

SCHEDULES

Schedule - A

(See Clauses 2.1 and 8.1)

Site of the Project

1 The Site

- (i) Project site starts at Chhatroo [Junction with NH -244 at existing km 140.870 (old NH-1B)] in Kishtwar District. The east portal is located near Singhpora (Kishtwar District) which is 17.088 km from Chhatroo. So, approach road on east portal side is 17.088 km and lies in Kishtwar District. The Singhpora-Vailoo Tunnel is 10.363 km long. The west portal is located at Gadole and the end point is located at Vailoo [Junction with NH -244 at existing km 235.070 (old NH-1 B)] which is 11.160 km from West Portal. So, the length of approach road on west portal side is 11.160 km and lies in Anantnag District. Site of the project Highway shall include the land, buildings, structures, and road works as described in Annex-I of this Schedule-A.
- (ii) The dates of handing over the Right of Way to the Contractor are specified in **Annex-II** of this Schedule-A.
- (iii) An inventory of the Site including the land, buildings, structures, road works, trees, and any other immovable property on, or attached to, the Site shall be prepared jointly by the Authority Representative and the Contractor, and such inventory shall form part of the memorandum referred to in Clause 8.2 (i) of this Agreement.
- (iv) The alignment plans of the Project Highway are specified in Annex-III. The proposed profile of the Project Highways shall be followed by the contractor with minimum FRL as indicated in the alignment plan. The Contractor, however, improve/upgrade the Road Profile as indicated in Annex-III based on site/design requirement.
- (v) The status of the environment clearances obtained or awaited is given in Annex-IV.

**Annex – I
(Schedule-A)
Site**

1. Site

Construction of Uni-directional Singhpora - Vailoo Tunnel (Under Sinthanpass) of length 10.331km/10.363km (Tube-1/Tube-2) and its approach road from Km 111+067 (at Chhatroo km 140.870 on NH-244) to 149+678 (at vailoo Junction with NH -244 i.e., existing km 235.070) of total length 38.611 km in Union Territory of Jammu & Kashmiron EPC mode

The land, carriageway and structures comprising the site are described below.

2. Land

The Site of the Project Highway comprises the existing road and realignment length along the full length of corridor.

3. Carriageway

The project road has a carriageway width varying from 3m – 5.5m and earthen shoulder of varying width from 1.0 m – 1.5 m exists along both sides of the road.

4. Major Bridges

The Site includes the following Major Bridges:

Sl. No.	Ex Chainage (km)	Type of Structure			No. of Spans with span length (m)	Width (m)
		Foundation	Sub-structure	Super- structure		
1	0+975	Open	RCC	Steel Truss	1x65.00	

5. Road over-bridges (ROB)/ Road under-bridges (RUB)

The Site includes the following ROB (road over railway line)/RUB (road under railway line):

Sl. No.	Chainage (km)	Type of Structure		No. of Spans with span length (m)	Width (m)	ROB/ RUB
		Foundation	Superstructure			
Nil						

6. Grade separators

The Site includes the following grade separators:

Sl. No.	Chainage (km)	Type of Structure		No. of Spans with span length (m)	Width (m)
		Foundation	Superstructure		
Nil					

7. Minor Bridges

The Site includes the following minor bridges:

Sl. No.	Ex Chainage (km)	Type of Structure			No. of Spans with span length (m)	Width (m)
		Foundation	Sub- structure	Super- structure		
1	3+944	Open	Stone Masonry	Steel Truss	1x46.00	
2	7+260	Open	Stone Masonry	Steel Truss	1x26.00	

8. Railway Level Crossings

The Site includes the following railway level crossings:

S. No.	Location (km)	Remarks
Nil		

9. Underpasses (vehicular, non-vehicular)

The Site includes the following underpasses:

S. No.	Chainage (km)	Type of Structure	No. of Spans with span length (m)	Width (m)
Nil				

10. Culverts

The Site has the following culverts:

Sl. No.	Design Chainage in Km	Existing Chainages	Type of structures (pipe, slab, box, Arch)	Total Length (m)	Overall Condition	Remarks
1	-	00+709	Slab Culvert			Abandoned due to proposed realignment
2	-	01+470	Pipe Culvert	1.00	Poor	Abandoned due to proposed realignment
3	112+097	02+253	Pipe Culvert	1.00	Poor	Reconstruction
4	112+237	02+395	Slab Culvert	Blocked	Poor	Reconstruction
5	112+640	02+831	Pipe Culvert	1.00	Poor	Abandoned due to proposed realignment
6	113+137	03+345	Pipe Culvert	1.00	Poor	Reconstruction
7	114+070	04+333	Slab Culvert	1.55	Poor	Reconstruction
8	115+780	05+794	Pipe Culvert	1.00	Poor	Abandoned due to proposed realignment
9	116+070	06+094	Pipe Culvert	1.00	Poor	Abandoned due to proposed realignment
10	116+375	06+445	Pipe Culvert	1.00	Poor	Reconstruction
11	116+435	06+797	Pipe Culvert	1.00	Poor	Reconstruction
12	116+895	06+858	Pipe Culvert	1.00	Poor	Reconstruction
13	117+240	07+359	Pipe Culvert	1.00	Poor	Reconstruction
14	117+370	07+694	Pipe Culvert	1.00	Poor	Reconstruction
15	117+515	07+823	Pipe Culvert	1.00	Poor	Reconstruction
16	117+835	07+978	Pipe Culvert	1.00	Poor	Reconstruction
17	118+104	08+296	Pipe Culvert	1.00	Poor	Reconstruction
18	118+441	08+540	Pipe Culvert	1.00	Poor	Reconstruction
19	118+615	08+885	Pipe Culvert	1.00	Poor	Reconstruction
20	121+350	11+934	Pipe Culvert	1.00	Poor	Abandoned due to proposed realignment
21	121+510	12+111	Pipe Culvert	1.00	Poor	Reconstruction
22	122+840	13+400	Pipe Culvert	1.00	Poor	Abandoned due to proposed realignment
23	123+189	13+749	Pipe Culvert	1.00	Poor	Reconstruction
24	123+217	13+773	Pipe Culvert	1.00	Poor	Reconstruction
25	123+843	14+413	Pipe Culvert	1.00	Poor	Reconstruction
26	124+092	14+695	Pipe Culvert	1.00	Poor	Reconstruction
27	124+380	14+965	Pipe Culvert	1.00	Poor	Reconstruction
28	124+860	15+436	Slab Culvert	1.00	Poor	Reconstruction
29	125+196	15+780	Slab Culvert	2.30	Poor	Reconstruction
30	125+410	16+009	Slab Culvert	3.25	Poor	Abandoned due to proposed realignment
31	126+012	16+600	Slab Culvert	1.75	Poor	Reconstruction
32	126+395	16+983	Slab Culvert	2.85	Poor	Reconstruction
33	126+720	17+318	Slab Culvert	1.50	Poor	Reconstruction

11. Bus Bays

The details of bus bays on the Site are as follows:

S. No.	Chainage (km)	Length (m)	Left Hand Side	Right Hand Side
Nil				

12. Truck Lay byes

The details of truck lay byes are as follows:

S. No.	Chainage (km)	Length (m)	Left Hand Side	Right Hand Side
Nil				

13. Roadside drains

The details of the roadside drains are as follows:

S. No.	Location		Type	
	From km	to km	Masonry/cc (Pucca)	Earthen (Kutcha)
1	115+442	115+687	Pucca	
2	115+897	116+142	Pucca	
3	116+872	117+067	Pucca	
4	127+181	127+280	Pucca	

14. Major Junctions

The details of major junctions are as follows:

S. No.	Location	At grade	Separated	Category of Cross Road			
				NH	SH	MDR	Others
1	Realignment at km 111+067	T		NH			

(NH: National Highway, SH: State Highway, MDR: Major District Road)

15. Minor Junctions

The details of the minor junctions are as follows:

S. No.	Location	Type	Remarks
1	112+702	T	To Sinthan top
2	115+679	Y	To Village
3	146+510	Y	To Vailoo Village

16. Bypasses

The details of the existing road sections proposed to be bypassed are as follows:

S. No.	Name of bypass (town)	Chainage (km) From km to km	Length (in Km)
Nil			

Annex – II

(As per Clause 8.3 (i))

(Schedule-A)

Dates for providing Right of Way of Construction Zone

The dates on which the Authority shall provide Right of Way of Construction Zone to the Contractor on different stretches of the Site are stated below:

Sl. No	Design Chainage Km		Length (km)	Width (m)	Date of providing ROW*
	From	To			
(A) Part Right of Way (part width)					
Stretch. 1	111.485	113.662	2.177	4.5	On Appointed Date
Stretch. 2	113.813	114.100	0.287	7.8	
Stretch. 3	114.476	115.620	1.144	5.5	
Stretch. 4	115.940	116.165	0.225	5	
Stretch. 5	116.230	116.650	0.420	6	
Stretch. 6	117.600	118.045	0.445	6	
Stretch. 7	118.500	120.900	2.400	5.5	
Stretch. 8	121.290	122.252	0.962	6	
Stretch. 9	123.555	124.373	0.818	5	
Stretch. 10	125.478	125.630	0.152	7	
Stretch. 11	138.800	138.980	0.180	5.5	
Stretch. 12	143.211	143.457	0.246	5.5	
Stretch. 13	144.000	144.390	0.390	6	
Stretch. 14	145.160	147.175	2.015	8	
(B) Balance Right of Way (Balance width)					
Stretch. 1	111.485	113.662	2.177	20.5	Within 90 days after the appointed Date
Stretch. 2	113.813	114.100	0.287	17.2	
Stretch. 3	114.476	115.620	1.144	19.5	
Stretch. 4	115.940	116.165	0.225	29.5	
Stretch. 5	116.230	116.650	0.420	20	
Stretch. 6	117.600	118.045	0.445	17	
Stretch. 7	118.500	120.900	2.400	19.5	
Stretch. 8	121.290	122.252	0.962	15	
Stretch. 9	123.555	124.373	0.818	19.5	
Stretch. 10	125.478	125.630	0.152	20	
Stretch. 11	138.800	138.980	0.180	19.5	
Stretch. 12	143.211	143.457	0.246	24.5	
Stretch. 13	144.000	144.390	0.390	17	
Stretch. 14	145.160	147.175	2.015	18	
			11.861		
(C) New Alignment full PROW					
Stretch. 1	111.067	111.485	0.418	20 to 60 m	Within 90 days after the appointed date
Stretch. 2	113.662	113.813	0.151		
Stretch. 3	114.100	114.476	0.376		
Stretch. 4	115.620	115.940	0.320		
Stretch. 5	116.165	116.230	0.065		
Stretch. 6	116.650	117.600	0.950		
Stretch. 7	118.045	118.500	0.455		
Stretch. 8	120.900	121.290	0.390		
Stretch. 9	122.252	123.555	1.303		
Stretch. 10	124.373	125.478	1.105		
Stretch. 11	125.630	128.100	2.470		
Stretch. 12	128.100	138.500	10.400	60 to 150 m	
Stretch. 13	138.500	138.800	0.300	20 to 60 m	
Stretch. 14	138.980	140.334	1.354		

Sl. No	Design Chainage Km		Length (km)	Width (m)	Date of providing ROW*
	From	To			
Stretch. 15	140.334	143.211	2.877		
Stretch. 16	143.457	144.000	0.543		
Stretch. 17	144.390	145.160	0.770		
Stretch. 18	147.175	149.678	2.503		

*The dates specified herein shall in no case be beyond 150 (one hundred and fifty) days after the Appointed Date.

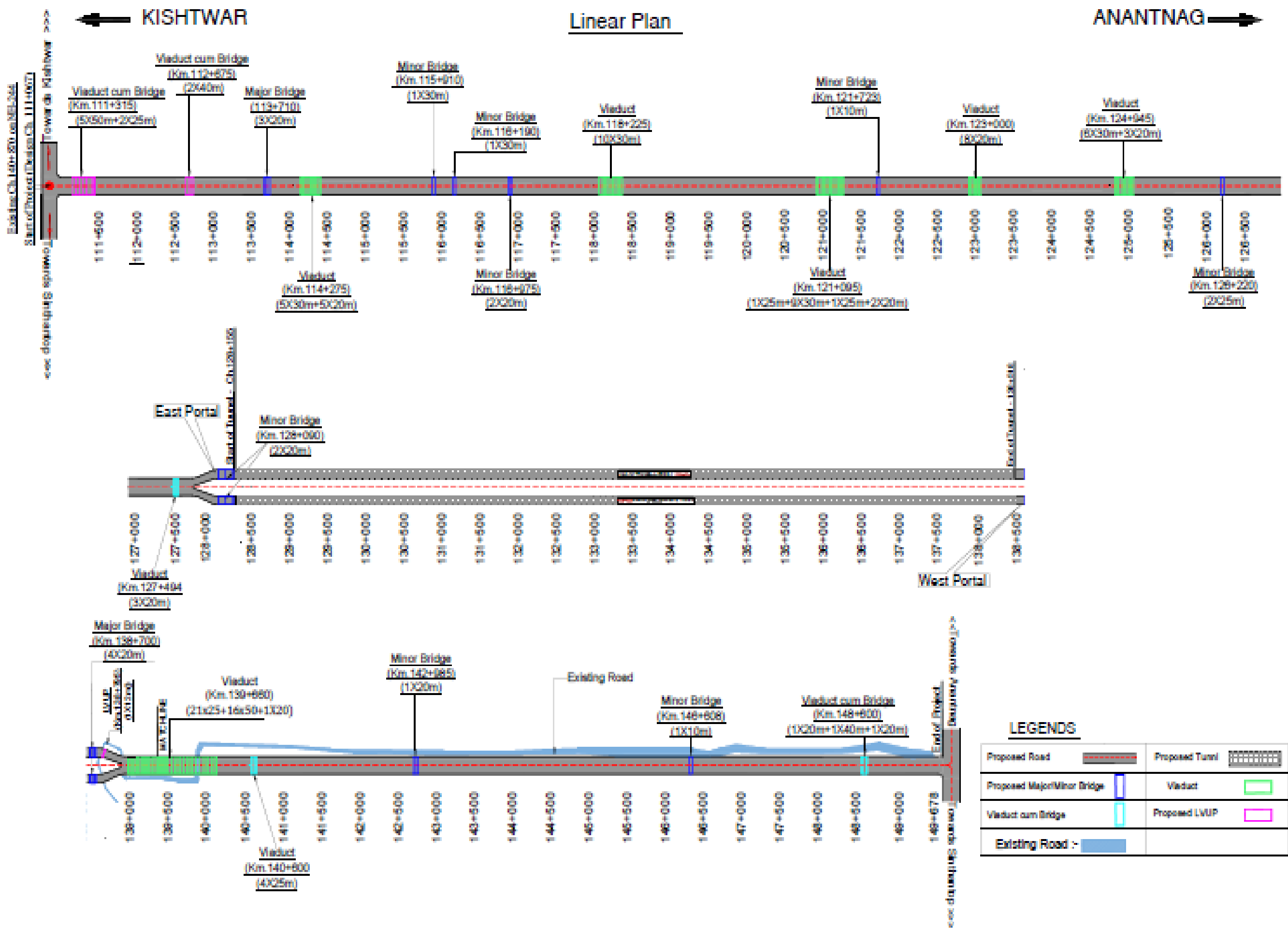
Annex - III

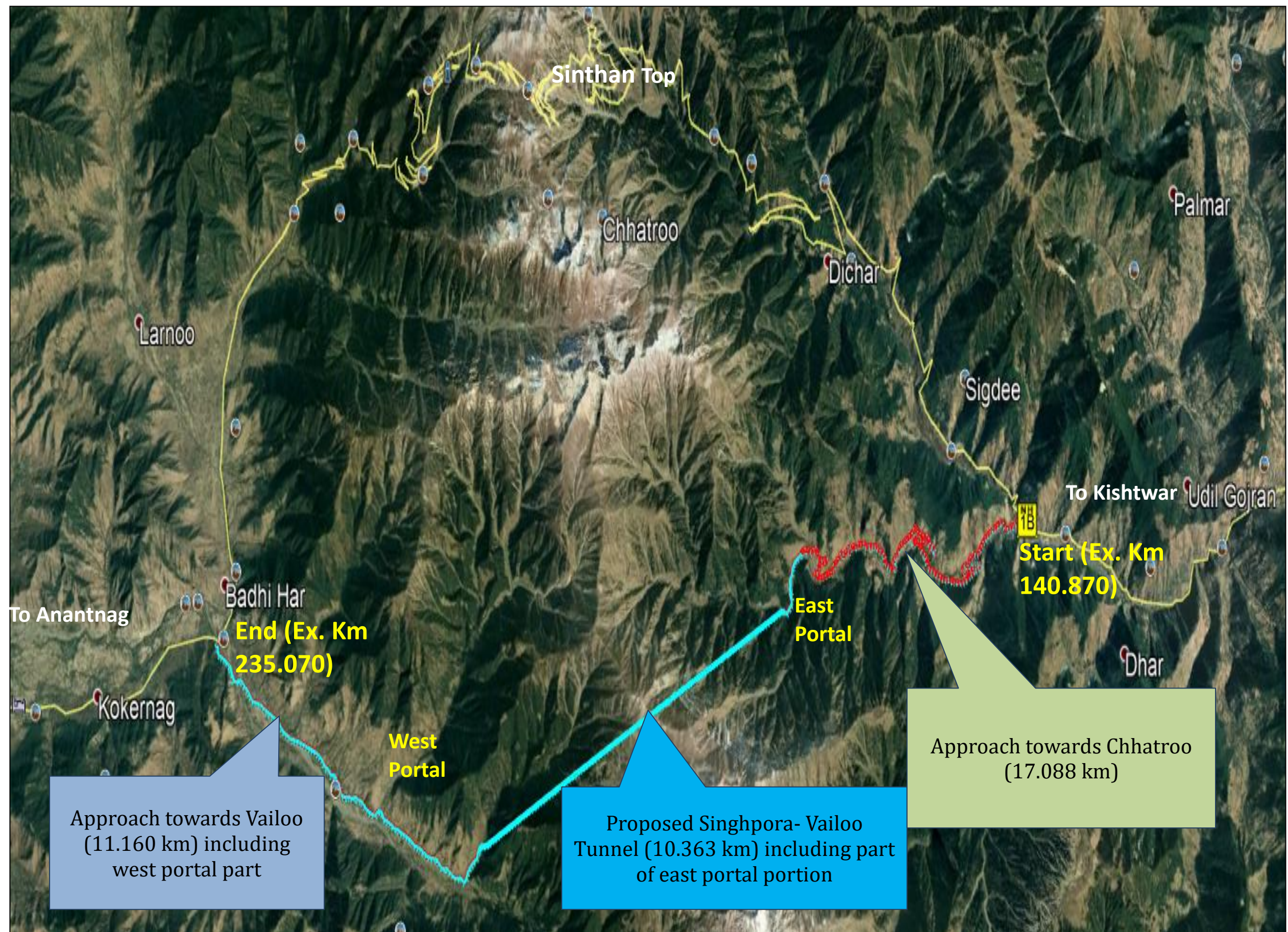
(Schedule-A)

Alignment Plans

The new alignment of the Project Highway shall be prepared as per the alignment plan indicated below:

- (i) The alignment of the Project Highway is enclosed in alignment plan and indicated below. Finished road level indicated in the alignment plan shall be followed by the contractor as minimum FRL. In any case, the finished road level of the project highway shall not be less than those indicated in the alignment plan. The contractor shall, however, improve/upgrade the Road profile as indicated in Annex-III based on site/design requirement.
- (ii) Traffic signage plan of the project highway showing numbers and location of traffic sign is enclosed. The contractor shall, however, improve/upgrade upon the traffic plan as indicated in Annex-III based on the site/design requirement as per relevant specifications/IRC Code/manual.





