion
- Contain louvers at the top and bottom with fine bronze wire mesh welded inside for switchboards larger than 0.3m 3 in volume
- Be fitted with gaskets to render the panel drip and vermin proof and preventing the ingress of dust and insects
- Have removable cover plates or cable entry knock outs at the top
- Be provided with removable panels, escutcheon plates and covers at the front be arranged so that the distance between floor level and top of switchboard does not exceed 2250 mm

- Have adequate provision for storage of operation manuals, logbooks and as installed drawings within cabinet. This storage shall be a separate drawer or shelf such that the documentation does not come into contact with any electrical components
- Have batteries housed in a separate, ventilated compartment of the alarm panel which shall be completely sealed off from the remainder of the panel to prevent corrosion. The batteries shall stand in a PVC or other approved corrosion resistant tray of adequate size to collect spilled or leaking electrolyte

10.39 PANEL CONFIGURATION

Each Alarm zone circuit shall be fully supervised for an open circuit fault condition.

Indications for alarm and faults from each zone shall be displayed on a 2 line x 40 character or larger alphanumeric Liquid Crystal Display.

The display shall also provide a user definable message associated with each device to identify the building, floor and room of alarm origin. Liaise with the facility such that the area/ room names on the display correspond with the everyday terminology used by the facility.

The panel shall be capable of providing individual LEDs for zone alarm, zone fault and zone isolated indication.

10.40 OPERATOR CONTROLS

Control of the FIP shall be via a keypad with dedicated function keys to simplify operations. The panel shall also have single key operation for fire fighter facilities for silence and reset alarms and isolate zones. This facility shall comply with the relevant Indian and International standards.

10.41 NETWORKING

The fire detection system shall be capable of being networked such that full addressable device point alarm and fault information from all sub panels are available at the main FIP. The network shall be peer or similar such that the failure of a single sub panel shall not affect the operation of others. In particular, the failure of the main FIP shall not affect the ability of, the local FIP to annunciate a warning message, activate local warning, release doors and appropriate air handling functions. A short circuit or open circuit in the network communications loop shall not impair the operation of the system.

10.42 PANEL COMMUNICATION

The panel data communications loop shall be fault tolerant and fire rated and may include 24V DC power feed to support distributed alarm zone circuit facilities or I/O modules located at selected points within the protected zone. Two core power cabling may be run independently in lieu of multi core. A short circuit or open circuit in the panel communications loop shall not impair the operation of any modules but the fault shall be reported at the panel. The failure of a module shall not impair the operation and communication with any other module.

10.43 EVENT PRINTER

All events, including date and time, shall be capable of being permanently recorded by a system printer.

- The printer shall be capable of receiving:
- Event, transaction and alarm reports,
- Records of operator entered commands,
- System logs,
- Information summaries and reports, and
- System advisory messages.

10.44 POWER SUPPLY

The standby batteries shall be of the sealed lead acid type and shall comply with Indian standards and requirements of the relevant Authorities. In the event of mains failure the standby batteries shall be capable of maintaining the system in the normal quiescent condition for a period of at least 24 hours, after which sufficient capacity shall remain to operate a minimum of two alarm zone facilities and all associated ancillary control functions for a further 30 minute period. The battery size shall incorporate 25% extra capacity above the calculated requirement to allow for the expected losses over the battery life.

10.45 PROGRAMMING AND SOFTWARE

Simple device additions or changes shall be possible through the keypad interface. All system configuration parameters shall be field programmable using a portable terminal. The panel configuration shall be capable of being printed for a permanent record and checking and be able to be stored (unloaded) on a floppy disk for later downloading if required.

10.46 PANEL TEST PROCEDURE

The panel shall have an automatic and manually activated system test procedure. This procedure must allow the complete panel to be tested by the activation of dedicated keys on the keyboard. The panel shall also be capable of selecting a particular zone or function for individual testing. Addressable detectors shall have internal test capability under the control of the main fire indicator panel. Testing of a detector shall cause the detector chamber to be biased into alarm whereby an actual alarm value is sent back for processing through software. The automatic system test procedure, whilst testing alarm zones and functions, must not activate any ancillary equipment, such as air conditioning shutdown, direct brigade alarm, etc. Facilities shall be provided to test these functions if required by initiating zone tests or dedicated key functions.

10.47 SCHEDULE OF CONTROLS

Controls, indicators and equipment for each sub system shall be separately grouped and identified on the FIP. The FIP shall incorporate facilities for the following major items:

- Fire main hydrant pressure switches,

- Air conditioning and ventilation smoke control for fire fan controls,
- PMCS and TMCS outputs, and
- Alarm

10.48 HIGH LEVEL INTERFACE

A high level interface shall be provided by RS485 or RS232 output at the FIP and shall support Ethernet TCP/IP. The interface shall enable the fire detection system to interface with other systems. Full details of the high level interface shall be made available so the relevant equipment suppliers for them to program their equipment to accept the fire system interface.

Interface of other equipment to fire services as listed below shall be provided.

- Provision of interfacing public address and radio rebroadcast system for emergency purposes from the FIP,
- Provision of motorist/fire service telephones,
- Provision of reed switches to each emergency cabinet,
- Telephone in the fire control Centre/room directly connected to an external exchange
- Provision of data and alarm to the SCADA system, and
- Provision of automatic transmission of the fire alarm signal to the fire brigade or fire station.

