

**GOVERNMENT OF INDIA  
MINISTRY OF RAILWAYS  
(RAILWAY BOARD)**

2018/Proj./MEGA/DBR/30/26

New Delhi, dated 20.08.2018

**Managing Director,**

Metro Link Express for Gandhinagar and Ahmadabad  
(MEGA) Company Limited, 5th Floor,  
Nirman Bhawan, Opp. Sachivalaya Gate No.4,  
Sector-10-A, Gandhi Nagar,  
Gujarat -382010

**Sub: Approval of Design Basis Report (R/1, June, 2018) for Tunnels on  
UG-1 & UG-2 stretch of Metro Link Express for Gandhinagar and  
Ahmedabad (MEGA) for Standard Gauge (1435mm).**

Ref: MEGA Company Ltd's letter No. MEGA/DBR/RDSO/2018/625-A dated  
30.06.2018

The Design Basis Report (DBR) for design and construction of Bored  
Tunnels, (R/1, June, 2018) for Standard Gauge (1435mm) for Metro Link  
Express for Gandhinagar and Ahmedabad (MEGA) has been examined in  
consultation with RDSO and approval of Railway Board is hereby conveyed.

Accordingly, approved copy of DBR is enclosed.

Encl: As above

  
20-08-2018  
**(Ruth Changsan)**  
Director/MTP  
Railway Board  
☎ 011-23097061

Copy to: **Executive Director/UTHS**, RDSO, Manak Nagar, Lucknow w.r.t  
RDSO's letter No. UTHS/81/MEGA/Civil dated 07.08.2018



# DESIGN BASIS REPORT (DBR) FOR DESIGN AND CONSTRUCTION OF BORED TUNNEL

R-1/JUNE 2018



METRO-LINK EXPRESS FOR GANDHINAGAR AND AHMEDABAD  
(MEGA) COMPANY LIMITED.

(A SPV of Government of India and Government of Gujarat)

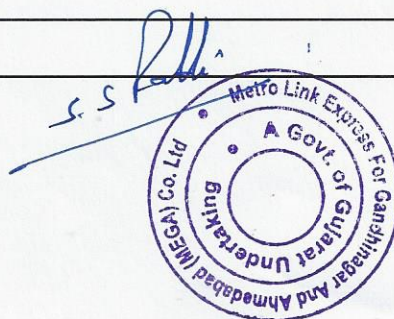
MEGA Co. Ltd. PROJECT PHASE - 1





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## **1 INTRODUCTION**

### **1.1 General:**

Provision of approved model DBR of viaduct to be followed where ever applicable

#### **Brief Description of the Project**

Ahmedabad is located in the meridians of 23.022505° N latitude and 72.5713621° E Longitude, spread over an area of 464.165 sq km. located at an altitude of 53 m. Ahmedabad Metro Rail Phase I comprises of two Corridors. The details of the two corridors are given below:

#### **Corridor-1(East-West):**

Vastral Gam- Nirant Cross Road- Vastral- Rabari Colony- Amraiwadi- Apparel Park- Kankaria East- Kalupur Railway Station- Gheekanta- Shahpur- Old High Court- Stadium- Commerce Six Road- Gujarat University- Gurukul Road- Doordarshan Kendra- Thaltej- Thaltej Gam

#### **Corridor-2(North-South):**

Motera Stadium- Sabarmati- AEC- Sabarmati Railway Station- Ranip- Vadaj-Vijaynagar- Usmanpura- Old High Court- Gandhigram- Paldi- Shreyas- Rajivnagar-Jivraj- APMC

The portions of Corridor-1 from Kankaria East to Shahpur will be underground and the remainder elevated.