Annex – IV

(Schedule-A)

Environment Clearances

As per EIA notification 2006 and its amendment S.O.2559 (E) Dt 22nd August 2013, S.O 996(E) Dt 10th April 2015, S.O 382(E) Dt 3rd February 2015 Environmental Clearance Exempted from the purview of the Environmental Impact Assessment.

[To be published in the Gazette of India, Extraordinary, Part II, Section 3, Sub-section(ii)]

**MINISTRY OF ENVIRONMENT AND FORESTS
NOTIFICATION**

New Delhi, the 22nd August, 2013

S.O. 2559 (E).- Whereas by notification of the Government of India in the Ministry of Environment and Forests vide number S.O.1533(E), dated the 14th September, 2006 issued under sub-section (1) and clause (v) of sub-section (2) of section (3) of the Environment (Protection) Act, 1986 read with clause (d) of sub-rule (3) of rule 5 of the Environment (Protection) Rules, 1986, the Central Government directed that on and from the date of its publication, the required construction of new projects or activities or the expansion or modernization of existing projects or activities listed in the Schedule to the said notification entailing the capacity addition with change in process or technology and or product mix shall be undertaken in any part of India only after prior environmental clearance from the Central Government or as the case may be, by the State level Environment Impact Assessment Authority, duly constituted by the Central Government under sub-section (3) of section 3 of the said Act, in accordance with the procedure specified therein;

And whereas the Government of India in the Ministry of Environment and Forests had constituted a High Level Committee under the Chairmanship of Member (Environment and Forests and Science and Technology), Planning Commission, vide OM No.21-270/2008-IA.III dated the 11th December, 2012 to review the provisions of Environmental Impact Assessment Notification, 2006 relating to granting Environmental Clearances for Roads, Buildings and Special Economic Zone projects and provisions under the OM dated the 7th February, 2012 issued by the Ministry of Environment and Forests regarding guidelines for High Rise Buildings;

And whereas one of the terms of reference (ToR) of the Committee was to review the requirement of Environmental Clearance for highway expansion projects upto the right of way of 60 meters and length of 200 kms under Environmental Impact Assessment notification;

And whereas the Committee has submitted its report to the Ministry and on this ToR, the Committee has recommended exempting highway expansion projects from the requirement of scoping and that Environmental Impact Assessment or Environment Management Plan for highway expansion projects may be prepared on the basis of model ToRs to be posted on Ministry's website and in respect of requirement of environmental clearance, **the Committee has recommended that expansion of National Highway projects up to 100 kms involving additional right of way or land acquisition upto 40 mts on existing alignments and 60 mts on re-alignments or by-passes may be exempted from the preview of the notification;**

Schedule - B

(See Clause 2.1)

Development of the Project Highway

1. Development of the Project Highway

Development of the Project Highway shall include design and construction of the Project Highway as described in this Schedule-B and in Schedule-C.

2. Rehabilitation and augmentation

Rehabilitation and augmentation shall include two lane and Strengthening of the Project Highway as described in Annex-I of this Schedule-B and in Schedule-C.

3. Specifications and Standards

The Project Highway shall be designed and constructed in conformity with the Specifications and Standards specified in Annex-I of Schedule-D.

Construction of Uni-directional Singhpora - Vailoo Tunnel (Under Sinthan pass) of length 10.331km/10.363km (Tube-1/Tube-2) and its approach road from Km 111+067 (at Chhatroo km 140.870 on NH-244) to 149+678(at vailooJunction with NH -244 i.e., existing km 235.070) of total length 38.611 km in Union Territory of Jammu & Kashmir on EPC mode

Annex – I

(Schedule-B)

Description of the Project

Construction of Uni-directional Singhpora - Vailoo Tunnel (Under Sinthanpass) of length 10.331km/10.363km (Tube-1/Tube-2) and its approach road from Km 111+067 (at Chhatroo km 140.870 on NH-244) to 149+678 (at vailoo Junction with NH -244 i.e., existing km 235.070) of total length 38.611 km in Union Territory of Jammu & Kashmiron EPC mode.Details of proposed project section are as given below.

Tunnel (Uni-directional)

Length of Tube-1 (Left) 10.331 km

Length of Tube-2 (Right) 10.363 km

Eastern Portal

Elevation 2243 m

Location Km 128.155

Western Portal

Elevation 2404 m

Location Km 138.518

Approaches:

East portal: Approach Road starts at Chhatroo [Junction with NH -244 at existing km 140.870 (NH-1 B)] in Kishtwar District andEnds at start of Eastern portal of Singhpora- Vailoo Tunnel. The east portal is located near Singhpora (Kishtwar District) which is 17.088 Km from Chhatroo.

West Portal: The west Portal is located at Gadole and the end point of the approach road is located at Vailoo [Junction with NH-244 at existing km 235.070 (NH-1 B)] which is 11.160 Km long including portal. So, the length of approach road on west portal side is 11.160 Km and lies in the Anantnag District.

1. Development of the project section

- (i) The Project Highway shall follow the existing village roads & new alignment unless otherwise specified by the Authority and shown in the alignment plans as specified in Annex-III of Schedule-A.
- (ii) Width of the proposed tunnel and its approach roads/carriageway.

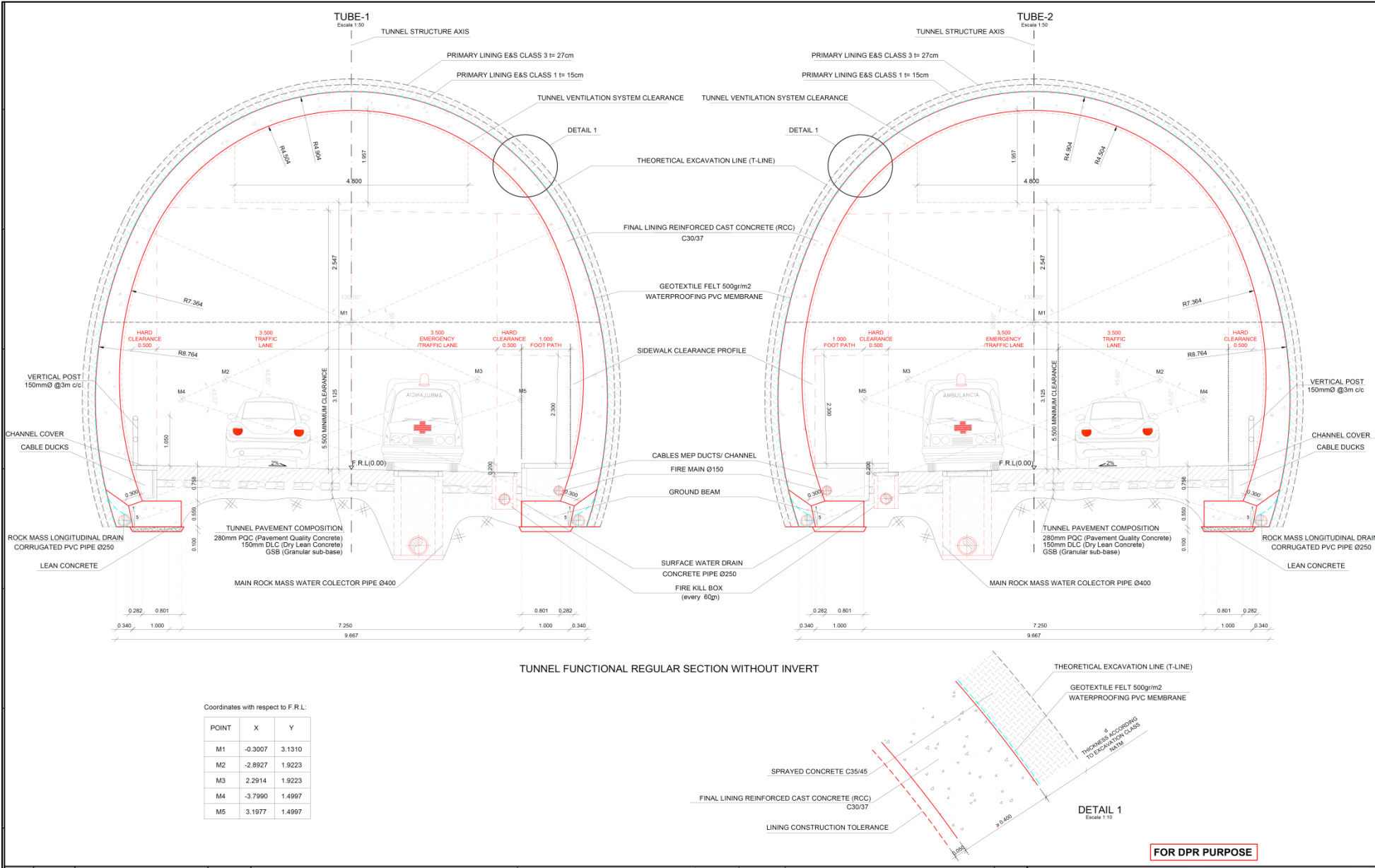
1.1 Cross Section Width and Height of proposed Tunnels

Summary of Road Cross Section inside the tunnel is given below,

Cross Section Element	Width in m
Hard Shoulder (either side)	2 x 0.50m
Traffic Lane	3.50m
Emergency Lane/ Traffic Lane	3.50m
Raised Footpath	1.00m
Overall width	9.00m

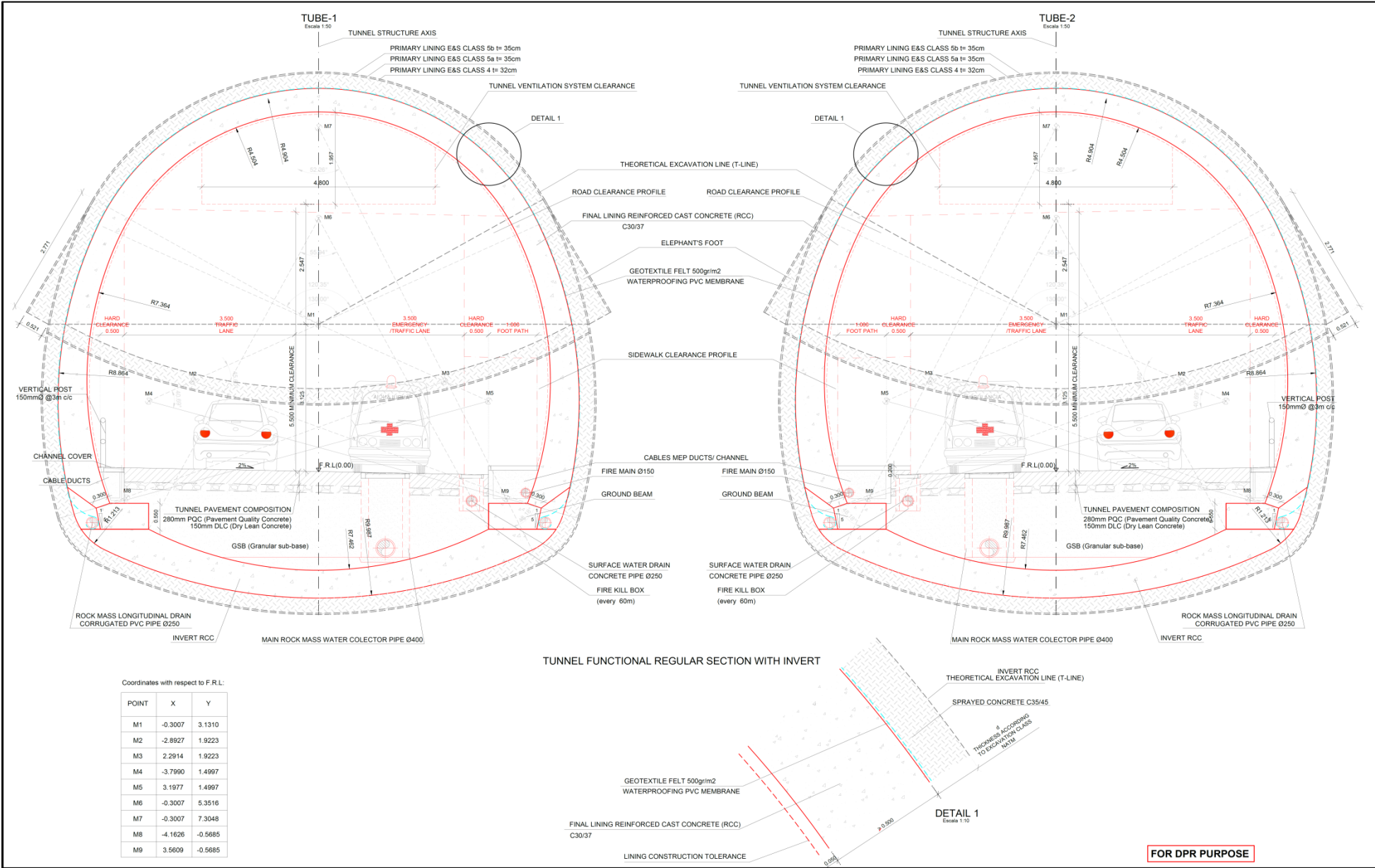
Cross section of the tunnel is given below.

Construction of Uni-directional Singhpora - Vailoo Tunnel (Under Sinthan pass) of length 10.331km/10.363km (Tube-1/Tube-2) and its approach road from Km 111+067 (at Chhatroo km 140.870 on NH-244) to 149+678(at vailooJunction with NH -244 i.e., existing km 235.070) of total length 38.611 km in Union Territory of Jammu & Kashmir on EPC mode



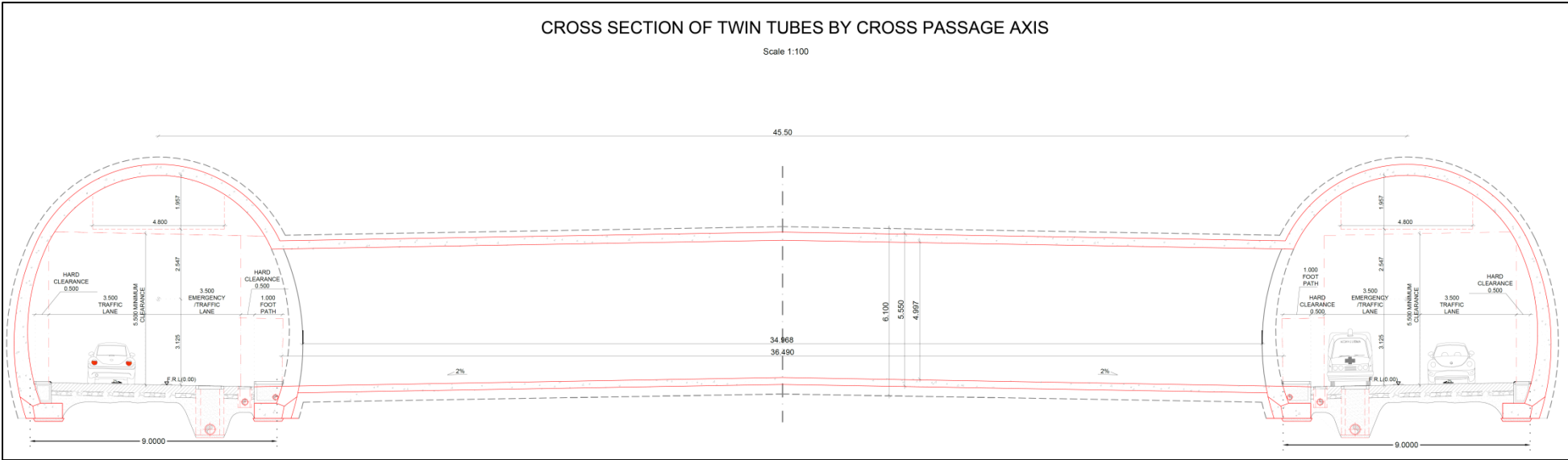
Uni-directional Tunnel Cross Section without invert

Construction of Uni-directional Singhpora - Vailoo Tunnel (Under Sinthan pass) of length 10.331km/10.363km (Tube-1/Tube-2) and its approach road from Km 111+067 (at Chhatroo km 140.870 on NH-244) to 149+678(at vailooJunction with NH -244 i.e., existing km 235.070) of total length 38.611 km in Union Territory of Jammu & Kashmir on EPC mode



Uni-directional Tunnel Cross Section with invert

Construction of Uni-directional Singhpura - Vailoo Tunnel (Under Sinthan pass) of length 10.331km/10.363km (Tube-1/Tube-2) and its approach road from Km 111+067 (at Chhatroo km 140.870 on NH-244) to 149+678(at vailooJunction with NH -244 i.e., existing km 235.070) of total length 38.611 km in Union Territory of Jammu & Kashmir on EPC mode



Cross-section for cross- passage

1.2 Pavement

The road pavement in the tunnel consists of following layers,

- 280 mm pavement quality concrete
- 150 mm dry lean cement concrete subbase layer
- 450 mm GSB

1.3 Ventilation

A longitudinal ventilation system shall be provided for Singhpora-Vailoo Tunnel. Ventilation system shall be provided as per the technical specifications and Guidelines for Road Tunnels IRC: SP:91-2019, NFPA 502 (2017), PIARC Technical Committee C4 – Road Tunnels: Vehicle Emissions and Air Demand for Ventilation (2011).