10.49 GRAPHIC USER INTERFACE AND INDICATOR PANEL

Fire detection system shall be capable of displaying individual detector and zone status on the Graphic user interface. The Graphic user interface shall incorporate an integral sounder that is activated upon receipt of an alarm. The Graphic user interface panel should have no direct control of the fire system. The user functions should be limited to local sounder isolate and scrolling of the display. The Graphic user interface panels shall be fully supervised such that if the Graphic user interface stops working, a fault will be generated at the main FIP.

Indicator Panel shall have the following features:

- Visual indicators of system status and faults,
- Automatic operation from standby power supply in the event of main power failure,
- Facilities to initiate fault signals,
- Facilities to communicate with operator,
- status of all control and supervisory equipment,
- Facilities to provide voice alarm signals,
- Connection to PA system,
- Supply 24V DC voltage, and
- Tone generators,

10.50 FIRE BRIGADE ALARM

The system shall be provided with Alarm Signalling Equipment (ASE) to provide automatic transmission of the fire alarm signal to the fire brigade or fire station dispatch Centre. Where the permanent connection for the fire brigade calls is of landline type requiring. A cable from the tunnel control room to the outside tunnel termination.

Cubicle, the cabling shall be fire rated. Where the permanent link comprises a radio link, signal strength tests shall be conducted to ensure the signal strength of the controlling station is in accordance with the monitoring service and Manufacturer's requirements.

10.51 FIRE CABINETS INSIDE THE TUNNEL

Fire Cabinet shall be located at suitable Intervals (approx. at distance of 150m) in the tunnel and shall include:

- Reed switch monitored access door,
- Emergency bush button,
- Two (2) x portable fire extinguishers,
- Motorist emergency telephone, and
- Signage

10.52 FIRE SUPPRESSION HYDRANT SYSTEM INTRODUCTION

Automatic fire hydrant system shall be provided throughout the tunnel. Two ring main configurations shall be providedEach ring main configuration will have its own electrically driven pump sets (1 main + 1 standby + 1 automatic jockey pump set)

One branch of hydrant ring main will run in the tunnel at high level and second branch will run in the cross passage at low level. Cross connection shall be provided between these two branches constructed from concrete encased pipes running through vent duct.

The piping material shall be hot dip galvanized steel pipe with 200 diameter NB pipe with wall thickness 6.35mm. The piping end will roll grooved and joined with roll grooved galvanized coupling. The gasket material fir the coupling shall be EPDM.

The pipe support shall be hot dip galvanized steel and consisting of thrust block, etc.

Suitable expansions joint shall be provided to allow for expansions and contraction of pipe. The pipe shall be provided with earthing point for the earthing connection to be performed by M&E electrical sub-contractor. The hydrant piping shall be provided with drain point at suitable locations to drain the system. Pressure relief valve and air relief valve shall be provided to relieve the air while pressurising the system. Portable water shall be used for the hydrant system.

Power supply for pump set shall be available from DG (diesel generator) sets as stand by.

The hydrant pipes running in the tunnel shall be provided with an automatic sprinkler head at every pipe joint. This sprinkler will be a fixed temperature type and will

operate at a predetermined temperature. The function of this sprinkler is to provide cooling effect to pipes and pipe joints so that the pipes can withstand the high temprature and heat loads.

For the purpose of the firefighting systems, the tunnel is divided into two sections (i.e two portals). Each tunnel section has been provided with an independently pressurised fire hydrant system.

The overall fire hydrant system mainly consists of:

- Twin hydrant tank compartment
- Pumping systems
- Pipework and Hydrant Outlets.
- The ring and pump selections shall be made to comply following:
- Maximum operating pressure under flow condition shall not exceed 1600 Kpa within the system
- Maximum static pressure within the system and hydrant point shall not exceed 1600 Kpa under no flow condition with the pump running

10.53 TWIN HYDRANT TANK COMPARTMENT

The hydrant system water tank is divided in to two equal compartments, each compartment is independent and provided with incoming water supply.

Nos.2 water tanks with a usable capacity of 230 m3 each will be adjacent to the firefighting station; they will supply water for pipes and hydrants during a firefighting event.

Each water tank will be divided into two, so to have 4 vessels of 125 m3 each; in case of maintenance of a single tank the total available water volume will be 375 m3.

Water tankers will use the valve arrangement provided end. A portable electric driven booster pump shall be maintained and store by the tunnel operator, for filling the hydrant water tank from the water tankers.

The tank compartment shall contain a level transmitter for remote indication and the control of the tanks filling pumping system and a low level switch also for hydrant pump controls, Access rung ladder to the infill valve box, tank water level sensor and low level float switch shall be provided.

The tank may not be provided with any drain/slug valve to empty the tank. Provide and use portable suction pump sets (diesel driven) to empty the tank and clean the residual manually.

Every tank will be equipped with the following:

- Check valve;
- Exhaust valve;
- Flanged bleeder valve leading to collecting basin;
- Water level control sensor for activating check valve;

- Alarm sensor for low water level (the alarm goes to the control room which is supervised 24/7 in case of a defect check valve in open position);
- Visual level warning;
- Collecting basin with lifting pump for water evacuation.