### **1.2 Underground Station and Project Details:**

#### **Project Details:**

Details	Corridor 1	Corridor 2	Total
	Vastral Gam to Thaltej Gam	Motera Stadium to APMC	
Underground Length (km)	6.335	NIL	6.335
Elevated Length(km)	14.402	18.522	32.924
Total Length(km)	20.737	18.522	39.259
Underground Station (nos)	4	NIL	4
Elevated Station (nos)	13	15	28
Total Station (nos)	17	15	32

#### **Underground Station Details:**

Sr. No.	Corridor 1
	Vastral Gam to Thaltej Gam
1	Kankaria East Metro Station
2	Kalupur Metro Station
3	Ghee Kanta Metro Station
4	Shahpur Metro Station





### 1.3 Geometric Design Criteria

Sr. No.	Criteria	Dimension
1	Gauge	1435mm
2	Max. Operating speed	80km/h
3	Max. Axle load, loaded condition	16 tonne
4	Max. Gradient running track Max. Gradient depot connecting track	4% 4%
5	Minimum vertical curve radius Minimum horizontal curve radius	1500m 120m (main line track)
6	Traction power collection	750 Volt DC Traction system
7	Inclination of rail	1 in 20
8	Wheel tread profile	UIC 510-2 (S1002)
9	Rail profile	UIC 60 E1
10	Maximum cant	125mm
11	Maximum cant deficiency	100mm

## 2 SCOPE OF DBR

The design basis report hereto provides minimum standards that are to govern the design of the bored tunnel by Tunnel Boring Machine (TBM). The purpose is to establish the minimum requirements for the investigation, design, instrumentation and monitoring for bored tunnel works. The design basis report shall be read in conjunction with the Outline Construction Specifications where appropriate.

The design of the permanent and temporary supporting works shall comply with code of practice and standards at the time of submission of Tender Documents, Regulations made and requirements issued by the Indian Government and by relative utility authorities shall be followed and specified.

## 3 MATERIALS

### 3.1 Cement

- (1) Ordinary Portland cement (OPC) of 33 grade, 43 grade and 53 grade conforming to IS: 269, IS: 8112-1989 and IS: 12269-1987, respectively shall be used.
- (2) Portland pozzolana cement (PPC) conforming to IS: 1489 may also be used.
- (3) The Employer's Representative may give notice for the usage of sulphate resistant Portland cement conforming to IS 12330 for structural elements exposed to soil.
- (4) For foundation and substructure, the Engineer may direct the OPC substitution by Blast Furnace Slag Cement conforming to IS: 455.
- (5) In all cases the cement shall meet the 28 day strength requirement of IS 8112-1989 or IS 12269-1987.

### 3.2 Concrete

- (1) The Density of concrete adopted shall be as below:
  - a. 24 kN/m<sup>3</sup> for prestressed concrete (IS:875 part-1 table-1 item 21 value rationalized).





- b.  $24 \text{ kN/ m}^3$  for reinforced concrete with 2% or less reinforcement (IS: 875 part-1 table-1 item 22 values rationalized).
  - c.  $25 \text{ kN/ m}^3$  for reinforced concrete with above 2% reinforcement (IS: 875 part-1 table-1 item 22 values rationalized).
  - d.  $23 \text{ kN/ m}^3$  for plain concrete (IS: 875 part-1 table-1 item 20).
- (2) Short term modulus of elasticity 'Ec' & Modular Ratio 'm' shall be as per clause no. 6.2.3.1 & B-1.3 (d) of IS: 456 respectively.
  - (3) Minimum grade of concrete shall be M35.
  - (4) Thermal Expansion Coefficient:  $1.17 \times 10^{-5} / ^\circ\text{C}$  (Cl.2.6.2 IRS Bridge Rules).
  - (5) Poisson's Ratio: 0.15 for all concretes.
  - (6) Minimum cement content and Maximum Water-cement ratio as per Table 5 of IS: 456.
  - (7) Strength of concrete is the specified characteristic compressive strength of 150 mm cube at 28 days.
  - (8) Minimum concrete cover as per IS: 456.

### 3.3 Reinforcement

Only thermo-mechanically treated reinforcement bars conforming to IS: 1786 shall be adopted. (For seismic zone III, IV & V with minimum total elongation of 14.5%).

### 3.4 Structural Steel

#### General

- (1) Design of Structural steelwork shall comply with IS: 800.
- (2) Two types of structural steel to be used and shall comply with the following standards.
  - a. IS: 4923 "Hollow steel sections for structural use with  $Y_{st} 310$ ".
  - b. IS: 2062 "Steel for General Structural Purposes (Grade B-Designation 410-B)".
- (3) Hollow steel sections shall be square (SHS) or rectangular (RHS). Other traditional rolled sections like plates, angles, channels, joists can also be used where required.
- (4) The connection with concrete shall be effected by internally threaded bolt sleeves (hot dipped galvanized @ 300 grams per square meters) manufactured from IS:2062 Grade B mild steel. The sleeve shall receive hexagon-head bolt M20 Class 8.8 as per IS: 1364 (Part 1) with galvanized spring washer.
- (5) The connections within the steel structure shall be designed as direct welded members with or without gusset plates. The minimum thickness of metal for SHS/RHS sections for main chord members as well as bracings shall be 4 millimeters as applicable for steel tubes in cl. 6.3 of IS: 806.