1.4 Final Interior Finish

The main traffic tunnel shall have a final interior finish of a fire-resistant material of suitable surface characteristics as per Contractor's detailed design subject to approval by Authority Engineer.

1.5 Lighting and E&M Facilities

As per Contractor's detailed design subject to approval by the Authority Engineer. Normal Lighting & Emergency Lighting in the Road tunnel shall be designed according to the Technical Specifications and CIE 88:2004 standard "Guide for the Lighting of Road Tunnels and Underpasses" for two-way traffic including Cable & cable laying, Main Electrical panel & Sub Panels, earthing of complete offered system, galvanized supporting structure and all other necessary accessories, etc. as per the design requirement. Also, the Guidelines for Road Tunnels IRC: SP:91-2019 will be considered. The luminous intensity at the entry and exit zones shall be adapted to the actual outside lighting level according to external conditions (day/night, regulation through measurement of luminous density).

Tunnel safety facilities such as CCTV- cameras, traffic lights, variable message signs, traffic loop detectors, emergency communications, alarm push buttons, fire detection systems etc. shall be provided as per Contractors detailed design/IRC:SP:2019.

1.6 Drainage and Waterproofing Concept

The tunnel shall be designed as a dry and drained tunnel as per contractor's detailed design. A waterproofing membrane shall be provided as per the drawing of cross section of tunnel. The water is drained along the bottom of the side walls with perforated drainage pipes.

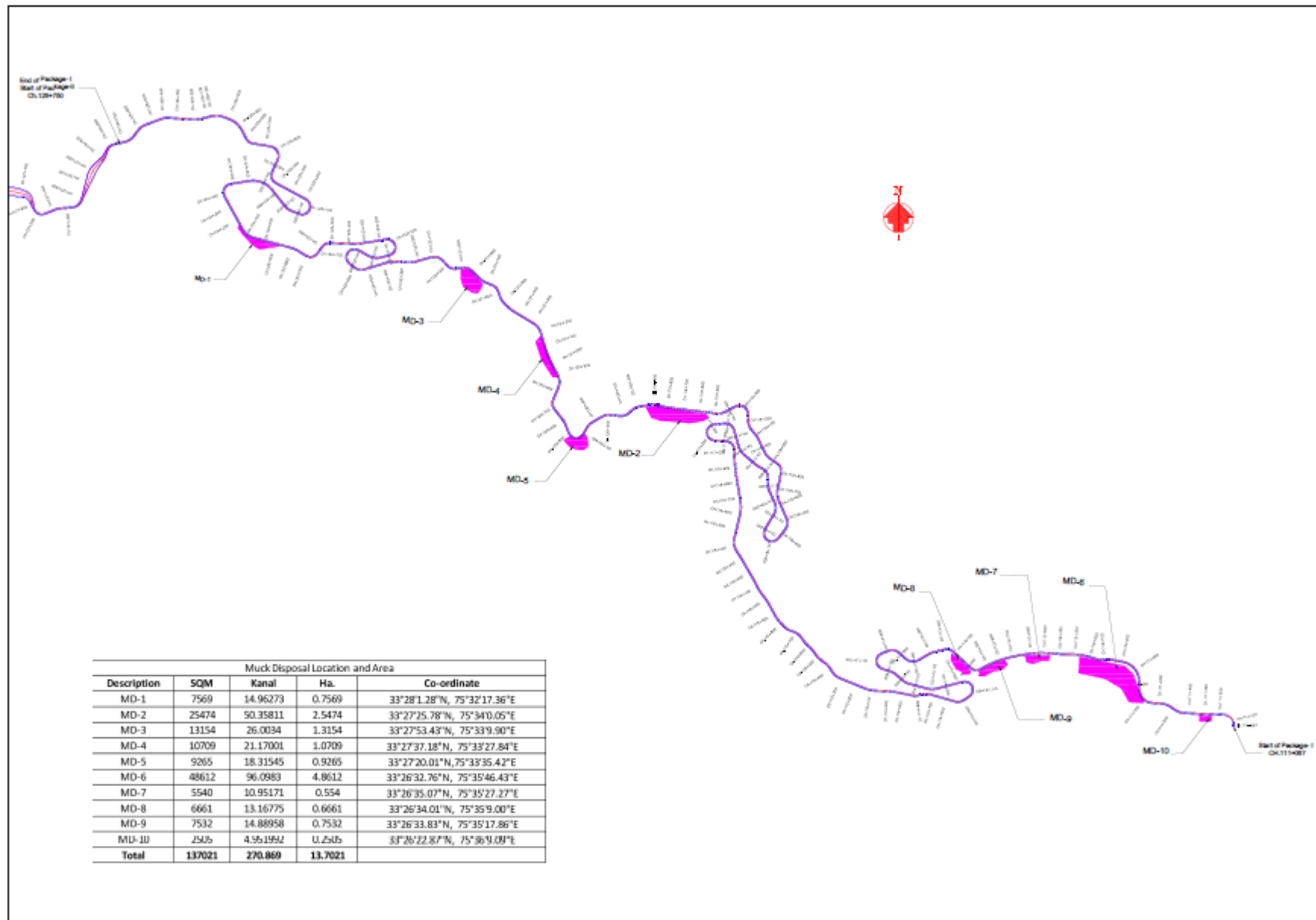
1.7 Construction Concept

The construction method of the tunnel shall be internationally accepted method as proposed in the technical proposal maintaining the clear profile with prior approval of NHIDCL in consultation with the Authority Engineer. However, the method of construction (TBM/Drill & Blast Method/NATAM) is Contractor's choice.

1.8 Muck Dump Disposal

Up to 10 on Kishtwar side & 4 on Anantnag side muck dumping sites have been identified for the purpose of muck dumping. However, suitability of these muck dumping sites and finding of additional muck dumping sites, if any, for muck dumping volume is the sole responsibility of the Contractor.

Prior to any disposal of muck dumping material at muck dumping sites, necessary permission shall be obtained from the local authorities (Civil administration/Forest/Wildlife) as per applicable law for which the local NHIDCL office will provide necessary assistance. For estimation of capacity of the individual pockets, the Contractors are required to carry out reconnaissance in coordination with local NHIDCL authorities. Muck disposal and management shall be carried out in accordance with the Environmental Laws of State/Central Govt.



2. Construction of Approaches

• Widening of the existing road

- i. The Project Highway shall follow the existing alignment unless otherwise specified by the Authority and shown in the alignment plans specified in Annex-III of Schedule-A. Geometric deficiencies, if any, in the existing horizontal and vertical profiles shall be corrected as per the prescribed standards for hilly/mountainous terrain to the extent land is available.
- ii. Width of Carriageway
 - (a) Two-Laning with paved shoulders shall be undertaken. The paved carriageway shall be 10m for road section in accordance with the typical cross section's drawings.
 - (b) Except as otherwise provided in this agreement, the width of the paved carriageway and cross-sectional features shall conform to paragraph 1.1 above.

3. Geometric Design and General Features

(i) General

Geometric design and general features of the Project Highway shall be in accordance with Section 2 of the Manual.

(ii) Design speed

The design speed shall be the minimum design speed of 40 km per hr. for mountainous/hilly terrain as per IRC SP 48:1998 and IRC SP: 73:2018.

(iii) Improvement of the existing road geometrics

In the following sections, where improvement of the existing road geometrics to the prescribed standards is not possible since the existing road is being abandoned and new alignment is being proposed.

Sl. No.	Stretch (from km to km)	Type of deficiency	Remarks
Nil			

(iv) Right of Way

Details of the Right of Way are given in Annex II of Schedule-A.

(v) Type of shoulders

- (a) In built-up sections, footpaths/fully paved shoulders shall be provided in the following stretches:

Sl. No.	Stretch (from km to km)	Fully paved shoulders/ footpaths	Reference to cross section
Nil			

- (b) In open country/hilly areas, paved shoulders of 1m & 1.5m width either side shall be provided and balance 1.0m width earthen shoulder at valley side only shall be covered with 150 mm thick compacted layer of granular material.

- (c) Design and specifications of paved shoulders and granular material shall conform to the requirements specified in the relevant Manual.

(vi) Lateral and vertical clearances at underpasses

- (a) Lateral and vertical clearances at underpasses and provision of guardrails/crash barriers shall be as per the provision of relevant Manual.

- (b) Lateral clearance: The width of the opening at the underpasses shall be as follows:

Sl. No.	Location (Chainage)	Span/ opening (m)	Vertical Clearance (m)	Remarks
Nil				

(vii) Lateral and vertical clearances at overpasses

(a) Lateral and vertical clearances at overpasses shall be as per the provision of relevant Manual.

(b) Lateral clearance: The width of the opening at the overpasses shall be as follows:

Sl. No.	Location (Chainage) (from km to km)	Span/ opening (m)	Remarks
Nil			

(viii) Service roads

Service roads shall be constructed at the locations and for the lengths indicated below:

Sl. No.	Location of service road (from km to km)	Right hand side (RHS)/Left hand side (LHS)/ or Both sides	Length (km) of service road
Nil			

(ix) Grade separated structures

(a) Grade separated structures shall be provided as per provision of the relevant Manual. The requisite is given below:

Sl. No.	Location of structure	Length (m)	Number and length of spans (m)	Approach gradient	Remarks, if any
Nil					

In the case of grade separated structures, the type of structure and the level of the Project Highway and the crossroads shall be as follows:

Sl. No.	Location	Type of structure Length (m)	Cross road at			Remarks, if any
			Existing Level	Raised Level	Lowered Level	
Nil						

(x) Overpass

Overpass shall be constructed as follows:

Sl. No.	Location at km	Span Arrangement (No. x Length) in m	Type of crossing
Nil			

(xi) Typical cross-sections of the Project Highway

Following typical cross sections shall be provided for the Project Highway.

Summary of TCS				
Sr. No.	Detail	TCS	Length	
			(m)	Kms
1	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1	6612.43	6.61
2	ONE SIDE CUT(CUT HEIGHT<2m) & ONE SIDE FILL(EMBANKMENT HEIGHT<2m) WITHOUT PROTECTION WORK(RECONSTRUCTION)	TCS-1A	750	0.75
3	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(NEW CONSTRUCTION)	TCS-1B	1528.03	1.53
4	ONE SIDE CUT(CUT HEIGHT<2m) & ONE SIDE FILL(EMBANKMENT HEIGHT<2m) WITHOUT PROTECTION WORK(NEW CONSTRUCTION)	TCS-1C	750	0.75
5	ONE SIDE CUT (Ht.>15m) & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1D	980	0.98
6	BOTH SIDE FILL WITH PROTECTION (AS APPLICABLE)(RECONSTRUCTION)	TCS-2	1961	1.96
7	BOTH SIDE FILL WITH NORMAL EMBANKMENT	TCS-2A	990	0.99

Summary of TCS				
Sr. No.	Detail	TCS	Length	
			(m)	Kms
	(HEIGHT.<2m)WITHOUT PROTECTION WORK(RECONSTRUCTION)			
8	BOTH SIDE FILL WITH PROTECTION (AS APPLICABLE)(NEW CONSTRUCTION)	TCS-2B	1110	1.11
9	BOTH SIDE FILL WITH NORMAL EMBANKMENT (HEIGHT.<2m)WITHOUT PROTECTION WORK(NEW CONSTRUCTION)	TCS-2C	1710	1.71
10	BOTH SIDE CUT WITH PROTECTION ON EITHER SIDE AS APPLICABLE (RECONSTRUCTION)	TCS-3	2140	2.14
11	BOTH SIDE CUT WITHOUT PROTECTION WORK (CUT HEIGHT<2m)(RECONSTRUCTION)	TCS-3A	250	0.25
12	BOTH SIDE CUT WITH PROTECTION ON EITHER SIDE AS APPLICABLE (NEW CONSTRUCTION)	TCS-3B	2960	2.96
13	BOTH SIDE CUT WITHOUT PROTECTION WORK (CUT HEIGHT<2m)(NEW CONSTRUCTION)	TCS-3C	380	0.38
14	BOTH SIDE CUT (Ht.>15m) WITH PROTECTION ON EITHER SIDE AS APPLICABLE (RECONSTRUCTION)	TCS-3D	690	0.69
15	BOTH SIDE CUT (Ht.>15m)WITH PROTECTION ON EITHER SIDE AS APPLICABLE (NEW CONSTRUCTION)	TCS-3E	1130	1.13
16	ONE SIDE CUT WITH ROCK BOLTING & ONE SIDE FILL WITH PROTECTION AS APPLICABLE(RECONSTRUCTION)	TCS-4	250	0.25
17	BOTH SIDE FILL FOR TUNNEL APPROACH WITH PROTECTION (AS APPLICABLE)(NEW CONSTRUCTION)	TCS-5	81	0.08
18	BOTH SIDE CUT FOR TUNNEL APPROACH WITH PROTECTION ON EITHER SIDE AS APPLICABLE (NEW CONSTRUCTION)	TCS-6	65	0.07
19	BOTH SIDE FILL FOR TUNNEL APPROACH WITH PROTECTION (AS APPLICABLE)(NEW CONSTRUCTION)	TCS-7	110	0.11
20	TUNNEL	As per indicative drawing	10363	10.36
21	TUNNEL Portal	As per indicative drawing	156	0.16
22	Major Bridge	As per indicative drawing	1670	1.67
23	Viaduct cum Bridge	As per indicative drawing	80	0.08
24	Viaduct	As per indicative drawing	1665	1.67
25	Minor Bridge	As per indicative drawing	230	0.23
	TOTAL DESIGN LENGTH		38611	

4. Intersections and Grade Separators

All intersections and grade separators shall be as per the provision of relevant Manual.

Properly designed intersections shall be provided at the locations and of the types and features given in the tables below:

- (i) At-grade intersections

SL. No.	Design Chainage in km	Type	Junction	Cross Road Direction to Village
1	111+130	T	Major	To Kishtwar
2	111+490	T	Minor	To Sinthan top
3	114+350	Y	Minor	To Village
4	127+615	T	Minor	To Village
5	141+005	X	Minor	To Gadol Village/To Trazi Village
6	142+345	X	Minor	To Gadol Village/To Village
7	142+560	T	Minor	To Gadol Village
8	142+915	Y	Minor	To Tuspura Village
9	143+015	Y	Minor	To Khatanpur Village
10	143+355	T	Minor	To Tuspura Village
11	143+755	T	Minor	To LoharSanzi Village
12	144+140	X	Minor	To LoharSanzi Village/To Khatanpur Village
13	144+530	X	Minor	To LoharSanzi Village
14	145+910	T	Minor	To Cherward Village
15	145+985	T	Minor	To Cherward Village
16	146+510	Y	Minor	To Vailoo

(ii) Grade separated intersection with/without ramps

Sl. No.	Location	Salient features	Minimum length of viaduct to be provided	Road to be carried over/under the structures	Remarks
			NIL		

5. Road Embankment and Cut Section

(i) Construction of new road embankment/ cuttings shall conform to the Specifications and Standards given in Section 4 of the Manual and the specified cross-sectional details.

(ii) Raising of the existing road

The existing road shall be raised in the following sections:

Sl. No.	Section (from km to km)	Length	Extent of raising [Top of finished road level]
			Nil

6. Pavement Design

(i) Pavement design shall be carried out in accordance with the provision of relevant Manual.

(ii) Type of pavement

Flexible pavement is proposed at the main carriageway of highway in accordance with IRC :37-2018 for CBR10%.

(iii) Design requirements

(a) Design Period and strategy

Flexible pavement for new pavement shall be designed for a period of 20 years and Rigid pavement shall be designed for a minimum design period of 30 years. Stage construction shall not be permitted.

(b) Design Traffic

Notwithstanding anything to the contrary contained in this Agreement or the Manual, the Contractor shall design the pavement for a minimum design traffic of 20 million standard axles.

Note:- EPC Contractor is free to adopt either Flexible or Rigid Pavement at the main carriageway of highway in accordance to design criteria in the Contract Agreement and MoRT&H/ IRC Specification.

7. Roadside Drainage

Drainage system including surface and subsurface drains for the Project Highway shall be provided as per the provision of relevant Manual.