10.54 PUMPING SYSTEMS

10.54.1 FIRE HYDRANT PUMPING STATION PUMPS

Provide independent electric boosters horizontal or end suction centrifugal fire hydrant pumping systems designed to maintain their respective delivery lines pressurized at all times for firefighting and wash-down. The pumps shall have cast iron housing, bronze impeller and stainless-steel shaft. The impeller shall be statically and dynamically balanced after assembly into the shaft.

The pumps shall comply in all respects to the requirements of the relevant standard.

Each station has been provided with a bypass valve for pump running test without interrupting the hydrant systems.

The pumps shall have soft staters in order to minimize the impact of water hammer and to reduce the motor starting currents.

The pump shall be sized to allow for a 10% upgrading of the maximum impeller size.

The pump seals shall be of the stuffing box and gland type with bronze glands and stainless steel or monel metal studs and nuts. Packing shall be coated with graphite grease before insertion. The shaft shall be fitted with renewable bronze wearing sleeves for the gland seal.

Pumps shall incorporate drip wells and screwed outlets under the exposed ends of the glands. Copper drain pipework shall be run from each drip well to discharge over the nearest waste point.

Bearings shall be deep groove ball or roller type designed for not less than 100,000 hours continuous service. Adequate provision shall be made in the bearing to take any axial trust a that may be imposed on the impeller. Grease nipples shall be provided on the pump casing adjacent to each bearing to enable manual lubrication of the bearings. Provision shall be made for releasing excess grease pressure.

The pump casing shall be of adequate strength to withstand the test pressure of the system or a minimum of 1400 kPa, whichever is the greater. The suction inlet shall be generously sized to handle the required flow without cavitation.

The impeller shall have machined sealing collars and shall be keyed to the shaft. The pump shall have a non-overloading power characteristic.

Each pump shall be direct coupled to its drive motor by means of rubber sheathed pin type flexible coupling. The coupling shall be fitted with a sheet metal guard.

Each pump and motor assembly shall be mounted on a common base of substantial mild steel or cast iron construction of adequate strength to maintain the components in correct alignment.

Pump and motor alignment shall be carried out after installation of the pump on site.

The base shall be bolted via vibration isolating mounts to the 150 mm high concrete plinth at to ensure pump is above the floor.

An orifice plate may be used if required to achieve the performance.

An identification plate of either brass or aluminum shall be screw fixed to the pump unit and shall include but not be limited to the following information:

- Manufacturer
- Model
- serial number
- size
- Impeller rpm
- Impeller size mm
- packing and Spacers make/size/catalogue number
- pump rating

10.55 PUMP CURVES

Provide to the Engineer for review, the pump curves for each pump showing the minimum and maximum main pressures, system duty points and the square law curve for the automatic fire sprinkler system hazard class.

10.56 PUMP START ARRANGEMENT

If a hydrant point is opened, the jockey pump would start first because of the pressure drop. Since the demand of hydrant point cannot be catered by a jockey pump, the main pump would start. The control arrangement will be provided such that when main pump start, the jockey pump is cut off. In case the main pump fails to start, the stand by pump set would come into the operation.

10.57 AUTO JOCKEY PUMP AND PRESSURE VESSEL

Provide an automatic electric low flow high pressure Jockey pressure maintenance pump to maintain the hydrant systems at a pre-determined pressure controlled by a self-contained cut in/out mechanism. The jockey pump acts to keep the line pressurised at all times as well as minimizes hydrant pump stop/start sequence.

The Auto Jockey Pump shall be stainless steel vertical multistage centrifugal with 2 kW 240V motor - 14 bar rated pressure tank, pressure switch and pressure gauge or approved equivalent.

The pump shall draw water from the water supply and discharge into the system distribution. The casing of the pump shall be suitable for the maximum working pressure of the system.

A gate valve shall be installed in the pump suction and discharge pipes. A check valves shall also be included in the suction and discharge pipe.

The pump motor shall be three 'phase, drip proof and shall be provided with a totally enclosed manuals DOL starter fitted with thermal overloads.

Power supply to the pump shall be taken from the electric booster pump control panel and all wiring and terminations from panel to the pump shall be provided.

Allow for all circuit breakers, contactors, connections and ancillary equipment at panel for the correct operation of the pump.

The pressure Maintenance Pump and Pressure vessel assembly Shall be Sized to provide. the pressure and flow requirement and shall start and stop automatically responding to the system Installation pressure.

The pump arrangement shall comply with the relevant Standard.

Power supply to the pump will be provided via the starter from a socket outlet provided by the Electrical Sub-Contractor.

10.58 PUMP CONTROL PHILOSOPHY

Each pumping system has its separate switchgear and control gear assembly cabinet (SCA) with the following modes of operation.

- Off Mode,
- Manual, and.
- Auto Mode.

Off mode: the whole pump system is wholly disabled n a lockable position.

Manual Mode: This mode is to enable the manual selection of a pump for operation.

Auto Mode: In this mode the following scenarios will take
place: Fire Hydrant Pumps:

The pumps duty and standby roles will switch over between each start.