### 3.4.1 Material Properties

Material Properties shall be as follows.

Steel Type	Young's Modulus	Tensile Strength	Yield Strength	Density	Poisson's Ratio	Thermal Expansion Coefficient
For Hollow Steel sections (conforming to IS: 4923)	200,000 MPA	450 Mpa	310 Mpa	78.5 KN/m <sup>3</sup>	0.30	1.2x10 <sup>-5</sup> per °C
Structural Steel (Conforming to IS:2062)		410 Mpa	250MPa (for t<20mm), 240MPa (for 20mm < t < 40mm), 230MPa (for t > 40mm)			

## 4 TUNNEL PROFILE, CONSTRUCTION METHODS AND SHAPE

The bored tunnels comprise twin single-track tunnels. The spacing between the tunnels shall be based on the soil strata and determined by numerical analysis. The minimum internal diameter for bored tunnel shall meet all services and SOD (Schedule of Dimensions) requirements. Bored tunnels in rock and soil will be excavated mainly using tunnel boring machines, other methods if required based on geological and hydrological condition to be decided. Initial tunnel support will generally include precast concrete segments, shotcrete/wire mesh, rock bolts, lattice girders, steel sets, or forepoles wherever necessary.

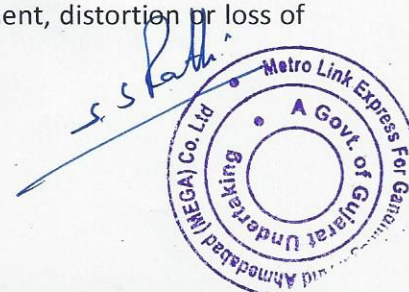
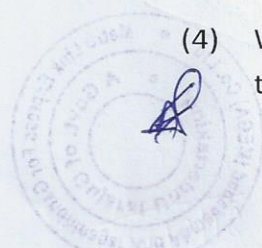
## 5 DESIGN LIFE/ DESIGN SPECIFICATIONS/ REQUIREMENTS/ PRINCIPLES

### 5.1 Design Life

Design life of bored tunnel segment lining is to be kept minimum 100 year.

### 5.2 Tunnel Design

- (1) The design of the bored tunnel lining shall be fully compatible with the construction methodology and shall be carried out using suitable software.
- (2) The design shall also take into account all expected loads prescribed in item no.6.
- (3) The design shall take into account all additional loads, stresses and strains imposed by or on adjacent Existing Building Structures (EBS) and assumed distortions and loads by or on the proposed bored tunnels.
- (4) Where bored tunnels are adjacent to or beneath EBS, the design shall demonstrate that these EBS shall not be subjected to unacceptable movement, distortion or loss of



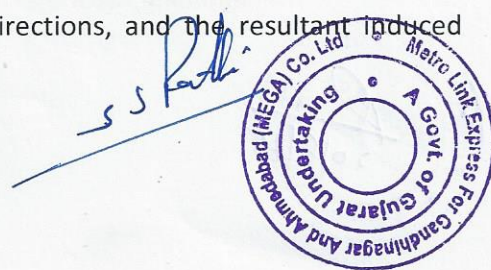


support which endangers the stability of the EBS and that any resulting movements and distortions will be within prescribed limits determined by the authority for that EBS, the Employer's Representative, or the Owner.