- Location of PCC Roadside drain

Roadside PCC Drainage List				
Design Chainage		Design Length (m)	Side	Roadside Drain Length (m)
From	To			
111+067	111+150	83	RIGHT	83.43
111+500	111+540	40	RIGHT	40
111+540	111+660	120	RIGHT	120
111+660	111+700	40	BOTH	80
111+700	111+730	30	RIGHT	30
111+730	111+770	40	BOTH	80
111+770	111+800	30	RIGHT	30
111+850	112+010	160	RIGHT	160
112+010	112+050	40	BOTH	80
112+050	112+080	30	RIGHT	30
112+080	112+110	30	RIGHT	30
112+110	112+130	20	RIGHT	20
112+130	112+330	200	RIGHT	200
112+330	112+400	70	RIGHT	70
112+400	112+490	90	RIGHT	90
112+490	112+510	20	RIGHT	20
112+510	112+530	20	RIGHT	20
112+530	112+560	30	RIGHT	30
112+560	112+600	40	RIGHT	40
112+600	112+635	35	RIGHT	35
112+715	112+740	25	RIGHT	25
112+740	112+870	130	RIGHT	130
112+870	112+900	30	RIGHT	30
112+900	112+930	30	RIGHT	30
112+930	112+960	30	RIGHT	30
112+960	113+000	40	RIGHT	40
113+060	113+110	50	BOTH	100
113+110	113+190	80	RIGHT	80
113+190	113+240	50	RIGHT	50
113+240	113+280	40	BOTH	80
113+280	113+310	30	BOTH	60
113+310	113+340	30	RIGHT	30
113+340	113+370	30	BOTH	60
113+370	113+390	20	RIGHT	20
113+390	113+450	60	RIGHT	60
113+450	113+470	20	RIGHT	20
113+470	113+510	40	RIGHT	40
113+510	113+540	30	RIGHT	30
113+540	113+560	20	RIGHT	20
113+560	113+620	60	RIGHT	60
113+620	113+640	20	RIGHT	20

Roadside PCC Drainage List				
Design Chainage		Design Length (m)	Side	Roadside Drain Length (m)
From	To			
113+640	113+680	40	RIGHT	40
113+740	113+890	150	RIGHT	150
113+890	114+040	150	RIGHT	150
114+410	114+810	400	RIGHT	400
114+810	114+860	50	BOTH	100
114+860	115+070	210	RIGHT	210
115+070	115+130	60	RIGHT	60
115+130	115+570	440	RIGHT	440
115+570	115+630	60	RIGHT	60
115+780	115+860	80	RIGHT	80
115+950	116+070	120	RIGHT	120
116+070	116+120	50	RIGHT	50
116+120	116+175	55	BOTH	110
116+205	116+280	75	BOTH	150
116+280	116+450	170	BOTH	340
116+450	116+630	180	BOTH	360
116+630	116+880	250	RIGHT	250
116+880	116+920	40	RIGHT	40
116+920	116+955	35	RIGHT	35
117+030	117+080	50	BOTH	100
117+080	117+130	50	BOTH	100
117+130	117+220	90	RIGHT	90
117+220	117+270	50	BOTH	100
117+270	117+500	230	RIGHT	230
117+500	117+530	30	BOTH	60
117+530	118+075	545	RIGHT	545
118+400	118+430	30	BOTH	60
118+430	118+490	60	BOTH	120
118+490	118+520	30	BOTH	60
118+520	118+660	140	RIGHT	140
118+660	118+690	30	BOTH	60
118+690	118+730	40	BOTH	80
118+730	118+790	60	RIGHT	60
118+790	118+840	50	BOTH	100
118+840	119+040	200	RIGHT	200
119+040	119+150	110	BOTH	220
119+150	119+230	80	BOTH	160
119+230	119+290	60	BOTH	120
119+340	119+450	110	BOTH	220
119+450	119+570	120	RIGHT	120
119+570	119+630	60	BOTH	120
119+630	119+640	10	RIGHT	10
119+640	119+690	50	RIGHT	50
119+690	120+090	400	RIGHT	400
120+090	120+120	30	RIGHT	30
120+120	120+170	50	RIGHT	50

Roadside PCC Drainage List				
Design Chainage		Design Length (m)	Side	Roadside Drain Length (m)
From	To			
120+170	120+310	140	BOTH	280
120+310	120+400	90	RIGHT	90
120+420	120+470	50	RIGHT	50
120+470	120+530	60	RIGHT	60
120+600	120+770	170	RIGHT	170
120+770	120+810	40	RIGHT	40
120+810	120+915	105	RIGHT	105
121+370	121+560	190	RIGHT	190
121+560	121+710	150	BOTH	300
121+740	122+030	290	BOTH	580
122+030	122+130	100	BOTH	200
122+130	122+160	30	BOTH	60
122+160	122+270	110	RIGHT	110
122+270	122+310	40	BOTH	80
122+310	122+670	360	BOTH	720
122+670	122+780	110	BOTH	220
122+780	122+840	60	BOTH	120
123+090	123+110	20	BOTH	40
123+110	123+230	120	BOTH	240
123+230	123+310	80	RIGHT	80
123+410	123+490	80	RIGHT	80
123+490	123+530	40	RIGHT	40
123+810	123+840	30	RIGHT	30
123+840	123+910	70	RIGHT	70
123+910	124+060	150	BOTH	300
124+060	124+120	60	RIGHT	60
124+180	124+290	110	RIGHT	110
124+350	124+770	420	BOTH	840
124+770	124+825	55	RIGHT	55
125+100	125+150	50	BOTH	100
125+150	125+350	200	BOTH	400
125+350	125+380	30	BOTH	60
125+380	125+460	80	RIGHT	80
125+460	125+500	40	RIGHT	40
125+820	126+030	210	BOTH	420
126+030	126+090	60	BOTH	120
126+090	126+195	105	BOTH	210
126+245	126+270	25	BOTH	50
126+420	126+610	190	RIGHT	190
126+610	126+770	160	RIGHT	160
126+770	126+910	140	RIGHT	140
126+910	126+950	40	BOTH	80
126+950	127+040	90	RIGHT	90
127+110	127+150	40	BOTH	80
127+150	127+240	90	BOTH	180
127+240	127+280	40	RIGHT	40

Roadside PCC Drainage List				
Design Chainage		Design Length (m)	Side	Roadside Drain Length (m)
From	To			
127+280	127+330	50	BOTH	100
127+330	127+400	70	BOTH	140
127+400	127+440	40	BOTH	80
127+440	127+464	24	RIGHT	24
127+540	127+570	30	RIGHT	30
127+570	127+610	40	BOTH	80
127+610	127+680	70	BOTH	140
127+680	127+710	30	RIGHT	30
127+710	127+750	40	BOTH	80
127+750	127+900	150	RIGHT	150
127+900	127+930	30	BOTH	60
127+930	127+970	40	BOTH	80
127+970	128+040	70	BOTH	140
128+040	128+070	30	RIGHT	30
138+518	138+640	122	Both	244
138+740	138+775	35	RIGHT	35
138+865	138+930	65	Both	130
140+360	140+550	190	Both	380
140+650	140+780	130	RIGHT	130
140+780	140+960	180	Both	360
140+960	141+000	40	Both	80
141+000	141+120	120	Both	240
141+240	141+290	50	RIGHT	50
141+290	141+460	170	Both	340
141+460	141+490	30	RIGHT	30
141+490	141+590	100	RIGHT	100
141+650	141+710	60	RIGHT	60
141+710	142+010	300	Both	600
142+100	142+170	70	RIGHT	70
142+170	142+220	50	RIGHT	50
142+410	142+490	80	Both	160
142+490	142+580	90	RIGHT	90
142+730	142+770	40	RIGHT	40
142+770	142+960	190	Both	380
142+960	142+975	15	RIGHT	15
142+995	143+190	195	Both	390
143+320	143+500	180	RIGHT	180
143+530	143+570	40	RIGHT	40
143+570	143+750	180	Both	360
143+750	143+810	60	RIGHT	60
143+810	143+960	150	Both	300
144+050	144+100	50	RIGHT	50
144+560	144+610	50	Both	100
144+730	144+780	50	Both	100
144+780	144+870	90	Both	180
144+870	144+930	60	Both	120

Roadside PCC Drainage List				
Design Chainage		Design Length (m)	Side	Roadside Drain Length (m)
From	To			
145+020	145+070	50	Both	100
145+330	145+450	120	RIGHT	120
145+450	145+490	40	RIGHT	40
145+490	145+540	50	Both	100
145+540	145+580	40	RIGHT	40
145+660	145+720	60	Both	120
146+290	146+520	230	RIGHT	230
146+520	146+570	50	Both	100
146+570	146+603	33	RIGHT	33
146+613	146+680	67	RIGHT	67
146+680	146+750	70	RIGHT	70
146+750	146+890	140	Both	280
146+890	147+200	310	RIGHT	310
147+200	147+270	70	RIGHT	70
147+370	147+490	120	RIGHT	120
148+700	148+870	170	RIGHT	170
148+870	148+920	50	RIGHT	50
148+920	148+960	40	RIGHT	40
148+960	149+010	50	RIGHT	50
149+010	149+080	70	RIGHT	70
149+110	149+678	568	RIGHT	568.034
Total Roadside PCC Drainage Length				26189.5

- Location of PCC Catch Drain

Design Chainage		Design Length (m)	Side	PCC Catch Drain Length (m)
From	To			
111+067	111+150	83	RIGHT	83
111+500	111+540	40	RIGHT	40
111+540	111+660	120	RIGHT	240
111+660	111+700	40	BOTH	160
111+700	111+730	30	RIGHT	60
111+730	111+770	40	BOTH	160
111+770	111+800	30	RIGHT	30
111+850	112+010	160	RIGHT	160
112+010	112+050	40	BOTH	160
112+050	112+080	30	RIGHT	60
112+080	112+110	30	RIGHT	30
112+110	112+130	20	RIGHT	40
112+130	112+330	200	RIGHT	200
112+330	112+400	70	RIGHT	140
112+400	112+490	90	RIGHT	90
112+490	112+510	20	RIGHT	40
112+510	112+530	20	RIGHT	20
112+530	112+560	30	RIGHT	60
112+560	112+600	40	RIGHT	40

Design Chainage		Design Length	Side	PCC Catch Drain Length (m)
From	To	(m)		
112+600	112+635	35	RIGHT	35
112+715	112+740	25	RIGHT	25
112+740	112+870	130	RIGHT	260
112+870	112+900	30	RIGHT	30
112+900	112+930	30	RIGHT	60
112+930	112+960	30	RIGHT	30
112+960	113+000	40	RIGHT	40
113+060	113+110	50	BOTH	200
113+110	113+190	80	RIGHT	80
113+190	113+240	50	RIGHT	100
113+240	113+280	40	BOTH	160
113+280	113+310	30	BOTH	60
113+310	113+340	30	RIGHT	60
113+340	113+370	30	BOTH	60
113+370	113+390	20	RIGHT	20
113+390	113+450	60	RIGHT	60
113+450	113+470	20	RIGHT	0
113+470	113+510	40	RIGHT	40
113+510	113+540	30	RIGHT	30
113+540	113+560	20	RIGHT	40
113+560	113+620	60	RIGHT	60
113+620	113+640	20	RIGHT	40
113+640	113+680	40	RIGHT	40
113+740	113+890	150	RIGHT	150
114+410	114+810	400	RIGHT	400
114+810	114+860	50	BOTH	100
114+860	115+070	210	RIGHT	210
115+070	115+130	60	RIGHT	120
115+130	115+570	440	RIGHT	440
115+780	115+860	80	RIGHT	80
115+950	116+070	120	RIGHT	120
116+070	116+120	50	RIGHT	100
116+120	116+175	55	BOTH	110
116+205	116+280	75	BOTH	150
116+280	116+450	170	BOTH	680
116+450	116+630	180	BOTH	360
116+630	116+880	250	RIGHT	250
116+880	116+920	40	RIGHT	80
116+920	116+955	35	RIGHT	35
117+030	117+080	50	BOTH	100
117+220	117+270	50	BOTH	100
117+270	117+500	230	BOTH	920
117+500	117+530	30	BOTH	60
117+530	118+075	545	RIGHT	545
118+400	118+430	30	BOTH	60
118+430	118+490	60	BOTH	240

Design Chainage		Design Length	Side	PCC Catch Drain Length (m)
From	To	(m)		
118+490	118+520	30	BOTH	60
118+520	118+660	140	RIGHT	140
118+660	118+690	30	BOTH	120
118+690	118+730	40	BOTH	80
118+730	118+790	60	RIGHT	60
118+790	118+840	50	BOTH	100
118+840	119+040	200	RIGHT	200
119+040	119+150	110	BOTH	220
119+150	119+230	80	BOTH	320
119+230	119+290	60	BOTH	120
119+340	119+450	110	BOTH	220
119+450	119+570	120	RIGHT	120
119+570	119+630	60	BOTH	240
119+630	119+640	10	RIGHT	10
119+640	119+690	50	RIGHT	50
119+690	120+090	400	RIGHT	400
120+090	120+120	30	RIGHT	60
120+120	120+170	50	RIGHT	50
120+170	120+310	140	BOTH	560
120+310	120+400	90	RIGHT	90
120+420	120+470	50	RIGHT	50
120+470	120+530	60	RIGHT	60
120+600	120+770	170	RIGHT	170
120+770	120+810	40	RIGHT	80
120+810	120+915	105	RIGHT	105
121+370	121+560	190	RIGHT	190
121+560	121+710	150	BOTH	300
121+740	122+030	290	BOTH	580
122+130	122+160	30	BOTH	60
122+160	122+270	110	RIGHT	110
122+310	122+670	360	BOTH	720
122+670	122+780	110	BOTH	440
122+780	122+840	60	BOTH	120
123+090	123+110	20	BOTH	40
123+110	123+230	120	BOTH	480
123+230	123+310	80	RIGHT	80
123+410	123+490	80	RIGHT	80
123+840	123+910	70	RIGHT	70
123+910	124+060	150	BOTH	300
124+060	124+120	60	RIGHT	60
124+180	124+290	110	RIGHT	110
124+350	124+770	420	BOTH	840
124+770	124+825	55	RIGHT	55
125+100	125+150	50	BOTH	100
125+150	125+350	200	BOTH	800
125+350	125+380	30	BOTH	60

Design Chainage		Design Length	Side	PCC Catch Drain Length (m)
From	To	(m)		
125+380	125+460	80	RIGHT	80
125+460	125+500	40	RIGHT	40
125+820	126+030	210	BOTH	420
126+030	126+090	60	BOTH	240
126+090	126+195	105	BOTH	210
126+245	126+270	25	BOTH	50
126+420	126+610	190	RIGHT	190
126+610	126+770	160	RIGHT	320
126+770	126+910	140	RIGHT	140
126+910	126+950	40	BOTH	160
126+950	127+040	90	RIGHT	90
127+110	127+150	40	BOTH	80
127+150	127+240	90	BOTH	360
127+240	127+280	40	RIGHT	40
127+280	127+330	50	BOTH	100
127+330	127+400	70	BOTH	280
127+400	127+440	40	BOTH	80
127+440	127+464	24	RIGHT	24
127+540	127+570	30	RIGHT	30
127+570	127+610	40	BOTH	80
127+610	127+680	70	BOTH	280
127+680	127+710	30	RIGHT	30
127+710	127+750	40	BOTH	160
127+750	127+900	150	RIGHT	150
127+900	127+930	30	BOTH	60
127+930	127+970	40	BOTH	160
127+970	128+040	70	BOTH	140
128+040	128+070	30	RIGHT	30
138+518	138+640	122	BOTH	244
138+740	138+775	35	RIGHT	35
138+865	138+930	65	BOTH	130
140+360	140+550	190	BOTH	380
140+650	140+780	130	RIGHT	130
140+780	140+960	180	BOTH	360
141+000	141+120	120	BOTH	240
141+240	141+290	50	RIGHT	50
141+290	141+460	170	BOTH	340
141+490	141+590	100	RIGHT	100
141+650	141+710	60	RIGHT	60
141+710	142+010	300	BOTH	600
142+170	142+220	50	RIGHT	50
142+730	142+770	40	RIGHT	40
142+770	142+960	190	BOTH	380
142+960	142+975	15	RIGHT	15
142+995	143+190	195	BOTH	390
143+320	143+500	180	RIGHT	180

Design Chainage		Design Length	Side	PCC Catch Drain Length (m)
From	To	(m)		
143+530	143+570	40	RIGHT	40
143+570	143+750	180	BOTH	360
143+750	143+810	60	RIGHT	60
143+810	143+960	150	BOTH	300
144+780	144+870	90	BOTH	180
145+330	145+450	120	RIGHT	120
145+540	145+580	40	RIGHT	40
146+290	146+520	230	RIGHT	230
146+520	146+570	50	BOTH	100
146+570	146+603	33	RIGHT	33
146+613	146+680	67	RIGHT	67
146+750	146+890	140	BOTH	280
148+870	148+920	50	RIGHT	50
148+960	149+010	50	RIGHT	50
149+110	149+678	568.034	RIGHT	568
Total Roadside PCC Catch Drain Length				28259

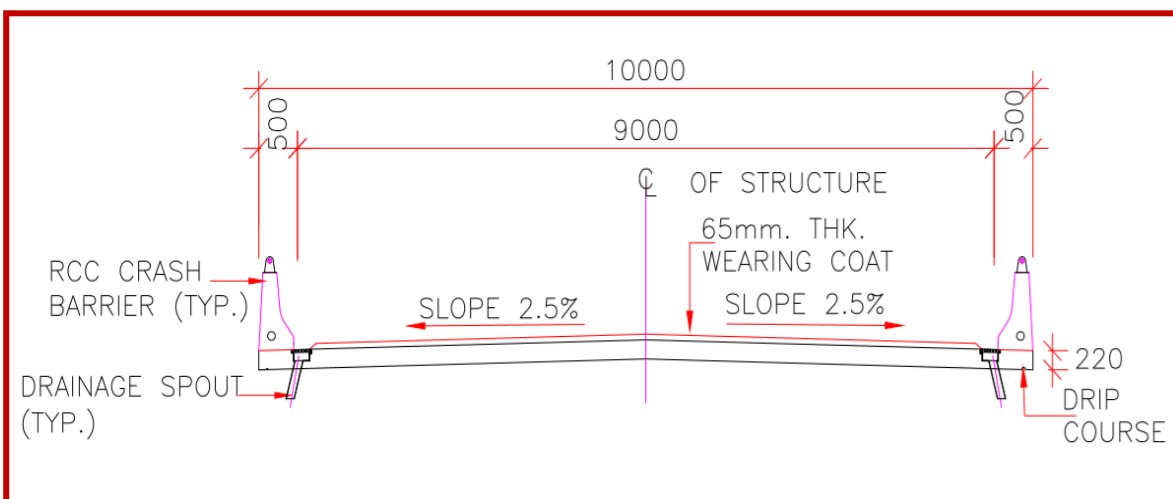
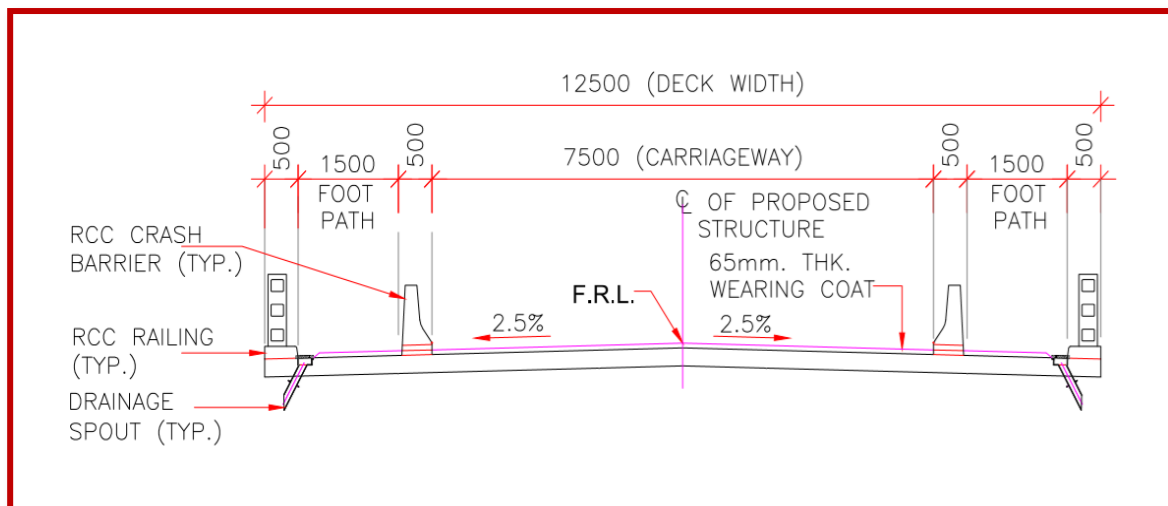
8. Design of Structures

(i) General

(a) All bridges, culverts and structures shall be designed and constructed in accordance with the provision of relevant Manual and shall conform to the cross- sectional features and other details specified therein.