On starting, if the discharge pressure has not gone pass the low limit, within 10 sec, then the standby pump will take over. The standby pump will be also subject to the same conditions of operation, if in Auto mode.

Via a differential pressure switches, the duty pump will start and stop between the operating pressure limits as indicated in the table above so that the delivery lines are fully pressurised at all times.

The Auto Jockey Pump and pressure vessel connected to the discharge line acts to keep the line pressurised all times as well as minimizes pump stop/start sequence.

10.59 PIPEWORK GENERAL

Piping drawings shall be developed which shall be considered as schematic for clarity in indicating the general run and connections. Piping drawing shall include its true position in every instance and all bends, offsets, elbows as required for approval and site execution.

Be Responsible for full coordination with the building/twin tube tunnel components and provide all pipework, fittings and supports as required in their correct location for the correct operation of the system.

All proposed deviations from the drawings shall be submitted to the Engineer for approval.

All pipework and equipment shall be accurately set, plumbed and levelled and hanger rods shall be true vertical alignment. Pipework and supports may have to be offset, lowered or raised as required or as directed on site for coordination with structure and building services.

Pipework or any other works which, in the opinion of the Engineer, are not installed as , required shall be removed and replaced at no extra cost.

All pipework shall be located so that it will not interfere with the operation and maintenance of other building/tunnel services.

All pipework except foam suppression system pipework shall be flushed out with water.

Foam suppression system: pipework shall be cleaned with solvent and sealed prior to installation.

After installation the system shall be flushed with dry compressed air prior to testing.

Should any leaks develop in the various piping systems during installation, testing, and/or warranty period, repair same and make good any damage to the building structure, contents, etc. resulting from such leaks.

All piping which is concealed from view (within ceiling spaces', walls, ducts, trenches etc.) shall be pressurised with water and tested for leakage in the presence of the Engineer before it is enclosed.

Pipe subject to external weather and freezing shall be protected with heat trace or insulation for antifreeze protection.

10.60 MATERIALS AND INSTALLATION

All distribution, hydrant and tank filling pipelines will be galvanised steel of Schedule 40 to ASME 836.10 (or equivalent) with heavy duty Victaulic shouldered couplings and bracket supports.

The external surfaces of hydrant pipelines only will be coated with bonding primer followed by two coats of fire-red epoxy paint. However the pipework within the pump station will have flanged connections for ease of maintenance and durability.

Roll Groove (Victaulic Shouldered) or Similar Grooved
Couplings Roll groove couplings shall:

- not be used for underground, buried or inaccessible pipework
- only be used for pipes up to 300 mm diameter
- contain indication of size and manufacturer's name
- be installed and supported strictly in accordance with the manufacturer's recommendations
- all roll grooving shall be done with approved machines and roll sets with bevel cut up to 200 mm diameter and square cut for larger diameter pipe
- all coupling joints shall be bolted up metal to metal at the pads

- suit the pressure rating of the pipework on which it is installed

Where roll groove coupling systems are installed then the following conditions apply:

- the Installing Sub-Contractor shall have significant experience with the product
- the Sub-Contractor shall have completed a one day training session for grooving of pipe and control of quality records, conducted by the Coupling Manufacturer
- Sub-Contractor's staff shall have completed a one day training session for installation procedures for roll groove products, conducted by the Manufacturer
- Housings, gaskets and grooves shall be an approved combination and all couplings and gaskets shall be readily available from local suppliers.

Each housing and gasket shall be compatible with the pipe to which it is fitted.

The whole assembly shall be used in accordance with the manufacturer's recommendations.

The grooves shall not be cut, but are to be rolled and will be dimensionally compatible with the gaskets and couplings.

The gaskets shall be a central cavity pressure responsive design suitable for the application and will be of rubber grade and compound approved for continual service within the applicable temperature and pressure ranges.

Housings shall consist of a one or more piece, ductile or malleable iron casting with nuts, bolts, locking toggle or lugs to secure the unit together. They shall be free from obvious surface porosity and mould flash,

10.61 PIPE TESTING

All pipework shall be hydrostatically pressure tested in sections or in their entirety at an early stage to avoid delaying the work of other trades.

Testing shall be carried out before piping is boxed or otherwise covered by false ceilings, walls, ducts, etc.

Pipework in the vicinity of electrical and other equipment shall be tested before the equipment is installed. Alternatively, the equipment shall be adequately protected during testing.

Testing pressures for hydrant pipework shall be 1700 kPa and held for a period of 24 hours without any pressure drop.

All defects disclosed during testing shall be immediately rectified and new tests carried out after rectification work.

Items of plant and equipment liable to damage at the test pressure to be applied shall not be connected while pressure tests are being carried out.

Supply a sufficient number of plugs to blank off all outlets of the section of pipework to be hydrostatically tested. The plugs shall be removed on satisfactory completion of hydrostatic testing of each progressive section of work.

Pipe Hangers and Supports

The piping system and all associated equipment shall be properly supported by suitable clips,

brackets and hangers in such a manner as to provide all necessary restraint to ensure its capability of accepting all normal loads and movements which can occur in the building areas served by the system without excessive noise transmission, vibration or displacement at connections and joints.

Pipe shall not be supported from non-fire rated or dry wall building structure. Sagging pipes or untidy runs will not be accepted.