- (5) The Designer shall ensure that ground movements and distortions, and changes to the loads and piezometric pressures which may affect adjacent EBS either at surface or underground, are within the allowable tolerances for each of those EBS.
- (6) The design shall consider and minimize the short- and long-term influence of the bored tunnels on the groundwater regime, and similarly the influence of the groundwater on the bored tunnels.
- (7) During tunneling, Designer to be constantly review the ground conditions based on envisaged and actual condition encountered, to allow excavation to be carried out in the safest and most efficient manner. This review shall be fully integrated into the construction risk control and should typically include:
  - a. Probing ahead of and around the bored tunnel face in rock conditions.
  - b. Interpretation of fresh data and correlation with previous information.
  - c. Prediction of ground conditions likely to be encountered.
  - d. Investigation on the surface for the presence of water wells/bore wells for domestic use in residential areas that intersect the alignment.
- (8) Ground Information from all construction activities shall be collated and interpreted.

### **5.3 Tunnel Lining Segment**

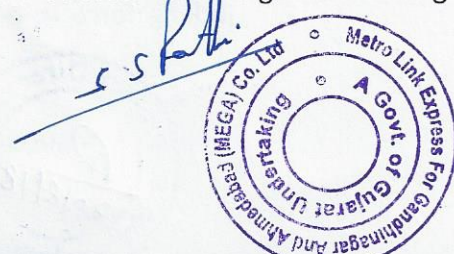
- (1) The design of the segments shall be adequate for all stresses induced during stacking, lifting, transport, erection jacking and impact, including in-service stress & impact.
- (2) The design shall consider in-situ ground stresses and shall provide evidence and/or measurements in support of the parameters adopted in the design as part of the calculations. The ground load on the tunnel shall be based on the actual height of overburden above the tunnel lining and the coefficient of earth pressure at rest of the soil strata surrounding the tunnel.
- (3) The design of the bored tunnel linings shall take into account the proximity of the bored tunnels one to another, the sequence and timing of construction and the proximity of adjacent EBS.
- (4) The design shall also consider the relative rates of loading / unloading due to TBM jacking force in both the lateral and vertical directions, and the resultant induced





tunnel deformations whether temporary or permanent.

- (5) The segment has to be designed for 4hr fire rating as per IS 456:2000.
- (6) The design method shall take in to account the interaction between the lining and the ground, the deflection of the lining and the redistribution of the loading dependent upon the relative flexibility of the lining, the variability and compressibility of the ground.
- (7) The designer shall consider and conform to all durability aspects of the permanent bored tunnel lining including permeability / transmissivity and electrical resistivity.
- (8) The design shall take into account the proximity of the lining to the tunnel face at the time of installation and the potential for additional ground loads as the face advances.
- (9) The design shall allow for the expected variation in ground conditions and the size, proximity, timing and method of construction of adjacent excavations. The lining flexibility shall make due allowance for likely deflection of the lining during Construction and operation.
- (10) Where a permanent or secondary lining is to be installed inside a temporary or primary lining, the ground loads used in permanent lining design shall consider all loads as described in the Contract and any additional ground loads that may arise from time-dependent ground strains.
- (11) The stiffness of the permanent lining should be such that the deflections are within permissible limits as per BS: 8110-part1 and IS:456.
- (12) The thickness of segments shall suit the method of construction and shall not be so large that part shoving of the shield becomes a general necessity.
- (13) The thickness of the segments shall be consistent with the capacity of the circle bolting arrangements to withstand the shear forces induced in linings built with staggered joints and for the planned reinforcement and required concrete cover.
- (14) A groove for a single elastomeric gasket shall be provided on all joint faces of each segment and key in accordance with the gasket dimensions. The elastomeric gasket shall be suited to the conditions under which it is required to operate for the design life. The gasket grooves shall allow for accurate mating of the gaskets of adjacent segments.
- (15) A groove for post-construction grouting/caulking as necessary shall be provided on the intrados for each segment joint.
- (16) The lengths of segments shall be chosen with regard to bending stresses during handling, storage and erection and the long term stresses due to ground loading





and the resultant deflections.

- (17) The design of linings shall include tapered rings in order to negotiate the alignment curvature and to correct for line and level during construction with the minimum use of circumferential joint packers consistent with attaining the required degree of watertightness of the bored tunnels in accordance with the Contract.
- (18) The design for segment lining shall address aspects including the following, as appropriate
- Ring configurations,
  - Segment size and form,
  - Fixing details including for:
    - ring to ring fixings;
    - segment to segment fixings;
    - fixings for all equipment to be installed
    - handling, stacking and installation of segments;
    - holes, recesses-and fixtures for other system components.
  - Tolerances in production and installation of segments shall be accounted in the design.
  - Installation of Other components, such as:
    - grout hole valves;
    - gaskets;
    - bedding and packing materials.
  - Cavity grout, between lining and ground.
  - Instrumentation and monitoring to demonstrate performance of the installed linings.
  - Short-term (during construction) intermediate (immediately after construction) and long-term (full design life) loading conditions.
  - Stresses induced by grouting and ground pre-treatment, where applicable.