(b) Width of the carriageway of new bridges and structures shall be as follows:

Sl. No.	Structure/ Bridge at km	Width of carriageway and cross-sectional features*
1	111+315, 112+675, 113+710, 114+275, 115+910, 116+190, 116+975, 118+225, 121+095, 121+723, 123+000, 124+945, 126+220, 127+494, 138+795, 139+660, 140+600, 142+985, 146+608 and 148+600	Width of Carriageway – 7.5 mincluding KS Foot Path – 1.5 m (both sides) Crash Barrier – 0.5m (both sides) RCC Railing – 0.5 m (both sides) Total Width – 12.5m
2	128+090 and 138+700	Width of Carriageway –9.0m including KS Crash Barrier – 0.5m (both sides) Total Width – 10.0m



(c) The following structures shall be provided with footpaths:

Sl. No.	Location at km	Span Arrangement No.x Length (m)	Remarks
Nil			

(d) All bridges shall be high-level bridges.

Refer to the provision of relevant Manual and state if there is any exception

(e) The following structures shall be designed to carry utility services specified in table below:

Sl. No.	Bridge at km	Utility service to be carried	Remarks
1	111+315	Electricity cables, OFC cables etc.	Remarks
2	112+675	Electricity cables, OFC cables etc.	2 Lane bridge
3	113+710	Electricity cables, OFC cables etc.	2 Lane bridge
4	114+275	Electricity cables, OFC cables etc.	2 Lane bridge
5	115+910	Electricity cables, OFC cables etc.	2 Lane bridge
6	116+190	Electricity cables, OFC cables etc.	2 Lane bridge
7	116+975	Electricity cables, OFC cables etc.	2 Lane bridge
8	118+225	Electricity cables, OFC cables etc.	2 Lane bridge
9	121+095	Electricity cables, OFC cables etc.	2 Lane bridge
10	121+723	Electricity cables, OFC cables etc.	2 Lane bridge
11	123+000	Electricity cables, OFC cables etc.	2 Lane bridge
12	124+945	Electricity cables, OFC cables etc.	2 Lane bridge
13	126+220	Electricity cables, OFC cables etc.	2 Lane bridge

Sl. No.	Bridge at km	Utility service to be carried	Remarks
14	127+494	Electricity cables, OFC cables etc.	2 Lane Bridge
15	128+090	Electricity cables, OFC cables etc.	2 Lane Bridge
16	138+700	Electricity cables, OFC cables etc.	2 Lane bridge on both LHS and RHS
17	138+795	Electricity cables, OFC cables etc.	2 Lane bridge on both LHS and RHS
18	139+660	Electricity cables, OFC cables etc.	LHS
19	140+600	Electricity cables, OFC cables etc.	2 Lane bridge
20	142+985	Electricity cables, OFC cables etc.	2 Lane Bridge
21	146+608	Electricity cables, OFC cables etc.	2 Lane bridge
22	148+600	Electricity cables, OFC cables etc.	2 Lane bridge

(f) Cross-section of the new culverts and bridges at deck level for the Project Highway shall conform to the typical cross-sections given in the provision of relevant Manual.

(ii) Culverts

(a) Overall width of all culverts shall be equal to the roadway width of the approaches.

(b) Reconstruction of existing culverts:

The existing culverts at the following locations shall be re-constructed as new culverts:

Sr. No.	Proposed Chainage	Span	Structure type	Remark
1	112+096	2X2	Box culvert	Re-const.
2	112+237	2X2	Box culvert	Re-const.
3	113+137	2X2	Box culvert	Re-const.
4	114+080	3X3	Box culvert	Re-const.
5	116+498	3X3	Box culvert	Re-const.
6	116+558	1X2X2	Box culvert	Re-const.
7	117+020	1X3X3	Box culvert	Re-const.
8	117+665	1X3X3	Box culvert	Re-const.
9	117+810	1X3X3	Box culvert	Re-const.
10	118+520	1X3X3	Box culvert	Re-const.
11	118+855	1X2X2	Box culvert	Re-const.
12	119+030	1X2X4	Box culvert	Re-const.
13	121+885	1X2X2	Box culvert	Re-const.
14	124+197	1X2X2	Box culvert	Re-const.
15	127+255	1X6X6	Box culvert	Re-const.
16	127+598	1X3X3	Box culvert	Re-const.
17	127+836	1X3X3	Box culvert	Re-const.
18	144+046	1X2X2	Box culvert	Re-const.
19	144+126	1X2X2	Box culvert	Re-const.
20	144+225	1X2X2	Box culvert	Re-const.
21	145+172	1X3X3	Box culvert	Re-const.
22	145+200	1X3X3	Box culvert	Re-const.
23	145+498	1X3X2	Box culvert	Re-const.
24	145+589	1X2X2	Box culvert	Re-const.
25	145+691	1X3X2	Box culvert	Re-const.
26	146+053	1X3X3	Box culvert	Re-const.
27	146+199	1X2X2	Box culvert	Re-const.
28	146+257	1X3X3	Box culvert	Re-const.
29	146+376	1X3X3	Box culvert	Re-const.
30	146+641	1X2X2	Box culvert	Re-const.
31	147+018	1X2X2	Box culvert	Re-const.

(c) Widening of existing culverts:

All existing culverts which are not to be reconstructed shall be widened to the roadway width of the Project Highway as per the typical cross section given in the provision of relevant Manual. Repairs and strengthening of existing structures where required shall be carried out.

Sl. No.	Culvert location	Type, span, height and width of existing culvert (m)	Repairs to be carried out [specify]
Nil			

(d) Additional new culverts shall be constructed as per given in the table below:

Sr. No.	Proposed Chainage	Span	Structure type	Remark
1	111+102	2X2	Box culvert	New-const.
2	111+820	3X3	Box culvert	New-const.
3	111+985	3X3	Box culvert	New-const.
4	112+485	3X3	Box culvert	New-const.
5	112+590	3X3	Box culvert	New-const.
6	113+530	3X3	Box culvert	New-const.
7	114+700	3X3	Box culvert	New-const.
8	115+035	2X2	Box culvert	New-const.
9	115+635	3X3	Box culvert	New-const.
10	115+730	3X3	Box culvert	New-const.
11	117+545	3X3	Box culvert	New-const.
12	119+320	3X3	Box culvert	New-const.
13	119+652	3X3	Box culvert	New-const.
14	120+060	3X3	Box culvert	New-const.
15	120+142	3X3	Box culvert	New-const.
16	120+342	2X4	Box culvert	New-const.
17	122+270	2X2	Box culvert	New-const.
18	123+580	3X3	Box culvert	New-const.
19	123+730	2X2	Box culvert	New-const.
20	124+095	3X3	Box culvert	New-const.
21	125+445	3X3	Box culvert	New-const.
22	125+615	3X3	Box culvert	New-const.
23	125+958	2X2	Box culvert	New-const.
24	126+154	2X2	Box culvert	New-const.
25	126+840	2X2	Box culvert	New-const.
26	126+975	3X3	Box culvert	New-const.
27	127+685	2X2	Box culvert	New-const.
28	140+686	2X2	Box culvert	New-const.
29	140+980	2X2	Box culvert	New-const.
30	141+148	3X3	Box culvert	New-const.
31	141+228	3X3	Box culvert	New-const.
32	141+418	2X2	Box culvert	New-const.
33	141+633	2X4	Box culvert	New-const.
34	142+055	2X2	Box culvert	New-const.
35	142+183	2X2	Box culvert	New-const.
36	142+339	2X2	Box culvert	New-const.
37	142+543	2X2	Box culvert	New-const.
38	142+629	2X2	Box culvert	New-const.
39	142+704	3X3	Box culvert	New-const.
40	142+927	2X2	Box culvert	New-const.
41	143+212	3X3	Box culvert	New-const.
42	143+320	2X2	Box culvert	New-const.
43	143+504	3X3	Box culvert	New-const.
44	143+849	2X2	Box culvert	New-const.
45	143+974	2X2	Box culvert	New-const.
46	144+263	2X2	Box culvert	New-const.

Sr. No.	Proposed Chainage	Span	Structure type	Remark
47	144+414	2X2	Box culvert	New-const.
48	144+533	2X2	Box culvert	New-const.
49	144+608	2X2	Box culvert	New-const.
50	144+729	2X2	Box culvert	New-const.
51	144+974	2X2	Box culvert	New-const.
52	145+302	2X2	Box culvert	New-const.
53	145+418	2X2	Box culvert	New-const.
54	145+643	2X2	Box culvert	New-const.
55	145+777	2X2	Box culvert	New-const.
56	145+852	2X2	Box culvert	New-const.
57	146+718	2X2	Box culvert	New-const.
58	147+126	2X2	Box culvert	New-const.
59	147+247	2X2	Box culvert	New-const.
60	147+311	2X2	Box culvert	New-const.
61	147+437	2X2	Box culvert	New-const.
62	147+522	2X2	Box culvert	New-const.
63	147+591	2X2	Box culvert	New-const.
64	147+937	2X2	Box culvert	New-const.
65	147+976	2X2	Box culvert	New-const.
66	148+166	2X2	Box culvert	New-const.
67	148+312	2X2	Box culvert	New-const.
68	148+890	3X3	Box culvert	New-const.
69	149+108	6X3	Box culvert	New-const.
70	149+273	3X3	Box culvert	New-const.
71	149+437	3X3	Box culvert	New-const.
72	149+530	3X3	Box culvert	New-const.
73	149+583	2X2	Box culvert	New-const.

Note: The chainages are indicative and culverts to be provided as per the site requirement with the approval of the Authority's Engineer

(e) Floor protection works shall be as specified in the relevant IRC Codes and Specifications.

(iii) Bridges

(a) Existing bridges to be re- constructed/widened.

(i) The existing bridges at the following locations shall be re-constructed as new Structures

Sl. No.	Bridge location (km)	Salient details of existing bridge	Adequacy or otherwise of the existing waterway, vertical clearance, etc.*	Remarks
Nil				

*Attach GAD

(ii) The following narrow bridges shall be widened:

Sl. No.	Location (km)	Existing width (m)	Extent of widening (m)	Cross-section at deck level for widening @
Nil				

@ Attach cross-section

(b) Additional new bridges

New bridges at the following locations on the Project Highway shall be constructed. GADs for the new bridges are attached in the drawings folder.

Type of Structure	Design Chainage in km	Total Length (M)	Span Arrangement (No.xlength) in m	Deck Width (M)
Viaduct cum Bridge	111+315	300	5X50+2X25	12.50
Viaduct cum Bridge	112+675	80	2X40	12.50
Major Bridge	113+710	60	3X20	12.50
Viaduct	114+275	250	5x 30 + 5X20	12.50
Minor bridge	115+910	30	1X30	12.50
Minor bridge	116+190	30	1X30	12.50
Minor bridge	116+975	40	2X20	12.50
Viaduct	118+225	300	10 x 30	12.50
Viaduct	121+095	360	1x25+9 x30+1x25+2x20	12.50
Minor bridge	121+723	10	1X10	12.50
Viaduct	123+000	160	8 x 20	12.50
Viaduct	124+945	240	6 x 30 + 3 x 20	12.50
Minor Bridge	126+220	50	2x25	12.50
Viaduct (new)	127+494	60	3x20	12.50
Minor Bridge	128+090	40	2x20 (Skew)	10.00
Major bridge	138+700	80	4X20	10.00
LVUP	138+795	12	12 (Skew)	12.50
Viaduct	139+660	1345	21x25+16x50+1x20	12.50
Viaduct	140+600	100	4x25	12.50
Minor bridge	142+985	20	1X20	12.50
Minor bridge	146+608	10	1X10	12.50
Viaduct cum Bridge	148+600	80	1X20+1X40+1X20 (Skew)	12.50

(c) The railings of existing bridges shall be replaced by crash barriers at the following locations:

Sl. No.	Location at km	Remarks
Nil		

(d) Repairs/replacements of railing/parapets of the existing bridges shall be undertaken as follows:

Sl. No.	Location at km	Remarks
Nil		

(e) Drainage system for bridge decks

An effective drainage system for bridge decks shall be provided as specified in the provision of relevant Manual

(f) Structures in marine environment

Refer to the provision of relevant Manual and specify the necessary measures / treatments for protecting structures in marine environment, where applicable.

(iv) Rail-road bridges

(a) Design, construction and detailing of ROB/RUB shall be as specified in the provision of relevant Manual.

(b) Road over-bridges

Road over-bridges (road over rail) shall be provided at the following level crossings, as per GAD drawings attached:

Sl. No.	Location of Level crossing (Chainage km)	Length of bridge (m)
Nil		

(c) Road under-bridges

Road under-bridges (road under railway line) shall be provided at the following level crossings, as per GAD drawings attached:

Sl. No.	Location of Level crossing (Chainage km)	Number and length of span (m)
Nil		

(v) Grade separated structures

The grade separated structures shall be provided at the locations and of the type and length specified in paragraphs 2 (ix) and 3 of this Annex-I.

(vi) Repairs and strengthening of bridges and structures

The existing bridges and structures to be repaired/strengthened, and the nature and extent of repairs /strengthening required are given below:

(a) Bridges

Sl. No.	Location of bridge (km)	Nature and extent of repairs / strengthening to be carried out
Nil		

(b) ROB / RUB

Sl. No.	Location of ROB/RUB (km)	Nature and extent of repairs /strengthening to be carried out
Nil		

(c) Overpasses/Underpasses and other structures

Sl. No.	Location of Structure (km)	Nature and extent of repairs /strengthening to be carried out
Nil		

(vii) List of Major Bridges and Structures

The following is the list of the Major/Minor Bridges and Structures:

Sl. No.	Description	Location at km	Remarks
1	Viaduct cum Bridge	111+315	2 Lane bridge
2	Viaduct cum Bridge	112+675	2 Lane bridge
3	Major Bridge	113+710	2 Lane bridge
4	Viaduct	114+275	2 Lane bridge
5	Minor bridge	115+910	2 Lane bridge
6	Minor bridge	116+190	2 Lane bridge
7	Minor bridge	116+975	2 Lane bridge
8	Viaduct	118+225	2 Lane bridge
9	Viaduct	121+095	2 Lane bridge
10	Minor bridge	121+723	2 Lane bridge
11	Viaduct	123+000	2 Lane bridge
12	Viaduct	124+945	2 Lane bridge
13	Minor Bridge	126+220	2 Lane Bridge
14	Viaduct (new)	127+494	2 Lane Bridge
15	Minor Bridge	128+090	2 Lane bridge on both LHS and RHS
16	Major bridge	138+700	2 Lane bridge on both LHS and RHS
17	LVUP	138+795	LHS
18	Viaduct	139+660	2 Lane bridge
19	Viaduct	140+600	2 Lane Bridge
20	Minor bridge	142+985	2 Lane bridge
21	Minor bridge	146+608	2 Lane bridge
22	Viaduct cum Bridge	148+600	2 Lane bridge

Note: All Bridges/viaduct cum bridges and viaduct should high level bridge in accordance to the standard & specification set forth in relevant IRC/MoRT&H guidelines.