Pipework shall be supported at each change of direction.

Provide all necessary supplementary support work to secure pipe supports. Pipe supports shall be constructed of galvanised mild steel.

Pipe exposed supports shall be hot dip galvanised after fabrication and shall be provided with galvanized hardware.

Hangers, etc. shall be placed as close as practicable to pipe flanges, valves etc. where these occur and shall be at intervals sufficiently close to allow not more than normal anticipated design stresses and deflections under full load conditions.

Pipe supports shall be of an approved pattern obtained through normal trade sources, or, alternatively, detailed designs of the supports proposed shall be submitted and approval obtained prior to commencing work.

10.62 VALVES

Valves shall:

- be provided as required for safe and proper operation of all equipment and distribution.
- be manufactured and approved to international/Indian Standards with international approval such as FM, UL etc.
- be new and line sized unless otherwise noted
- be approved by the local Water Authority for valves installed in the town main connections
- be installed in positions where they are easily accessible for operation and maintenance
- not be welded to pipes or fittings
- Connection to pipe shall be roll grove type or flanged
- be suitable for a test pressure of not less than 400 kPa above the maximum working pressure of the system in which it is installed
- Where over 50 mm diameter, be flanged valves or approved roll groove type Valves of 50 mm
- close with clockwise rotation of the hand wheel for all gate valves

- have bronze body, bronze or stainless steel spindle or hinge pin, bronze valve and seat for all valves up to and including 50 mm
- have cast iron or steel body, bronze or stainless steel spindle or hinge pin and bronze value and seat for all values of 65mm and over
- be fitted with name plates to indicate both their use and to open and to shut direction
- have a red engraved white plastic laminated label clearly indicating its function attached to the body of the valve. The labels shall be readily visible to an operator and attached to the valve by means of a durable, non-corroding key ring or other approved means
- be of the one approved manufacturer for each type of valve
- be fitted with an approved monitoring device which monitors whether the valve is in the closed or open position where the valve is specified to be monitored
- Gate valves shall be used for on/off control and butterfly valves shall be used for throttling.
- Gate valves larger than 65 mm bore shall be cast iron with bronze facing rings and be of the outside screw and yoke or butterfly type.
- Isolation gate valves on Hydrant Pump Suction line shall be Rising Spindle Gate valve type and on the discharge side shall be gear operated butterfly type.

10.63 PRESSURE GAUGES

Pressure gauges shall be Bourdon tube actuated type with a minimum face diameter of 100 mm. The normal operating pressure shall be marked in red on the dial face and the selection of the gauge shall provide this pressure at not more than 75% of maximum calibrated pressure on the dial. Provide a gauge cock with each gauge.

The gauges shall have a matt black finish and shall be pipe mounted.

Each gauge shall have its function indicated by an engraved label

Provide the following pressure gauges as a part of the installation:

- Compound gauge with a range of-100 to +150 kPA on the hydrant pump suction line.
- Pressure Gauge with a range of 0-1600 kPa on the hydrant pump discharge line
- Immediately upstream and downstream of any pressure reducing valve adjacent to any fire brigade booster connectional each pressure switch including jockey pump pressure vessels.

10.64 PRESSURE SWITCH

The pressure switches shall be micro switch type with a pressure range up to 2000 kPa with a general-purpose metal housing.

Provide pressure switches in hydrant systems to perform the following functions.

- actuate an electric alarm bell on fall in installation pressure
- ancillary alarms via the Fire Indicator Panel (FIP), (eg., building monitoring system, emergency warning and intercommunication system)

10.65 HYDRANT OUTLETS

Two types of hydrant outlet, Type-A & Type-B, alternatively installed at suitable intervals. Each Hydrant point is equipped with two 80mm valves.

Type-A contains two standard hose connection outlets, a telephone, an alert button, a 2.7 kg CO2 extinguisher and a 2.7 kg dry chemical extinguisher. All are in a red painted fire cabinet.

Type- B only contains two standard hose connection outlets. All are in a red painted fire cabinet.

10.66 FIRE HOSE

Provide and mount at each electric niche and water storage cavern within the tunnel two fire hoses and one aluminum pipe and branch pipe can be mounted on wall. Provide sign outside the wall - FIRE HOSE INSIDE. The hose shall be 36m long.

10.67 PRE-HYDROSTATIC TESTING

Following installation and prior to testing, all pipework shall be thoroughly cleaned out by repeated filling and draining until the condition of the drain water indicates that the system is clean.

10.68 FIRE BRIGADE BOOSTER CONNECTIONS

The fire hydrant systems shall be fitted with Fire Brigade booster connections to enable the Fire Brigade to pressurise or pump water into the systems. Supply shall be provided with booster connections at hydrant water storage tank.

The booster connections shall comply with latest standards and the requirements of the local Fire Brigade.

Fire Brigade booster connections shall be adequately supported and located in a position that is readily accessible to fire brigade personnel. They shall each be fitted with an integral full way non return valve, and any other fittings required by the local and approved hose connections equipped with standard caps with securing chain.

The pipe between the full way non return valve and the outside hose connection shall be galvanised and fitted with a plug cock that shall drain to a suitable place. Provide Storz couplings to suit.