## 6 DESIGN LOADS AND LOADING CONDITIONS

### 6.1 Loads

Linings shall be designed to withstand all environmental loadings, distortions and other effects without detriment. In general, bored tunnel linings shall be designed to fulfill the following requirements and to resist the following loads.

- Dead Load
- Superimposed surface loads from traffic, existing structures over and adjacent to the bored tunnel, and any specified future loads.





**c. Seismic Loads:**

Ahmedabad falls in seismic zone III as per the Indian Earthquake standard IS 1893:2002.

The zone factor (Z) related to Zone III is 0.16 (Table 2 and Annex E in IS 1893:2002).

The importance factor (I) was chosen to be 1.5 to meet the seismic design requirements (Table 6 in IS1893:2002).

- d. Appropriate Ground Loads and Water Pressure.
- e. Railway Loads where appropriate.
- f. Structural requirements for resisting buckling.
- g. Long- and short-term ground yield or squeeze.
- h. Unequal grouting pressures.
- i. Adjacent bored tunnelling or excavation.
- j. Openings in, or extensions to, the lining.
- k. Long-or short-term loads induced by construction.
- l. Temperature and shrinkage.
- m. Handling loads, including impact, especially in the case of unreinforced segments.
- n. Jacking forces, where appropriate.
- o. Accidental loading such as fire and derailment.

**6.2 Loading Conditions**

- a. Dead load comprises the self-weight of the basic structure and secondary elements supported and the weight of earth cover. The depth of cover shall be the actual depth or a minimum of one diameter of tunnel. The depth of cover shall be measured from the ground surface to the tunnel crown.
- b. Traffic surcharge shall be as per the loading of IRC/IRS as applicable.
- c. Loads from existing or known future adjacent structures above or within the area of influence, which will remain in place above the bored tunnels, or any specified future loading. The applicable foundation load and its influence shall be computed based on the type and use, and the foundation type which supports that structure.
- d. Additional support, ground treatment or additional lining thickening shall be provided unless it can be shown that adequate provision already exists. Any structure surrounding tunnel should be supported by grouting and shotcreting techniques, should not be supported from tunnel lining.
- e. Where provision for a specific future structure is not made a minimum uniformly distributed surcharge of 60 kilo Pascal at the design finished ground level shall be assumed.
- f. Hydrostatic pressure, ignoring pore pressure relief arising from any seepage into the tunnel. Water at ground level to be considered for design.





- g. Loads and load changes due to known construction activity in the vicinity of the bored tunnel, such as the excavation and the formation of underpasses, basements, pile groups, bridges, diaphragm walls and cable ground anchors.
- h. The grouting pressure will not exceed the hydrostatic pressure by more than 1 bar, however the actual pressure will be decided by in-charge chief Engineer based on the geological conditions.
- i. Structural requirements for resisting buckling are to be checked since tunnel is being designed as compression member.
- j. Additional Loads / stresses in adjacent rings due to openings at cross passages locations to be considered.

### **6.3 Flotation**

For flotation check, the water table is assumed to coincide with the ground level. Where the bored tunnels are relatively shallow they shall be checked for the possibility of flotation due to differential water pressure at representative typical locations. Uplift due to displaced water to be considered in the design. The overall factor of safety against flotation shall not be less than 1.1 for any of the condition.

### **6.4 Crack width**

All structural concrete elements shall be designed to prevent excessive cracking due to flexure, early & long term age thermal shrinkage. Flexural crack width shall be checked in accordance with Appendix F of IS: 456. The limits specified in cl.35.3.2 of IS: 456 has to be followed.

### **6.5 Load Cases, Load Factors and Combinations.**

All analysis shall clearly show the designs achieve the design factors of safety.