9. Design of Tunnel

(i) General

- Tunnel shall be designed and constructed in accordance with the provision of relevant Indian/International standards and shall conform to the cross- sectional features and other details specified therein.
- Width of the carriageway of tunnel shall be as follows:

Tunnel No.	Tunnel Chainage from to in km	Rock Classes wise length		Width of carriageway
		Length (in m)	Class	
Tunnel-1 (Tube-1)	Km 128+155 to Km 138+486	1504	ESC 1	9 m
		296	ESC 3	
		704	ESC 4	
		265	ESC 5	
		5163	ESC 10	
		2399	ESC 11	
Tunnel-1 (Tube-2)	Km 128+155 to Km 138+518	1504	ESC 1	9 m
		296	ESC 3	
		736	ESC 4	
		265	ESC 5	
		5163	ESC 10	
		2399	ESC 11	

Note: - ESC-1, ESC-3, ESC-4, ESC-5, ESC-10 & ESC-11 classified as under: -

Rock Class	Classification	Recommended Rock Support	Excavation

Rock Class	Classification	Recommended Rock Support	Excavation
Good to very good	ESC-1, ESC 10& ESC-11	Tunnel is self-standing with minimum support requirements of 150mm shotcrete and spot bolting 4m long. Final lining thickness of 400-660 mm.	Heading /Benching (3.5m/6.5m)
Fair	ESC-3	Systematic Rock Bolt – 5.0 m with spacing – 2.0 m and steel fiber shotcrete – 270mm. Final lining thickness of 400-660 mm	Heading/ Benching (2.5m-3.0m/5.0m-6.0m)
Poor to very poor	ESC-4 & ESC-5	Systematic Rock Bolt – 9.0m-12.0m with spacing – 1.0-1.25 m with steel fiber Shotcrete of 320-350 mm thickness. Steel Rib- TH 29/TH36 or equivalent, @ 0.8m -1.25 c/c spacing. Pipe roofing poling 6.0m long @88.9 of dia. Final lining thickness of 500-700 mm	Heading/ Benching (1.3m-1.5m/2.5m-3.0m)

(c) The following tunnel shall be provided with footpaths:

Sl. No.	Location at km	Remarks
1	Tunnel –Km 128+155 to km 138+486/ Km 138+518 (Tube 1/ Tube 2)	Tube 1 & Tube 2

(d) Cross-section of the tunnel in the Project Highway shall conform to the typical cross-sections provided in schedule.

(iv) Tunnels

a. Rehabilitation of existing Tunnels

S. No.	Location	Start Chainage (km)	End Chainage (km.)	Length (m)	Proposed Rehabilitation
Nil					

b. Proposed Tunnels on the Project Road Section

S. No.	Location	Start Design Chainage (Ch.)	End Design Chainage (Ch.)	Length of Tunnel (m)	Carriageway width including Footpath & Walkway (m)	Remarks
1	LHS Carriageway	128+155	138+486	10331	2x9.00	New 2-lane Twin tube Tunnel
	RHS Carriageway	128+155	138+518	10363		

Note: i. The tunnel mentioned at s.no.1 shall be uni-directional twin tube (2X2-lane) configuration, tunnel as per the chainages mentioned in the above table.

Lighting system-

The lighting system shall be calculated regarding the Guide for Lighting Road Tunnels and Underpasses CIE 88/2004. Also, the Guidelines for Road Tunnels IRC: SP:91-2019 will be taken into account.

The time that a motorist needs to get adapted to the tunnel lighting environment is generally considered as about 4 seconds. In the case of the Vailootunnel, although the speed limit will be lower, considering –for security reasons- a speed of 80 kmph, the length travelled in 4 seconds would be about 89 m. Nevertheless, considering the CIE 88/2004, the distance that is used as a reference to divide the zones is the stopping distance, which is different in each tube, since it depends on the slope among other factors.

It has been decided to follow the CIE 88/2004 as it is the most recognized standard worldwide in relation to

tunnel lighting design, and regarding the security aspect, it shows just slightly more restrictive values than the IRC for the tunnel entrance area.

Tube	CIE 88/2004	IRC: SP:91-2019
	Stopping Distance in the entrances (m)	Zones Length (m)
Tube 1	98	89
Tube 2	98	89

It must be taken into account that, although the speed limit in the tunnel is 50 kmph, for the tunnel lighting design, a higher speed has been used (80 kmph) in order to minimize the risk in the case of some vehicles exceeding the speed limit. This decision can be considered safe, as the layout of the road is favorable.

The characteristics of each one of the zones are described below:

- Access Road Sections: The access sections of the different tubes will start 200 m before the portals and will finish in the portals.
- Threshold Zone: This zone will have a different length in each tunnel as it is shown in the following table:

Tube	Length (m)
Tube 1	98
Tube 2	98

The threshold zone of each tube will be divided into two different parts, so that there are two jumps between the luminance of the access zone and the luminance of the transition zone.

- Transition Zone: This zone is similar in the two tubes that are being studied. Each zone will be divided into four parts. In this way, the luminance will vary from 45 cd/m² to 8 cd/m² progressively.
- Interior zone: The interior zone of each tube will be composed by two parts. The first one will serve as an intermediate jump between the last part of the transition zone and the interior zone that will cover most of the tube.

In this zone, the IRC recommends using a luminance between 15 and 20 cd/sq.m. However, as the IRC indicates values for the luminance in the interior zone that are significantly higher than the usual designs and that overcome what the main international recommendations indicate, in order to obtain a better energy efficiency, the criterion established by the CIE for the interior zone has been considered. Nevertheless, the CIE criterion has been slightly upgraded considering a higher-class road. The considered luminance for the interior zone is 3 cd/m²

- Exit zone: According to the CIE 88/2004, it is important to have a zone in the tunnel that allows the adaptation of the driver to the exterior light. In this manner, the exit zone length of each tube will depend on the stopping distance in the exit part.

Ventilation system-

A longitudinal ventilation system has been proposed for Vailoo Tunnel. The design of the ventilation system has been performed according to two different criteria:

- Pollutants concentration below threshold limits for sanitary ventilation
- Critical velocity (VC) achieved for emergency ventilation

Ventilation system has been designed for the following conditions:

- 200 MW fire (equivalent to HGV fire)
- Enough jet fans pairs would be installed to achieve a ventilation velocity over the critical velocity according

to NFPA 502 (2017)

- An extra jet fan pair will be installed for redundancy (failure or maintenance)

Jet fans pairs would be installed to achieve a ventilation velocity over the critical velocity according to NFPA 502 (2017).

TUNNEL	NUMBER OF JET FAN PAIRS
<i>TUBE 1</i>	31
<i>TUBE 2</i>	25

Smoke Detection & Firefighting system-

A linear fire detection system will be installed in both tunnels, being able to detect a fire source, its magnitude and evolution. It has been planned to install a conventional fire detection system by means of thermal and thermogeometric detectors. In addition, fire buttons and alarms will be added in order to increase security in case of fire. A water pipe of ductile cast iron will be installed under the right sidewalk in the driving direction of the road, with transverse connections between both tunnel tubes, providing and “ring” configuration. This pipe will connect the tunnel with the Fire Pumping Station. The underground main pipe will have a diameter of 8”, whereas the diameter of the derivation to the fire hydrants will be 4” and the derivations to the hose connections will be 2 ½”. There will be fire hydrants of 4” diameter installed every 250 meters. Each hydrant will be equipped with 2 connection types, one of 2 x 2 ½” and the second of 4”.

The Fire Pumping Station will supply the water to the hydrants in order to be able to provide water for 1 hour with a flow of 946 l/min in 2 hydrants simultaneously. For fulfilling this requirement, the reservoir will have a capacity of 120 m³. This tank will be divided into two symmetric volumes in order to enable maintenance operations and availability of 50 % of the capacity in any circumstance. The firefighting system will be complemented by hand – operated fire extinguishers installed in a cabinet every 83,33 meters in the right side along the tunnel, in combination with the hose connections, hydrants or emergency station, depending on the position.

Each egress passageway will have an emergency station composed by two fire extinguishers.

All the fire extinguishers will be type ABC dry powder extinguisher of 13 lb (6 kg).

The control units will be distributed in the different technical rooms, inside and outside the tunnels, and they will be able to control the condition of the tunnel.

The fire hydrants will be installed at the entrance of the tunnels and every 250 meters in the right side along the tunnel, where the emergency lane and the cross - passages are located. Furthermore, the hand – operated fire extinguishers will be mounted every 83.33 meters and the hose connections will be fixed every 83, 33 meters between hydrants.

The tunnel cross section shall be as per TCS enclosed in Schedule B.

c. Details of Cross Passages for Tunnels as below:

S. No.	Design Chainage (Tube-1)	Design Chainage (Tube-2)	Type of cross passage	Width of Cross Passage(m)	Length of Cross Passage(m)
1	128+400	128+400	Pedestrian	6.1 m	35 m
2	128+730	128+730	Vehicular	6.1 m	35 m
3	129+060	129+060	Pedestrian	6.1 m	35 m
4	129+390	129+390	Traffic refuge	9.0 m	35 m
5	129+720	129+720	Vehicular	6.1 m	35 m
6	130+050	130+050	Pedestrian	6.1 m	35 m
7	130+380	130+380	Vehicular	6.1 m	35 m
8	130+710	130+710	Pedestrian	6.1 m	35 m
9	131+040	131+040	Traffic refuge	9.0 m	35 m
10	131+370	131+370	Vehicular	6.1 m	35 m
11	131+700	131+700	Pedestrian	6.1 m	35 m
12	132+030	132+030	Vehicular	6.1 m	35 m
13	132+360	132+360	Pedestrian	6.1 m	35 m
14	132+690	132+690	Traffic refuge	9.0 m	35 m
15	133+020	133+020	Vehicular	6.1 m	35 m
16	133+350	133+350	Pedestrian	6.1 m	35 m
17	133+680	133+680	Vehicular	6.1 m	35 m
18	134+010	134+010	Pedestrian	6.1 m	35 m
19	134+340	134+340	Traffic refuge	9.0 m	35 m
20	134+670	134+670	Vehicular	6.1 m	35 m
21	135+000	135+000	Pedestrian	6.1 m	35 m
22	135+330	135+330	Vehicular	6.1 m	35 m
23	135+660	135+660	Pedestrian	6.1 m	35 m
24	135+990	135+990	Traffic refuge	9.0 m	35 m
25	136+320	136+320	Vehicular	6.1 m	35 m
26	136+650	136+650	Pedestrian	6.1 m	35 m
27	136+980	136+980	Vehicular	6.1 m	35 m
28	137+310	137+310	Pedestrian	6.1 m	35 m
29	137+640	137+640	Traffic refuge	9.0 m	35 m
30	137+970	137+970	Vehicular	6.1 m	35 m
31	138+300	138+300	Pedestrian	6.1 m	35 m

The proposed twin tube tunnel shall be connected by cross passage at an inclination of 90^0 at center to facilitate pedestrian/ traffic diversion in the event of any emergency at every 330 m spacing (Chainages are given in table above). The cross-section for cross- passage shall be as enclosed in Schedule-B. Other tunnel ancillary works including drainage, water proofing, ventilation, tunnel illumination including electrical sub-station on both sides' portals, furnishing, signage's, emergency facilities, etc. shall be provided as specified in IRC: SP:84-2019, IRC: SP:91-2019 and specification as per **Schedule-D**. The Longitudinal gradient of the tunnel is less than 3%. Apart from the geological challenges the topography of the stretch is bound with steep mountains with limited access to the faces for excavation this limitation leads to opening the excavation faces only at proposed portals of the tunnels with negligible options of creating adits in long tunnels. Given the limitation in number of faces the most critical activities remain the portal creation and stabilization for starting and achieving

significant progress in tunnel drive. For every face of the excavation for portal and tunnel the set of critical machinery involving the hydraulic boomer, shotcrete machine, grouting machine, excavation mucking and dumping machinery shall be maintained dedicated for each face of excavation. The excavation & support installation for portal face and underground excavation opening within stipulated cycle can only be achieved if the excavation, mucking and dumping, support installation, shotcrete, grouting and tunnel formwork set for final lining, Plant, machinery and manpower resources are provided dedicatedly for each face of each tunnel tube. It should be noted that the minimum drifting scheme has to be adopted as per the specifications and drawings but shall be revised (by EPC contractor) based upon the geological findings of the ground and if required the stages shall be increased to achieve the desired excavation stability and hence the provisioning of resources shall be accounted for any such requirements.

d. The details of the distribution of rock- mass conditions on the Basis of Geological strength index are as below:

Vailoo Tunnel- Tube-1								
RD (m)		Length (m)	Rock Type	Rock Characteristics as per site visit	RMR/Q			Cover
From	To				Values	Description	Rock mass Class	
128+155	128+705	550	Quartzite, Shales, Siltstone, Slate & Conglomerate	Slightly weathered	46-54/4-6	Fair	III	10-185
128+705	128+955	250	Quartzite, Shales, Siltstone, Slate & Conglomerate	Moderately to Highly weathered	18-35/0.5-1.8	Poor Very Poor	IV-V	185-218
128+955	129+650	695	Diamictite, Arenite with Phyllite & Ash Beds	Slightly weathered	48-57/4-6	Fair	III	218-500
129+650	129+950	300	Diamictite, Arenite with Phyllite & Ash Beds	Moderately to Highly weathered	16-36/0.5-2.0	Poor Very Poor	IV-V	500-547
129+950	130+869	919	Andesitic & Basaltic Lava Flows	Slightly weathered	48-58/4-8	Fair	III	547-830
130+869	131+645	776	Andesitic & Basaltic Lava Flows	Fresh	62-68/11-14	Good	II	830-1023
131+645	131+955	310	Andesitic & Basaltic Lava Flows	Slightly weathered	50-56/5-8	Fair	III	1023-1118
131+955	132+155	200	Andesitic & Basaltic Lava Flows	Moderately to Highly weathered	15-35/0.5-2.0	Poor	IV-V	1118-1221
132+155	132+439	284	Andesitic & Basaltic Lava Flows	Slightly weathered	50-57/4-7	Fair	III	1221-1347
132+439	135+388	2949	Andesitic & Basaltic Lava Flows	Fresh	62-72/11-17	Good	II	1347-575
135+388	136+448	1060	Andesitic & Basaltic Lava Flows	Slightly weathered	52-58/5-8	Fair	III	575-366
136+448	136+648	200	Andesitic & Basaltic Lava Flows	Moderately to Highly	15-35/0.5-2.0	Poor to Very Poor	IV-V	366-339

Vailoo Tunnel- Tube-1								
RD (m)		Length (m)	Rock Type	Rock Characteristics as per site visit	RMR/Q			Cover
From	To				Values	Description	Rock mass Class	
				weathered				
136+648	136+907	259	Calcareous shales & Crystalline Limestone	Slightly weathered	44-52/4-6	Fair	III	339
136+907	137+390	483	Calcareous shales & Crystalline Limestone	Fresh to Slightly weathered	61-66/10-12	Good	II	339-366
137+390	137+686	296	Calcareous shales & Crystalline Limestone	Moderately to Highly weathered	42-48/5-7	Fair	III	366-285
137+686	137+836	150	Calcareous shales & Crystalline Limestone	Moderately to Highly weathered	15-35/0.5-2.0	Poor to Very Poor	IV-V	285-200
137+836	137+936	100	Andesitic & Basaltic Lava Flows	Fresh to Slightly weathered	50-55/6.0	Fair	III	200-144
137+936	138+355	419	Andesitic & Basaltic Lava Flows	Fresh to Slightly weathered	61-66/10-12	Good	II	10-144
138+355	138+409	54	Andesitic & Basaltic Lava Flows	Fresh to Slightly weathered	10-30/0.2-1.5	Fair	III	112-84
138+409	138+486	77	Andesitic & Basaltic Lava Flows	Moderately to Highly weathered	15-35/0.5-2.0	Poor to Very Poor	IV-V	83-28

Vailoo Tunnel- Tube-2								
RD (m)		Length (m)	Rock Type	Rock Characteristics as per site visit	RMR/Q			Cover
From	To				Values	Description	Rock mass Class	
128+155	128+705	550	Quartzite, Shales, Siltstone, Slate & Conglomerate	Slightly weathered	46-54/4-6	Fair	III	10-185
128+705	128+955	250	Quartzite, Shales, Siltstone, Slate & Conglomerate	Moderately to Highly weathered	18-35/0.5-1.8	Poor Very Poor	IV-V	185-218
128+955	129+650	695	Diamictite, Arenite with Phyllite & Ash Beds	Slightly weathered	48-57/4-6	Fair	III	218-500
129+650	129+950	300	Diamictite, Arenite with Phyllite & Ash Beds	Moderately to Highly weathered	16-36/0.5-2.0	Poor Very Poor	IV-V	500-547
129+950	130+869	919	Andesitic & Basaltic Lava Flows	Slightly weathered	48-58/4-8	Fair	III	547-830
130+869	131+645	776	Andesitic & Basaltic Lava Flows	Fresh	62-68/11-14	Good	II	830-1023
131+645	131+955	310	Andesitic & Basaltic Lava Flows	Slightly weathered	50-56/5-8	Fair	III	1023-1118
131+955	132+155	200	Andesitic & Basaltic Lava Flows	Moderately to Highly weathered	15-35/0.5-2.0	Poor	IV-V	1118-1221
132+155	132+439	284	Andesitic & Basaltic Lava Flows	Slightly weathered	50-57/4-7	Fair	III	1221-1347
132+439	135+388	2949	Andesitic & Basaltic Lava Flows	Fresh	62-72/11-17	Good	II	1347-575
135+388	136+448	1060	Andesitic & Basaltic Lava Flows	Slightly weathered	52-58/5-8	Fair	III	575-366