A pressure gauge shall be provided to indicate the boosted pressure.

The enclosure in which the Fire Brigade booster connections are housed shall be marked with the words Fire Brigade Sprinkler and Hydrant Booster Connection, as applicable, in 50 mm high lettering in a contrasting colour to the booster enclosure.

An engraved sign shall be fitted in the booster enclosure showing a block plan of the site and installation/sand the working and test pressures of the systems.

A block diagram of the installation shall be provided.

10.69 EMERGENCY WARNING AND COMMUNICATION SYSTEM

The tunnel roadways and associated tunnel structures such as electrical niche, etc. shall be provided with visual and audible emergency warning system. The warning system shall consist of speakers, strobe lights, etc. The emergency phones shall be provided at interval of 150m in the tunnel. The emergency cabinet shall house the fire phone. A manual break glass call point shall also be provided in this cabinet.

Master emergency control panel shall be provided in Control room at portal buildings

Various secondary emergency control panels shall be provided in the tunnel electrical niches.

All the above master and secondary emergency control panel shall be networked with 2 physically separate network path. All the master controls shall be performed from one portal control room and other panels cannot override the master controls from one portal control room.

A paging console shall be provided with each master control panel.

The system should be capable to use the entire speaker at a time in the emergency.

The EWIS subdivides the tunnel into above evacuation zones. Each evacuation zone shall have amplifier(s) and a number of associated speakers (existing). In sections of the building where background noise is high, visual alarm devices shall be used in addition to speakers. Each evacuation zone may have one of three audio channels. These channels are Alert signal, Evac signal and OFF. The Off channel shall be configured on site (via a jumper) on a zone basis to one of the following sources: silence.

The EWIS system shall have a microphone for the PA input, and a tone generator module (TGM), which is responsible for generating the alert and evacuation signals.

The EWIS shall have TWO possible types of alarm signal inputs to indicate that an emergency condition is occurring in the building.

These are:

- Emergency Alarm Initiating Devices (EAIDS) i.e. manual call points
- Fire Indicator Panel (FIP)

When an input, (i.e. EAID or FIP), initates an alarm signals, the EWIS if in automatic mode, shall initiate a preset evacuation sequence. The evacuation sequence shall sound the alert and the Evac signals to the evacuation zones within the building (and activating the visual alarm devices if installed) according to the pre-programmed evacuation, sequence. The manual override shall cease the pre-programmed evacuation sequence, and output alert and Evac signals to evacuation zones as dictated via the EWIS panel control switches.

The EWIS shall provide full system status and fault indication facilities.

10.70 EWIS CONTROLS

The control switches shall allow any of the three audio channels (PA, Alert or Evac) to be switched to any of the zones. The Control Switches shall be inhibited when the EWIS is in the AUTOMATIC state.

Pressing any of the control switches for an evacuation zone shall automatically cancel the previous selection for that zone, i.e. only one audio channel shall be assigned to a zone at any one time.

For each evacuation zone there shall be a set of control switches and associated indicators:

- CANCEL Control switch only
- PA Control switch and Indicator
- ALERT Control switch and Indicator
- EVAC Control switch and Indicator

10.71 EMERGENCY WARNING SYSTEM ZONE FAULT:

EWIS Zone Fault Indicator shall flash when a fault is detected by the MAIN EQUIPMENT on any of the wiring or components associated with that zone, and go steady when the fault is, acknowledged by the buzzer mute switch.

10.72 ALARM ORIGIN:

Alarm Origin Indicator shall flash when an input, i.e. FIP and EAID associated with that zone, has been activated and go steady when the alarm is, acknowledged by the buzzer mute switch.

Fault and Alarm Indicators shall not be inhibited by any key-switch operation.

10.73 NETWORKING GENERAL

The Emergency Warning & Intercommunication system shall be configured as a multi master, peer to peer network. Each node on the network shall be an ECP or Remote Equipment Rack which shall be able to operate in stand-alone mode in the event of network failure or partial implementation of the system.

10.74 ZONE MAPPING

The indications and controls for each zone on a networked ECP shall be able to be mapped by software to any amplifier outputs, strobe outputs.

Amplifier outputs, strobe outputs, and WIPs shall be able to be programmed to be controlled by one or more ECPs on the network.

Sequential Evacuation Options

The network shall provide flexible sequential evacuation program options for alert and evacuate tones so that a particular sequence can be spread across various nodes of the network or unique sequences can be allocated for each node.

Allocation of Manual Control

The WIP keys for a zone shall be always active on any ECP to which they are mapped and they shall effectively work in parallel.

The evacuation keys for a zone shall be only active at one node at a time (or inactive at all nodes if all mapped zones are switched to AUTO).

Zones shall be grouped for the purpose of assigning manual control to various ECPs. Each group shall be assigned its own priority amongst the ECPs. For each group, manual control shall be able to be allocated to the highest priority ECP which is switched to MANUAL or ISOLATE.

10.75 NETWORK EVENT LOGGING AND DIAGNOSTICS

A serial communications port shall be available at each node of the network to make diagnostic and configuration data available to the user. This port shall make the following information available as a minimum:

- Factory configuration of the node.
- Network set-up and diagnostic information.
- Log of any fault conditions on any equipment on the node (amplifier cards, speaker lines, strobe lines, WIP lines).
- Log of FIP alarms and operation of the evacuation sequence.
- Setting of evacuation sequence time delays if applicable.