#### **6.5.1 Load cases**

The following load cases will be considered at each design section:

- i. Load case-1: Ground water table at the ground surface with uniform surcharge of 60 KN/m<sup>2</sup>
- ii. Load case-2: Ground water table at the ground surface with no surcharge
- iii. Load case-3: Ground water table at 3m below existing ground water level with uniform surcharge of 60 KN/m<sup>2</sup>
- iv. Load case-4: Ground water table at 3m below existing ground water level with no surcharge.
- v. Load case-5: Ground water table at extreme water level with no surcharge.

#### **6.5.2 Load factors and Combinations**

The design forces will be derived based on the following load factors Based on IS:456-2000, BS 8110-part1 (1997) and Hong Kong DSM-Section 4 (2009).





Load Case	Dead Load	Hydro Static Pressure	Earth Pressure	Surcharge Load
Case1	1.4	1.4	1.4	1.4/1.5/1.6 <sup>#</sup>
Case2	1.4	1.4	1.4	
Case3	1.4	1.4	1.4	1.4/1.5/1.6 <sup>#</sup>
Case4	1.4	1.4	1.4	
Case5	1.4	1.4*	1.4	
Serviceability**	1.0	1.0	1.0	1.0

- # - If Surcharge load is taken as per British standards then load factor should be 1.6.  
 - If Surcharge load is taken as per Indian standards then load factor should be 1.5.  
 - For Special cases of conservative surcharge load (such as future flyover construction etc.) load factor of 1.4 can be adopted.
- \* - Load factor for extreme water table (flooding case) can be reduced to 1.0.
- \*\* - Water level for serviceability is to be at ground level.

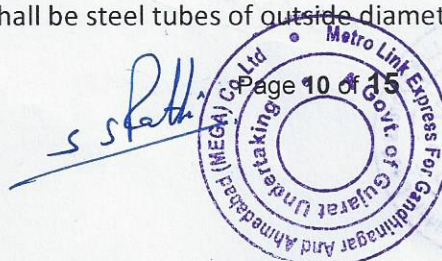
## **7 GENERAL CONSTRUCTION METHODS**

- (1) Initial ground support for the bored tunnels is expected to comprise ground pre-treatment (where necessary) and/or precast concrete segments.
- (2) Methods for excavation spoil removal, ground treatment, installation of initial support and the permanent lining construction to be prepared.
- (3) Excavation shall be carried out in a uniform and controlled manner, over-cutting shall be kept to a minimum.
- (4) Appropriate methods and necessary steps to be taken to control flows and movement into, and to maintain the stability of the excavation.
- (5) Instrumentation and monitoring arrangements for ground and existing building structures (EBS) movement and distortion and changes to the groundwater table(s) and the trigger (Alert, Action & Alarm) levels for each and every identified EBS to be performed. Designer has to specify the required instrumentation and monitoring arrangement to maintain the safety of the EBS.

### **7.1 Tunnel Lining – General**

#### **7.1.1 Tunnel Lining - Temporary Support**

- (1) Steel sets and lattice arch girders shall be rolled to suit the dimensional requirements of the designed opening. The Contractor shall provide dimensional details of the steel sets or lattice arches girders and lagging which include all calculations regarding imposed loads before and after any ground pre-treatment.
- (2) Spiles shall be steel rods or tubes of outside diameter not less than 25 millimeters.
- (3) Pipe piles shall be steel tubes of outside diameter not less than 100 millimeters.





- (4) Rock dowels shall be untensioned steel bars threaded at one end and provided with a face plate, shim plates and a conical seated washer and nut, or split or deformed steel tubes, or glass fiber reinforced resin rods.
- (5) Rock bolts shall be tensioned bar manufactured out as one of the following types - solid steel bar, slit or deformed steel tube, glass fiber reinforced resin rods.
- (6) Alternative materials shall be subject to the notice of the Employer's Representative.