Vailoo Tunnel- Tube-2								
RD (m)		Length (m)	Rock Type	Rock Characteristics as per site visit	RMR/Q			Cover
From	To				Values	Description	Rock mass Class	
136+448	136+648	200	Andesitic & Basaltic Lava Flows	Moderately to Highly weathered	15-35/0.5-2.0	Poor to Very Poor	IV-V	366-339
136+648	136+907	259	Calcareous shales & Crystalline Limestone	Slightly weathered	44-52/4-6	Fair	III	339
136+907	137+390	483	Calcareous shales & Crystalline Limestone	Fresh to Slightly weathered	61-66/10-12	Good	II	339-366
137+390	137+686	296	Calcareous shales & Crystalline Limestone	Moderately to Highly weathered	42-48/5-7	Fair	III	366-285
137+686	137+836	150	Calcareous shales & Crystalline Limestone	Moderately to Highly weathered	15-35/0.5-2.0	Poor to Very Poor	IV-V	285-200
137+836	137+936	100	Andesitic & Basaltic Lava Flows	Fresh to Slightly weathered	50-55/6.0	Fair	III	200-144
137+936	138+355	419	Andesitic & Basaltic Lava Flows	Fresh to Slightly weathered	61-66/10-12	Good	II	10-144
138+355	138+409	54	Andesitic & Basaltic Lava Flows	Fresh to Slightly weathered	10-30/0.2-1.5	Fair	III	112-84
138+409	138+518	109	Andesitic & Basaltic Lava Flows	Moderately to Highly weathered	15-35/0.5-2.0	Poor to Very Poor	IV-V	83-30

e. Based on the surface Geological Mapping and Geotechnical investigation of tunnel, the support measures recommended are as follows:

Rock Class	Classification	Recommended Rock Support	Excavation
Good to very good	ESC-1, ESC 10 & ESC-11	Tunnel is self-standing with minimum support requirements of 150mm shotcrete and spot bolting 4m long. Final lining thickness of 400-660 mm.	Heading /Benching (3.5m/6.5m)
Fair	ESC-3	Systematic Rock Bolt – 5.0 m with spacing – 2.0 m and steel fiber shotcrete – 270mm. Final lining thickness of 400-660 mm	Heading/ Benching (2.5m-3.0m/5.0m-6.0m)
Poor to very poor	ESC-4 & ESC-5	Systematic Rock Bolt – 9.0m-12.0m with spacing – 1.0-1.25 m with steel fiber Shotcrete of 320-350 mm thickness. Steel Rib- TH 29/TH36 or equivalent, @ 0.8m -1.25 c/c spacing. Pipe roofing poling 6.0m long @88.9 of dia. Final lining thickness of 500-700 mm	Heading/ Benching (1.3m-1.5m/2.5m-3.0m)

Notes:

- Above details of the tunnel has been prepared as per the field survey of the geologist and the report submitted by the geologist based on the Geotechnical and Geophysical studies.*
- ESC1, ESC3, ESC4, ESC5, ESC10 & ESC11 are the tunnel support categories applicable to different types of rock classes mentioned in the table.*
- Above details for the tunnel support system has been prepared as per the Geological/Geotechnical data collected from the field. This shall form Geotechnical Baseline Report (GBR) and any variation in tunnel support system due to deviation from the GBR shall be treated as change of scope under the provision of the **Article 13** of the EPC Contract agreement subject to following conditions: -*
 - Any positive variation upto the 5% of the cost of the Tunnel due to change in length in particular rock classification shall not be treated as Change of Scope (COS). (Ex: Awarded cost x Weightage defined in Schedule H for Tunnel cost x 5%)*
 - Beyond positive 5% of the cost of the Tunnel may be treated as Change of Scope in only such case where variation in length interchanges from one rock class to other rock class beyond the classification specified in para 9 above of Schedule-B. In addition, Contractor is required to submit the Change of Scope Proposal +/- due to interchange in length of rock classification after consuming of length of respective classification as specified in Schedule B.*
- Provisions for Probe holes: Where the geological data collected so warrants advance probe holes by percussion or core drilling, as required, shall be drilled ahead of the tunnel faces to locate any gas, flowing mass of rock, auriferous strata, geological disturbances, etc. 2 probe holes of 15-20m long and 1 probe hole of 35-40m long shall be drilled at the tunnel face during each advancement.*

f. The Summary Details of the Support system of Tunnel is indicated in the Figure below.

Summary Details of Support System in Tunnels								
	Support Classification	Type						
		ESC-1, ESC-10, ESC-11	ESC-2	ESC-3		ESC-4	ESC-5	
				ESC-3a	ESC-3b		ESC-5a	ESC-5b
	RMR Rating Range		62-76	62-68	42-58	42-59	22-35	10-18
Excavation Method		Heading/Benching	Heading/Benching	Heading/Benching	Heading/Benching	Heading/Benching	Heading/Benching	Heading/Benching
Excavation Length (m)		3.5/6.5	3.5/6.5	2.5/5.0	3.0/6.0	1.5/3.0	1.3/2.5	1.3/2.5
Shotcrete Thickness (mm)	Steel Fiber Reinforced Shotcrete	150	150	270	270	320	350	350
Rock Bolt	Length (m)	4	4	5	5	9	12	12
	Longitudinal Spacing (m)	3	2.5	2	2	1.25	1	1.25
	Transverse Spacing (m)	3.25	2.75	2	2	1.5	1.25	1.25
Steel Support (m)	Lattice Girder (Dia. of the bar)							
	Space							
	Steel RIB	-	-	TH-29 Steel Arches @ 1m c/c		TH-29 Steel Arches @ 0.8-1m c/c	TH-36 Steel Arches @0.8m c/c	TH-36 Steel Arches @1.25m c/c
Inner Lining Thickness (mm)		400-660	400-660	400-660	400-660	500-700	500-700	500-700
Auxiliary Support		-	-	-	-	Pipe Roofing (88.9φ, 6m Long)	Pipe Roofing (88.9φ, 6m Long)	Pipe Roofing (88.9φ, 6m Long)

10. Traffic Control Devices and Road Safety Works

(i) Traffic control devices and road safety works shall be provided in accordance with the provision of relevant Manual.

(ii) Specifications of the reflective sheeting shall be as per IRC specifications and manual.

The minimum quantity *of Traffic signages and pavement marking are tabulated here:

Sl. No.	Traffic Signages, Road Marking and other appurtenances	unit	Quantity
1	Road Marking: -Lines, dashes, arrows,	Sqm	22726
2	90 cm equilateral triangle	Nos.	222
3	60 cm x 50 cm rectangular	Nos.	568
4	90 cm x 30 cm rectangular	Nos.	32
5	60 cm circular	Nos.	196
6	60 cm x 45 cm rectangular	Nos.	2
7	90 cm Octagon	Nos.	21
8	120 cm x 70 cm	Nos.	62
9	Over Head sign (Gantry Mounted)	Nos.	4
10	Variable message Sign (Gantry Mounted)	Nos.	7
11	Ordinary Km Stone	Nos.	28
12	5 th km stone	Nos.	7
13	Hectometer Stone	Nos.	150
14	Studs	Nos.	14806
15	Boundary pillars	Nos.	668
16	Delineator	Nos.	2061
17	“Thrie” Beam Crash Barrier	Rm	22751

***These are the minimum quantity. Any increase in quantity from the minimum quantity defined in the Schedule-B shall not be considered as Change of Scope.**

11. Roadside Furniture

Roadside furniture shall be provided in accordance with the provision of relevant Manual and minimum shall be given as given above table. However, additional Traffic control devices and road safety work devices if required on the site shall be install as per IRC manual for safety point view.

12. Compulsory Afforestation

Refer to the provision of relevant Manual and 5500 number of trees which are required to be planted by the Contractor as compensatory afforestation.

13. Hazardous Locations

The safety barriers shall also be provided at the following hazardous locations:

Sl. No.	Location stretches from (km) to (km)	LHS/RHS
	Nil	

14. Special Requirement for Hill Roads

In accordance with section 13 of the manual (from IRC: SP: 73-2018), IRC: SP: 48: 1998, IRC: 52: 2019 and Recommended practices for Treatment of Embankment and Roadside slopes for erosion control (First Revision), IRC: 56: 2011 and relevant IRC codes.

15. Retaining Wall/ Gabion Wall/ Breast Wall

Retaining Walls: Retaining walls shall be provided to arrest damage cause to the valley side and the road, by under cutting by stream or other water course as per site requirement.

a) RRM Retaining wall/ Gabion Wall: -

- b) Retaining wall to be provided where height is varying from 1 m to 4m and Gabion wall to be provided where height is varying more than 4 m up to 10 m.

- RRM Retaining wall

Chainage		Length(m)	Min. Height (m)
From	To		
111590	111620	30	2.00
111860	111890	30	3.50
111950	111970	20	3.50
112080	112120	40	3.50
112160	112240	80	3.50
112290	112330	40	1.50
112380	112410	30	3.50
112470	112510	40	3.50
112900	112920	20	3.50
112950	112960	10	3.50
113140	113180	40	4.00
114040	114110	70	3.00
115710	115750	40	3.00
115870	115890	20	3.50
117000	117020	20	2.50
118560	118620	60	2.50
118760	118770	10	2.50
118840	118920	80	2.00
119020	119030	10	3.50
119650	119690	40	2.50
119760	119800	40	2.50
119870	119890	20	2.50
119960	120030	70	2.00
120340	120380	40	2.50
120460	120470	10	1.50
120630	120650	20	3.50
121280	121320	40	2.50
121380	121530	150	2.50
122230	122260	30	2.00
122870	122880	10	2.00
123260	123480	220	2.00
123530	123550	20	2.50
123860	123890	30	3.50
124170	124310	140	2.00
125420	125430	10	2.50
125780	125810	30	2.00
126270	126290	20	3.00
126720	126730	10	2.50
127090	127100	10	2.50
127880	127890	10	2.50
128040	128060	20	3.50
138750	138770	20	2.50
138920	138930	10	3.00
140350	140360	10	3.00
140510	140520	10	3.00
140710	140750	40	3.50
141220	141260	40	2.50
141480	141510	30	1.50
141530	141590	60	2.00
141650	141660	10	2.00

Chainage		Length(m)	Min. Height (m)
From	To		
142030	142200	170	2.50
142370	142410	40	3.00
142530	142600	70	2.00
142670	142750	80	3.00
143260	143330	70	3.00
143440	143450	10	1.50
143480	143560	80	2.50
143760	143800	40	2.50
143970	143990	20	1.50
145280	145310	30	2.00
145330	145400	70	2.00
145420	145430	10	2.00
145540	145600	60	2.00
145950	145980	30	1.50
146220	146360	140	3.00
146410	146480	70	3.00
146620	146630	10	1.50
148520	148550	30	1.50
Total Length		2940	

Chainage		Length/(m)	Min. Height (m)
From	To		
115010	115080	70	3.50
115140	115170	30	2.00
115400	115560	160	2.00
115790	115840	50	2.50
115990	116080	90	2.50
116650	116770	120	2.00
116810	116850	40	2.50
116930	116950	20	4.00
117580	117630	50	2.50
117860	117880	20	3.50
117910	118000	90	2.50
119310	119320	10	2.00
120400	120410	10	2.00
121710	121730	20	2.50
122840	122890	50	2.00
123630	123650	20	2.00
123690	123770	80	2.00
125080	125090	10	1.50
125590	125600	10	2.00
125650	125690	40	4.00
125710	125720	10	4.00
125740	125780	40	2.50
126310	126340	30	2.00
127470	127480	10	2.00
127500	127510	10	2.00
138650	138660	10	2.50
138950	138970	20	2.50
140340	140350	10	3.00
140650	140670	20	3.00

Chainage		Length/(m)	Min. Height (m)
From	To		
141150	141180	30	2.00
141600	141630	30	3.00
142050	142070	20	1.50
142230	142260	30	3.50
142340	142390	50	2.50
142600	142650	50	2.00
143200	143220	20	2.00
143980	144000	20	1.50
148540	148560	20	2.00
148870	148910	40	2.50
149110	149130	20	2.00
149250	149260	10	3.00
149280	149320	40	3.00
149360	149370	10	1.50
149420	149430	10	3.00
149460	149470	10	2.00
149500	149520	20	3.00
149540	149580	40	2.50
149650	149660	10	2.00
Total Length		1630	

- **Gabion wall**

Chainage		Length (m)	Min. Height(m)
From	To		
111150	111160	10	5.48
111520	111530	10	4.55
111790	111850	60	5.80
111980	112000	20	5.61
112580	112590	10	5.41
112750	112860	110	6.43
112990	113050	60	5.97
113300	113320	20	6.54
113390	113440	50	5.41
113520	113550	30	5.21
113610	113630	20	6.47
113660	113680	20	6.42
113740	113770	30	5.59
113840	113880	40	6.50
114120	114150	30	7.10
115640	115650	10	4.31
118380	118390	10	4.12
118520	118550	30	7.66
118630	118650	20	4.62
119300	119330	30	6.57
119470	119550	80	5.05
120040	120080	40	5.34
120130	120160	30	6.27
120390	120430	40	7.25
120480	120620	140	7.73
120660	120770	110	6.07
120820	120910	90	5.67
121330	121370	40	4.59

Chainage		Length (m)	Min. Height(m)
From	To		
121720	121730	10	5.01
122170	122220	50	7.46
122890	122920	30	6.01
123560	123800	240	6.63
124060	124160	100	4.78
125440	125770	330	5.68
126300	126600	300	6.84
126740	126880	140	8.45
126960	127080	120	9.16
127250	127260	10	4.62
127450	127550	100	8.56
127680	127690	10	6.04
127760	127870	110	7.23
128070	128080	10	6.53
138730	138740	10	9.40
138940	138990	50	6.44
140530	140550	20	6.89
140650	140700	50	6.39
141120	141210	90	6.24
141600	141640	40	5.05
142210	142360	150	5.66
142610	142660	50	4.49
143190	143250	60	4.66
146370	146380	10	4.31
148560	148570	10	7.26
148650	148670	20	6.53
Total Length		3310	

Chainage		Length (m)	Min. Height (m)
From	To		
114450	114610	160	5.00
114670	114710	40	5.00
114770	114790	20	5.00
115630	115780	150	6.00
115850	115890	40	7.00
115930	115980	50	6.00
116780	116800	20	5.00
117530	117570	40	5.00
117660	117680	20	5.00
117780	117810	30	5.00
118060	118070	10	6.00
118380	118390	10	5.00
122900	122920	20	7.00
123560	123620	60	5.00
124800	124820	20	7.00
125610	125640	30	5.00
138980	138990	10	5.00
140540	140550	10	5.00
142270	142330	60	5.00
148650	148690	40	8.00
149440	149450	10	5.00

Chainage		Length (m)	Min. Height (m)
From	To		
Total Length		850	

a) **RRM Breast wall: -**

RRM Breast wall to be provided with height varying from 1 m to 3m and additional height varying up to 10m

Left Hand side			
From	To	Length(m)	Min. Height (m)
114+440	114+450	10	3
114+520	114+780	260	3
114+820	115+020	200	3
115+060	115+190	130	3
115+220	115+370	150	3
115+510	115+610	100	1
115+820	115+850	30	3
115+950	116+170	220	3
116+220	116+640	420	3
116+840	116+950	110	3
117+220	117+650	430	3
117+680	117+790	110	3
117+830	118+050	220	3
118+410	118+480	70	3
119+410	119+440	30	3
119+570	119+600	30	1
121+740	121+800	60	3
121+910	121+940	30	3
121+980	122+020	40	1
122+340	122+440	100	3
122+530	122+820	290	3
123+100	123+200	100	3
124+400	124+810	410	3
125+100	125+370	270	3
125+840	126+210	370	3
126+920	126+930	10	1
127+140	127+150	10	1
127+190	127+230	40	1
127+280	127+420	140	3
127+590	127+610	20	1
127+630	127+640	10	1
127+720	127+730	10	3
127+910	128+020	110	3
128+120	128+150	30	3
138+520	138+630	110	3
140+390	140+480	90	3
140+780	140+950	170	3
141+030	141+090	60	1
141+310	141+390	80	3
141+820	141+880	60	1

Left Hand side			
From	To	Length(m)	Min. Height (m)
142+780	142+950	170	3
143+000	143+170	170	3
143+580	143+720	140	3
143+820	143+830	10	3
143+860	143+910	50	3
144+790	144+870	80	3
148+760	148+870	110	1
148+960	149+000	40	3
149+150	149+510	360	3
149+550	149+650	100	3
Total Length		6370	

Right Hand Side			
From	To	Length(m)	Min. Height (in m)
111+070	111+140	70	3
111+500	111+790	290	3
111+850	111+960	110	3
112+010	112+620	610	3
112+750	112+990	240	3
113+050	113+390	340	3
113+450	113+520	70	3
113+540	113+650	110	3
113+770	113+850	80	3
116+220	116+490	270	1
117+030	117+070	40	3
117+220	117+520	300	3
118+410	118+500	90	3
118+550	118+840	290	3
118+870	119+280	410	3
119+350	119+470	120	3
119+550	119+640	90	3
119+690	119+860	170	3
119+890	120+020	130	3
120+040	120+120	80	3
120+160	120+330	170	3
120+350	120+390	40	3
120+420	120+470	50	3
120+600	120+670	70	3
120+730	120+840	110	3
120+880	120+910	30	3
121+420	121+700	280	3
121+740	122+020	280	3
122+130	122+160	30	3
122+310	122+830	520	3
123+090	123+300	210	3
123+410	123+520	110	1

Right Hand Side			
From	To	Length(m)	Min. Height (in m)
123+840	124+060	220	3
124+200	124+210	10	3
124+350	124+740	390	3
125+110	125+490	380	3
125+820	125+950	130	3
125+980	126+210	230	3
126+230	126+260	30	3
126+420	126+770	350	3
126+870	127+020	150	3
127+110	127+240	130	3
127+270	127+440	170	3
127+550	127+810	260	3
127+840	128+070	230	3
128+130	128+150	20	3
138+490	138+620	130	3
138+740	138+920	180	3
140+380	140+500	120	3
140+760	141+120	360	3
141+270	141+460	190	3
141+690	142+000	310	3
142+740	142+950	210	3
143+000	143+180	180	3
143+320	143+480	160	3
143+540	143+760	220	3
143+810	143+840	30	3
143+860	143+950	90	3
144+760	144+870	110	3
145+380	145+420	40	3
145+510	145+530	20	1
146+170	146+180	10	1
146+290	146+580	290	3
146+650	146+670	20	3
146+750	146+890	140	3
147+120	147+130	10	1
Total Length		11330	

Right			
From	To	Breast Wall Length (m)	Min. Height (m)
111+540	111+660	120	10
111+700	111+730	30	10
112+050	112+080	30	10
112+110	112+130	20	10
112+330	112+400	70	10
112+490	112+510	20	10

Right			
From	To	Breast Wall Length (m)	Min. Height (m)
112+530	112+560	30	10
112+740	112+870	130	10
112+900	112+930	30	10
113+190	113+240	50	10
113+310	113+340	30	10
113+540	113+560	20	10
113+620	113+640	20	10
115+070	115+130	60	10
116+070	116+120	50	10
116+880	116+920	40	10
120+090	120+120	30	10
120+770	120+810	40	10
126+610	126+770	160	10
Total Length		980 m	

Both Side			
From	To	Breast Wall Length (m)	Min. Height (m)
111+660	111+700	80	10
111+730	111+770	80	10
112+010	112+050	80	10
113+060	113+110	100	10
113+240	113+280	80	10
116+280	116+450	340	10
117+270	117+500	460	10
118+430	118+490	120	10
118+660	118+690	60	10
119+150	119+230	160	10
119+570	119+630	120	10
120+170	120+310	280	10
122+670	122+780	220	10
123+110	123+230	240	10
125+150	125+350	400	10
126+030	126+090	120	10
126+910	126+950	80	10
127+150	127+240	180	10
127+330	127+400	140	10
127+610	127+680	140	10
127+710	127+750	80	10
127+930	127+970	80	10

Both Side			
From	To	Breast Wall Length (m)	Min. Height (m)
Total Length		3640 m	

16. Slope Protection

As the project involves cutting of existing hill slopes, it is imperative that slopes are stabilized for ensuring longevity of the slope and the road. Slope stability, erosion control and landslide correction shall be accomplished in accordance with IRC: SP: 48-1998. Reference may be drawn from IRC: 56-2011.