10.76 REMOTE CONNECTION

A modem shall be provided at the network nodes designated on the approved drawings. Whenever a FIP alarm occurs, the system shall dial out to a remote computer or printer and display or print alarms and, if configured to do so, shall also log the evacuation sequence. The call shall automatically disconnect after a period of inactivity.

Facilities shall also be provided to allow the user to dial in and access system diagnostic functions.

10.77 MICROPHONE

The Microphone shall be used for the PA facility. The microphone shall have a press to talk (PTT) switch.

10.78 SYSTEM EQUIPMENT POWER SUPPLY/ CHARGER

Provide a power supply/battery charger of modular construction..

Mains supply shall be 230V AC at 50Hz .

10.79 BATTERIES

Be designed and installed in locations with a view to minimize the detrimental effects of moisture, dust, insects and other foreign materials.

Be installed in accordance with manufactures recommendations.

10.80 SPEAKERS

All ceiling speakers shall:

- Have an overall maximum diameter of 100mm.

- Be supplied with a matching grill or similar approved.
- All horn speakers shall have a minimum power rating of 10 watts.
- Be reflex horn type with a multi-tap transformer.

10.81 VISUAL ALARM

All visual alarms shall:

- Have an overall diameter of 100mm.
- Incorporate a xenon tube.
- Red/Amber xenon strobe light

10.82 EMERGENCY ALARM INITIATING DEVICE

Provide Break glass point (emergency alarm initiating device) along with fire phone.

10.83 SYSTEM CABLING

All cabling shall be halogen free cable material

The system cabling shall comply with the Indian Standards listed under rules and regulations of this document and follow the appropriate guidelines listed below.

10.84 MASTER EMERGENCY CONTROL PANEL TO SPEAKERS:

A two core 2 hours fire rated cable from each MECP amplifier shall be installed to the speaker and then looped to the other speakers in that zone.

10.85 MASTER EMERGENCY CONTROL PANEL TO VISUAL ALARMS:

A two core cable from the MECP shall be installed to the first pair of visual alarms and then looped to the other VA's in that zone.

10.86 CABLE SPECIFICATIONS:

Capacitance of 100 picofarads per meter or less. Resistance of 100 milliohms per meter or less. Impedance of loop typical 100 to 120 ohms.

10.87 CABLE TYPE:

Radox FR Communication 1.5mm 1 pair.

The data cable shall be wired as a redundant loop.

10.88 MASTER EMERGENCY CONTROL PANEL TO REMOTE PAGING CONSOLE:

One, two core shielded audio cable. The RPC shall connect to 240V AC

One, two core twisted pair shielded data cable shall be installed via the RS-485 data loop to the RPC.

10.89 CABLE SPECIFICATIONS:

Capacitance of 100 picofarads per meter or less, Resistance of 100 millohms per meter or less, Impedance of loop typical 100 to 120 ohms.

10.90 MASTER EMERGENCY CONTROL PANEL TO FIRE INDICATOR PANEL:

As per manufacturers recommendations.

Upon detection of gas, the automatic detection system will send a signal to the solenoid of deluge valve of the foam suppression system. The deluge valve will then open and discharge the foam into the tank. The open type of nozzle will be located at the top of the tank. Foam discharge will take place through these nozzles. Suitable type of foam compound shall be used. Minimum of 15 minutes discharges capacity of storage shall be provided.

10.91 PORTABLE EXTINGUISHERS GENERAL

Portable fire extinguishers shall be:

- provided at each emergency cabinet and ancillary areas
- mounted in position on an approved mounting bracket
- provided with corresponding identification plates above each extinguisher

Extinguishers: Portable extinguishers shall:

- be rechargeable
- be hand operated
- comply with relevant standards
- be of approved manufacture
- be acceptable to the Fire Authority
- be of the type and size as scheduled

Do not place extinguishers on the mounting brackets/cabinets until the day of the final inspection by the Authority engineer.

10.92 EMERGENCY EQUIPMENT

Emergency equipment with the tunnels will be located within emergency control cabinets. These cabinets will be located at suitable intervals in each tunnel tube and contain:

- read monitored access door
- portable fire extinguishers
- emergency/fire telephones
- push button alarm
- fire hydrant landing valves (2 No.)

11 WATER SUPPLY GENERAL DESCRIPTION OF WORKS

The M&E works are as follows:

- Design, supply, install, testing and commissioning of 2 No. Ecosol RSF 4300 Solid Pollutant Filter/Oil & Grease Arrestor (1 No. at each Portal).
- Design, supply, install, testing and commissioning of 1 No. 4,000 L Septic Tank at each portal.
- Design, supply, install, testing and commissioning of 2 No. Effluent Disposal System 1.2m wide x 150m long x 1.2m deep. (1 No. at each Portal) including DN100 uPVC pipes from Septic Tanks to the Effluent Disposal System.
- Design, supply, install, testing and commissioning of 1 No. 20,000 L Potable Water Storage Tank at each portal.