#### **7.1.2 Tunnel Lining – Permanent Support**

- (1) The permanent bored tunnel support or lining shall generally comprise segmental spheroidal graphite iron (SGI) or precast concrete (plain or reinforced) rings that are held securely in place and the will remain so for all known possible future conditions.
- (2) Exceptions to these permanent linings may be at cross-passages (links between tunnels), enlargements of the bored tunnel and at the junction between cut-and-cover and bored tunnel sections. In such locations cast-in-place linings shall be used, or alternative types of permanent lining may be proposed subject to the notice of The Employer's Representative.
- (3) The reinforcement for segmental concrete lining shall be detailed such that there is no electrical continuity across the circle joints. To prevent the stray current effects and to inhibit the corrosion, suitable property enhancers shall be added in to concrete. Such concrete shall be tested in accordance with ASTM C 1202 and DIN 1048. SGI lining segments and all concrete reinforcement shall be bonded to mitigate stray currents. The bonding shall be part of the corrosion control system designed and installed by the Contractor to the notice of the Employer's Representative. The corrosion control system shall be tested and proven to the satisfaction of the Designer that the corrosion control system functions as designed in all locations.

#### **7.1.3 Gasket Grooves**

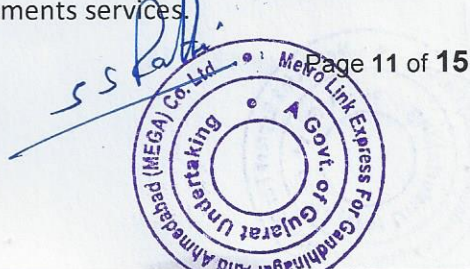
Gasket grooves shall be provided around all joint faces of each segment and key in accordance with the dimensions as approved by the engineer in charge. The design shall incorporate sealing gaskets in the segmental design.

#### **7.1.4 Grout holes**

Grout holes shall be provided in segment as per design excluding the key.

#### **7.1.5 Waterproofing**

Suitable waterproofing materials and methods shall be used to meet the requirements services.





#### 7.1.6 Cavity grouting

General purpose cement grout with suitable admixture shall be mixed in accordance with the proposed design mix and purpose of use. Grout shall be used within one hour of mixing.

#### 7.2 Underpinning of Existing Structures

Where the construction of tunnels or other underground works would necessitate removal of existing support or foundations to existing structures the Designer shall carry out investigations of the extent of the existing works, their design and loading conditions and propose a suitable supporting / underpinning arrangement where ever is applicable.

### 8 CROSS-PASSAGES

- (1) Where tunneling is carried out not using TBM (i.e. by hand or face excavator) temporary support using pipe piles, spiles, structural-steel sets, lattice-arch girders, base-plates, ties and connections and lagging sprayed concrete (shotcrete) or cast-in-place concrete. all of which comply with the relevant standards may be used together with appropriate ground pre-treatment as deemed necessary for the expected ground conditions.
- (2) Passenger emergency evacuation design for cross-passages between running tunnels which are constructed by either cut-and-cover or bored method shall generally be in accordance with the requirements of NFPA-130-2010 and standard for fixing guide way transit and passenger Rail system as follows.
  - a. In single-track tunnels the distance from the end of a station to a tunnel shaft to the surface shall be not exceed 762 metres. Cross-passages shall be permitted to be used in lieu of emergency exit stairways to the surface where train ways are located within separate structures.
  - b. The distance between adjacent cross-passages in tunnel shall be provided as per clause NFPA 130 2010 6.2.2.3.2.
  - c. Track cross-overs shall not be considered as cross-passages.
- (3) The openings into the running tunnels shall have a width of 1.2 meters and a height of 2.1 meters. Throughout the cross-passage the minimum headroom of 2.1 meters shall be maintained over a width of 1.2 meters.
- (4) The cross-passage floor screed shall be laid to fall and drain into the running tunnel drainage system. Floor level shall correspond with the level of the bored tunnel escape route.
- (5) A concrete bulkhead fitted with steel door and frame shall be constructed to isolate the cross-passage from each running tunnel. This door shall be self-latching, have a fire resistance of 2 hours minimum and shall be capable of withstanding the maximum





differential pressures on either side created by the passage of trains. The Maximum force to open the door shall be as per NFPA 130 2010 6.2.2.4.2.

- (6) The cross-passage permanent lining shall comprise concrete lining designed generally in accordance with the requirements of these documents with the following exception that the maximum allowable deflection on radius shall be as per IS:456 clause 23.2 (b).
- (7) The junctions with the running bored tunnels shall be steel-framed and encased with concrete. The junctions shall be designed to fully support the running tunnel linings at the openings together with the ground and groundwater loads on the junction itself.
- (8) The cross-passages and junctions shall comply with same water-tightness criteria as the bored tunnels.
- (9) Where openings for cross-passages and the like are to be formed in running tunnels with segmental concrete or SGI linings, temporary internal supports to the running tunnel lining shall be provided. These supports shall adequately restrain the ground and lining such that on completion of the openings and removal of the temporary supports the total deflection of the linings in either the opening, junction or running tunnel and water ingress do not exceed the limits.

## **9 TUNNEL WALKWAYS**

- (1) Walkways to be designated as per approved SOD.
- (2) The Escape Walkway shall provide continuous access from the trains to the cross-passages and/or station platforms.

## **10 TUNNEL BORING MACHINES**

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 for this project 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.

### **General design requirement of TBM:**

- a. TBM design shall ensure that the cutter-head can be retracted back from the unexcavated ground to minimise the risk of the TBM jamming and to facilitate maintenance.
- b. TBM design shall make adequate provision for the safety of the workmen and the application of safe methods of tunnelling.
- c. TBM shall be designed for and equipped with a supplemental ground stabilisation system. This system shall comprise regularly spaced grout ports built into the shield for drilling into and grouting the ground ahead of the tunnel face. The location and number of ports shall be adequate for implementation of face stabilisation measures needed





for access to the face in all ground conditions. All ports shall be readily accessible and fitted with valves.

- d. TBM shall be designed to enable the void between the segment lining and the ground (tunnel extrados) to be grouted continuously from the shield as the shield is propelled forward by synchronised operation. TBM design shall allow control of the grouting volume, pressure and pipes to be cleaned in the event of a blockage. Grout pipes shall be integral within the thickness of the TBM tail skin. A minimum of four (4) separate grout pipes shall be provided. External grout pipes will not be permitted.
- e. 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.

## 11 DRAINAGE ARRANGEMENT IN RUNNING TUNNELS

- (1) The Designer shall coordinate with the adjacent station plumbing design before finalizing the design for drainage arrangement and sump location.
- (2) The reserve capacity of a groundwater seepage sump shall be calculated on the basis of the area of bored tunnel lining applicable to the sump in accordance with the following formula.

$$VR = A * v * t * F.O.S. * 10^{-3}$$

Where,	VR	=	Volume of reserve, m <sup>3</sup>
	A	=	Bored tunnel lining area, m <sup>2</sup>
	v	=	Maximum leakage rate, l/m <sup>2</sup> /day
	t	=	Maximum response time, (day)
	F.O.S	=	Factor of Safety

- (3) For running tunnel lows, point sumps the response time "t" shall be 24 hours and the factor of safety shall be 1.5.
- (4) The sump design shall include outlets for the longitudinal drain pipe and discharge mains, pumps of suitable capacity and power connection. Sumps shall be fitted with steel covers and provided with step irons or access ladder. Permanent discharge mains shall be installed as well as embedment of conduits for permanent electric power cables to the pumps.
- (5) The linings of the sumps shall be designed for the appropriate ground and groundwater loads.

## 12 LIST OF DESIGN CODES AND STANDARDS

Subject to the requirements of this specification and other Control documents, all design work shall comply with the appropriate current standards issued by the Bureau of Indian Standards





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(BIS), or if such a standard does not exist, then the appropriate current standard issued by the British Standard Institute (BSI). If appropriate standard from BIS and BSI does not exist, then subject to approval by engineer, an appropriate current standard from a reputable institution may be used. The designer shall follow updated codes with latest correction slips

(Note: the years of the codes mentioned below are notional, hence each time the designer shall adopt latest code with the latest correction slip)

The Order Preferences of codes will be as follows:-

- i. BIS
- ii. BSI or Euro Code
- iii. IRC
- iv. IRS
- v. AASHTO

### **13 UNDERGROUND STATION BUILDING**

For the design of Underground station building load factors, and other provisions in IS:456 shall be adopted as in case of Elevated stations.

### **14 MECHANICAL & ELECTRICAL SYSTEMS**

The items like Fire Detection System, Fire Suppression System, Fire Alarm PA System, Emergency Lighting, Power Supply System, Tunnel Ventilation etc. should be designed and Commissioned as per best International Standards like NFPA130, NFPA101 etc. and the best. International practices. These sub-systems should be got approved from the concerned State Authorities.



*SSR*  
30/6/18