12 PROJECT OPERATIONAL VEHICLES

This document describes the design, manufacture, delivery, installation, testing and commissioning and operational maintenance requirements of the Project Operational Vehicles for the

12.1 MAINTENANCE VEHICLES

The Maintenance Vehicles shall be as follows:

- Located at the control building for maintenance purposes only.
- One shall be supplied for the maintenance manager, one shall be supplied for the electrical maintenance staff and one shall be supplied for the mechanical maintenance staff.
- The maintenance vehicles shall be twin cab.
- Similar to TATA TL Crew Cab 4x4 or approved equivalent.
- 1950cc engine capacity
- Run on diesel fuel
- Provided with a lockable tool box.
- Provided with a roof rack and rear frame for transporting equipment on the roof of the vehicle.
- Provided with a first aid kit.
- Suited to the local weather conditions and altitude at the project site.
- Vehicles provided shall be brand new, not second hand or rebuilt in any way and supplied with dealers paperwork.
- Number of vehicles – 03

12.2 EMERGENCY RESPONSE VEHICLES

The Emergency Response Vehicles shall be as follows:

- Similar to Fire Rescue Safety standard, Rapid Intervention Vehicle or approved equivalent.
- Fitted with CO2 and chemical fire extinguishers.

- Fitted with 4500 litre Foam Suppression System.
- Carry 3 off fire hoses for connection to fire hydrants located in the tunnel.
- Run on diesel fuel.
- Suited to the local weather conditions and altitude at the project site.
- Vehicles provided shall be brand new, not second hand or rebuilt in any way and supplied with dealers paperwork.
- Number of vehicles – 02

12.3 HIAB TRUCK (FOR LIFTING AND TRANSPORTING)

The Hiab truck shall be as follows:

- Similar to HIAB XS 044 D-4 CLX or approved equivalent.
- Suited to the local weather conditions and altitude at the project site.
- Vehicles provided shall be brand new, not second hand or rebuilt in any way and supplied with dealers paperwork.
- Number of vehicles – 02

12.4 FORKLIFT (FOR LIFTING GOODS OF INCOMING AND OUTGOING VEHICLES)

The Forklift shall be as follows:

- Similar to Crown Series 4210 Three Wheel Counter Balance Truck or approved equivalent.
- Suited to the local weather conditions and altitude at the project site.
- Vehicles provided shall be brand new, not second hand or rebuilt in any way and supplied with dealers paperwork.
- Number of vehicles – 02.

Annexure – XV
NABET Certificate

QUALITY COUNCIL OF INDIA

National Accreditation Board for Education and Training

Certificate of Accreditation

Ambiental Global Private Limited, Ghaziabad

Plot No.182, Ground Floor, Sector 7 Rajnagar, Ghaziabad

The organization is accredited as ***Category-B*** *under the QCI-NABET Scheme for Accreditation of EIA Consultant Organization, Version 3 for preparing EIA-EMP reports in the following Sectors –*

S.No	Sector Description	Sector (as per)		Cat.
		NABET	MoEFCC	
1	Mining of minerals including opencast/ underground mining	1	1 (a) (i)	A
2	Industrial estates/ parks/ complexes/areas, export processing Zones(EPZs), Special Economic Zones (SEZs), Biotech Parks, Leather Complexes	31	7 (c)	B
3	Highways	34	7 (f)	A
4	Common Effluent Treatment Plants (CETPs)	36	7 (h)	B
5	Common Municipal Solid Waste Management Facility (CMSWMF)	37	7(i)	B
6	Building and construction projects	38	8 (a)	B
7	Townships and Area development projects	39	8(b)	B

Note: Names of approved EIA Coordinators and Functional Area Experts are mentioned in RAAC minutes dated Aug 31, 2022 and posted on QCI-NABET website.

The Accreditation shall remain in force subject to continued compliance to the terms and conditions mentioned in QCI-NABET's letter of accreditation bearing no. QCI/NABET/ENV/ACO/22/2541 dated Oct 03, 2022. The accreditation needs to be renewed before the expiry date by Ambiental Global Private Limited, Ghaziabad following due process of assessment.

Sr. Director, NABET
Dated: Oct 03, 2022

Certificate No.
NABET/EIA/2225/RA 0259

Valid up to
April 09, 2025

For the updated List of Accredited EIA Consultant Organizations with approved Sectors please refer to the QCI-NABET website

Annexure – XVI
NABL Lab Certificate

National Accreditation Board for Testing and Calibration Laboratories

NABL

CERTIFICATE OF ACCREDITATION

ENVIRO-TECH SERVICES

has been assessed and accredited in accordance with the standard

ISO/IEC 17025:2017

"General Requirements for the Competence of Testing & Calibration Laboratories"

for its facilities at

1/32, SOUTH SIDE OF G.T.ROAD, GHAZIABAD, UTTAR PRADESH, INDIA

in the field of

TESTING

Certificate Number: TC-8771

Issue Date: 26/12/2019 Valid Until: 25/12/2021

This certificate remains valid for the Scope of Accreditation as specified in the annexure subject to continued satisfactory compliance to the above standard & the relevant requirements of NABL.
(To see the scope of accreditation of this laboratory, you may also visit NABL website www.nabl-india.org)

Signed for and on behalf of NABL

N. Venkateswaran
Chief Executive Officer