Rock Bolting with bioengineering

Design Chainage in Km		Side	Length (m)
From	To		
112+560	112+600	RHS	40.00
112+930	112+960	RHS	30.00
113+370	113+390	RHS	20.00
113+450	113+470	RHS	20.00
113+510	113+540	RHS	30.00
119+640	119+690	RHS	50.00
120+470	120+530	RHS	60.00
Total Length in m			250

Grass Turfing

Design Chainage in km		Length (m)	TCS No
From	To		
113+890	114+040	150	TCS-1A
115+570	115+630	60	TCS-1A
117+130	117+220	90	TCS-1C
123+490	123+530	40	TCS-1A
123+810	123+840	30	TCS-1A
124+320	124+350	30	TCS-2C
141+460	141+490	30	TCS-1C
142+010	142+040	30	TCS-2C
142+100	142+170	70	TCS-1C
142+490	142+580	90	TCS-1C
143+960	144+010	50	TCS-2C
144+010	144+050	40	TCS-2A
144+050	144+100	50	TCS-1A
144+100	144+410	310	TCS-2A
144+410	144+560	150	TCS-2C
144+610	144+730	120	TCS-2C
144+930	145+020	90	TCS-2C
145+070	145+150	80	TCS-2C
145+150	145+280	130	TCS-2A
145+450	145+490	40	TCS-1A
145+720	146+230	510	TCS-2A
146+680	146+750	70	TCS-1A
146+890	147+200	310	TCS-1A
147+200	147+270	70	TCS-1C

Design Chainage in km		Length (m)	TCS No
From	To		
147+270	147+370	100	TCS-2C
147+370	147+490	120	TCS-1C
147+490	148+520	1030	TCS-2C
148+700	148+870	170	TCS-1C
148+920	148+960	40	TCS-1C
149+010	149+080	70	TCS-1C
149+080	149+110	30	TCS-2C
Total Length		4200	

17. Change of Scope

The length of Structures and bridges & Tunnels specified hereinabove shall be treated as an approximate assessment. The actual lengths as required on the basis of detailed investigations shall be determined by the Contractor in accordance with the Specifications and Standards. Any variations in the lengths specified in this Schedule- B shall not constitute a Change of Scope, save and except any variations in the length arising out of a Change of Scope expressly undertaken in accordance with the provisions of Article 13.

18. Indicative Chainages with applicable typical Cross section

Sr. No.	Design Chainage		Design Length	TCS Detail	TCS Type
	From	To			
1	111+067	111+150	83.43	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1
2	111+150	111+165	15.00	BOTH SIDE FILL WITH PROTECTION (AS APPLICABLE)(RECONSTRUCTION)	TCS-2
3	111+165	111+465	300.00	MAJOR BRIDGE	MAJOR BRIDGE
4	111+465	111+500	35.00	BOTH SIDE FILL WITH PROTECTION (AS APPLICABLE)(RECONSTRUCTION)	TCS-2
5	111+500	111+540	40.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1
6	111+540	111+660	120.00	ONE SIDE CUT (Ht.>15m) & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1D
7	111+660	111+700	40.00	BOTH SIDE CUT (Ht.>15m) WITH PROTECTION ON EITHER SIDE AS APPLICABLE (RECONSTRUCTION)	TCS-3D
8	111+700	111+730	30.00	ONE SIDE CUT (Ht.>15m) & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1D
9	111+730	111+770	40.00	BOTH SIDE CUT (Ht.>15m) WITH PROTECTION ON EITHER SIDE AS APPLICABLE (RECONSTRUCTION)	TCS-3D

Sr. No.	Design Chainage		Design Length	TCS Detail	TCS Type
	From	To			
10	111+770	111+800	30.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1
11	111+800	111+850	50.00	BOTH SIDE FILL WITH PROTECTION (AS APPLICABLE)(RECONSTRUCTION)	TCS-2
12	111+850	112+010	160.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1
13	112+010	112+050	40.00	BOTH SIDE CUT (Ht.>15m) WITH PROTECTION ON EITHER SIDE AS APPLICABLE (RECONSTRUCTION)	TCS-3D
14	112+050	112+080	30.00	ONE SIDE CUT (Ht.>15m) & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1D
15	112+080	112+110	30.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1
16	112+110	112+130	20.00	ONE SIDE CUT (Ht.>15m) & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1D
17	112+130	112+330	200.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1
18	112+330	112+400	70.00	ONE SIDE CUT (Ht.>15m) & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1D
19	112+400	112+490	90.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1
20	112+490	112+510	20.00	ONE SIDE CUT (Ht.>15m) & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1D
21	112+510	112+530	20.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1
22	112+530	112+560	30.00	ONE SIDE CUT (Ht.>15m) & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1D
23	112+560	112+600	40.00	ONE SIDE CUT WITH ROCK BOLTING & ONE SIDE FILL WITH	TCS-4

Sr. No.	Design Chainage		Design Length	TCS Detail	TCS Type
	From	To			
				PROTECTION AS APPLICABLE(RECONSTRUCTION)	
24	112+600	112+635	35.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1
25	112+635	112+715	80.00	MAJOR BRIDGE	MAJOR BRIDGE
26	112+715	112+740	25.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1
27	112+740	112+870	130.00	ONE SIDE CUT (Ht.>15m) & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1D
28	112+870	112+900	30.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1
29	112+900	112+930	30.00	ONE SIDE CUT (Ht.>15m) & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1D
30	112+930	112+960	30.00	ONE SIDE CUT WITH ROCK BOLTING & ONE SIDE FILL WITH PROTECTION AS APPLICABLE(RECONSTRUCTION)	TCS-4
31	112+960	113+000	40.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1
32	113+000	113+060	60.00	BOTH SIDE FILL WITH PROTECTION (AS APPLICABLE)(RECONSTRUCTION)	TCS-2
33	113+060	113+110	50.00	BOTH SIDE CUT (Ht.>15m) WITH PROTECTION ON EITHER SIDE AS APPLICABLE (RECONSTRUCTION)	TCS-3D
34	113+110	113+190	80.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1
35	113+190	113+240	50.00	ONE SIDE CUT (Ht.>15m) & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1D
36	113+240	113+280	40.00	BOTH SIDE CUT (Ht.>15m) WITH PROTECTION ON EITHER SIDE AS APPLICABLE (RECONSTRUCTION)	TCS-3D
37	113+280	113+310	30.00	BOTH SIDE CUT WITH PROTECTION ON EITHER SIDE AS APPLICABLE (RECONSTRUCTION)	TCS-3
38	113+310	113+340	30.00	ONE SIDE CUT (Ht.>15m) & ONE	TCS-1D

Sr. No.	Design Chainage		Design Length	TCS Detail	TCS Type
	From	To			
				SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	
39	113+340	113+370	30.00	BOTH SIDE CUT WITH PROTECTION ON EITHER SIDE AS APPLICABLE (RECONSTRUCTION)	TCS-3
40	113+370	113+390	20.00	ONE SIDE CUT WITH ROCK BOLTING & ONE SIDE FILL WITH PROTECTION AS APPLICABLE(RECONSTRUCTION)	TCS-4
41	113+390	113+450	60.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1
42	113+450	113+470	20.00	ONE SIDE CUT WITH ROCK BOLTING & ONE SIDE FILL WITH PROTECTION AS APPLICABLE(RECONSTRUCTION)	TCS-4
43	113+470	113+510	40.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1
44	113+510	113+540	30.00	ONE SIDE CUT WITH ROCK BOLTING & ONE SIDE FILL WITH PROTECTION AS APPLICABLE(RECONSTRUCTION)	TCS-4
45	113+540	113+560	20.00	ONE SIDE CUT (Ht.>15m) & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1D
46	113+560	113+620	60.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1
47	113+620	113+640	20.00	ONE SIDE CUT (Ht.>15m) & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1D
48	113+640	113+680	40.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1
49	113+680	113+740	60.00	MAJOR BRIDGE	MAJOR BRIDGE
50	113+740	113+890	150.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1
51	113+890	114+040	150.00	ONE SIDE CUT(CUT HEIGHT<2m) & ONE SIDE FILL(EMBANKMENT HEIGHT<2m) WITHOUT PROTECTION WORK(RECONSTRUCTION)	TCS-1A

Sr. No.	Design Chainage		Design Length	TCS Detail	TCS Type
	From	To			
52	114+040	114+150	110.00	BOTH SIDE FILL WITH PROTECTION (AS APPLICABLE)(RECONSTRUCTION)	TCS-2
53	114+150	114+400	250.00	MAJOR BRIDGE	MAJOR BRIDGE
54	114+400	114+410	10.00	BOTH SIDE FILL WITH PROTECTION (AS APPLICABLE)(RECONSTRUCTION)	TCS-2
55	114+410	114+810	400.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1
56	114+810	114+860	50.00	BOTH SIDE CUT WITH PROTECTION ON EITHER SIDE AS APPLICABLE (RECONSTRUCTION)	TCS-3
57	114+860	115+070	210.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1
58	115+070	115+130	60.00	ONE SIDE CUT (Ht.>15m) & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1D
59	115+130	115+570	440.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1
60	115+570	115+630	60.00	ONE SIDE CUT(CUT HEIGHT<2m) & ONE SIDE FILL(EMBANKMENT HEIGHT<2m) WITHOUT PROTECTION WORK(RECONSTRUCTION)	TCS-1A
61	115+630	115+780	150.00	BOTH SIDE FILL WITH PROTECTION (AS APPLICABLE)(RECONSTRUCTION)	TCS-2
62	115+780	115+860	80.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1
63	115+860	115+895	35.00	BOTH SIDE FILL WITH PROTECTION (AS APPLICABLE)(RECONSTRUCTION)	TCS-2
64	115+895	115+925	30.00	MINOR BRIDGE	MINOR BRIDGE
65	115+925	115+950	25.00	BOTH SIDE FILL WITH PROTECTION (AS APPLICABLE)(RECONSTRUCTION)	TCS-2
66	115+950	116+070	120.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1
67	116+070	116+120	50.00	ONE SIDE CUT (Ht.>15m) & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS	TCS-1D

Sr. No.	Design Chainage		Design Length	TCS Detail	TCS Type
	From	To			
				APPLICABLE(RECONSTRUCTION)	
68	116+120	116+175	55.00	BOTH SIDE CUT WITH PROTECTION ON EITHER SIDE AS APPLICABLE (RECONSTRUCTION)	TCS-3
69	116+175	116+205	30.00	MINOR BRIDGE	MINOR BRIDGE
70	116+205	116+280	75.00	BOTH SIDE CUT WITH PROTECTION ON EITHER SIDE AS APPLICABLE (RECONSTRUCTION)	TCS-3
71	116+280	116+450	170.00	BOTH SIDE CUT (Ht.>15m) WITH PROTECTION ON EITHER SIDE AS APPLICABLE (RECONSTRUCTION)	TCS-3D
72	116+450	116+630	180.00	BOTH SIDE CUT WITH PROTECTION ON EITHER SIDE AS APPLICABLE (RECONSTRUCTION)	TCS-3
73	116+630	116+880	250.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1
74	116+880	116+920	40.00	ONE SIDE CUT (Ht.>15m) & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1D
75	116+920	116+955	35.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1
76	116+955	116+995	40.00	MINOR BRIDGE	MINOR BRIDGE
77	116+995	117+030	35.00	BOTH SIDE FILL WITH PROTECTION (AS APPLICABLE)(NEW CONSTRUCTION)	TCS-2B
78	117+030	117+080	50.00	BOTH SIDE CUT WITH PROTECTION ON EITHER SIDE AS APPLICABLE (NEW CONSTRUCTION)	TCS-3B
79	117+080	117+130	50.00	BOTH SIDE CUT WITHOUT PROTECTION WORK (CUT HEIGHT<2m)(NEW CONSTRUCTION)	TCS-3C
80	117+130	117+220	90.00	ONE SIDE CUT(CUT HEIGHT<2m) & ONE SIDE FILL(EMBANKMENT HEIGHT<2m) WITHOUT PROTECTION WORK(NEW CONSTRUCTION)	TCS-1C
81	117+220	117+270	50.00	BOTH SIDE CUT WITH PROTECTION ON EITHER SIDE AS APPLICABLE (NEW CONSTRUCTION)	TCS-3B
82	117+270	117+500	230.00	BOTH SIDE CUT (Ht.>15m)WITH PROTECTION ON EITHER SIDE AS APPLICABLE (NEW CONSTRUCTION)	TCS-3E

Sr. No.	Design Chainage		Design Length	TCS Detail	TCS Type
	From	To			
83	117+500	117+530	30.00	BOTH SIDE CUT WITH PROTECTION ON EITHER SIDE AS APPLICABLE (NEW CONSTRUCTION)	TCS-3B
84	117+530	118+075	545.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1
85	118+075	118+375	300.00	MAJOR BRIDGE	MAJOR BRIDGE
86	118+375	118+400	25.00	BOTH SIDE FILL WITH PROTECTION (AS APPLICABLE)(NEW CONSTRUCTION)	TCS-2B
87	118+400	118+430	30.00	BOTH SIDE CUT WITH PROTECTION ON EITHER SIDE AS APPLICABLE (NEW CONSTRUCTION)	TCS-3B
88	118+430	118+490	60.00	BOTH SIDE CUT (Ht.>15m)WITH PROTECTION ON EITHER SIDE AS APPLICABLE (NEW CONSTRUCTION)	TCS-3E
89	118+490	118+520	30.00	BOTH SIDE CUT WITH PROTECTION ON EITHER SIDE AS APPLICABLE (NEW CONSTRUCTION)	TCS-3B
90	118+520	118+660	140.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1
91	118+660	118+690	30.00	BOTH SIDE CUT (Ht.>15m) WITH PROTECTION ON EITHER SIDE AS APPLICABLE (RECONSTRUCTION)	TCS-3D
92	118+690	118+730	40.00	BOTH SIDE CUT WITH PROTECTION ON EITHER SIDE AS APPLICABLE (RECONSTRUCTION)	TCS-3
93	118+730	118+790	60.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1
94	118+790	118+840	50.00	BOTH SIDE CUT WITH PROTECTION ON EITHER SIDE AS APPLICABLE (RECONSTRUCTION)	TCS-3
95	118+840	119+040	200.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1
96	119+040	119+150	110.00	BOTH SIDE CUT WITH PROTECTION ON EITHER SIDE AS APPLICABLE (RECONSTRUCTION)	TCS-3
97	119+150	119+230	80.00	BOTH SIDE CUT (Ht.>15m) WITH PROTECTION ON EITHER SIDE AS APPLICABLE	TCS-3D

Sr. No.	Design Chainage		Design Length	TCS Detail	TCS Type
	From	To			
				(RECONSTRUCTION)	
98	119+230	119+290	60.00	BOTH SIDE CUT WITH PROTECTION ON EITHER SIDE AS APPLICABLE (RECONSTRUCTION)	TCS-3
99	119+290	119+340	50.00	BOTH SIDE FILL WITH PROTECTION (AS APPLICABLE)(RECONSTRUCTION)	TCS-2
100	119+340	119+450	110.00	BOTH SIDE CUT WITH PROTECTION ON EITHER SIDE AS APPLICABLE (RECONSTRUCTION)	TCS-3
101	119+450	119+570	120.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1
102	119+570	119+630	60.00	BOTH SIDE CUT (Ht.>15m) WITH PROTECTION ON EITHER SIDE AS APPLICABLE (RECONSTRUCTION)	TCS-3D
103	119+630	119+640	10.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1
104	119+640	119+690	50.00	ONE SIDE CUT WITH ROCK BOLTING & ONE SIDE FILL WITH PROTECTION AS APPLICABLE(RECONSTRUCTION)	TCS-4
105	119+690	120+090	400.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1
106	120+090	120+120	30.00	ONE SIDE CUT (Ht.>15m) & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1D
107	120+120	120+170	50.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1
108	120+170	120+310	140.00	BOTH SIDE CUT (Ht.>15m) WITH PROTECTION ON EITHER SIDE AS APPLICABLE (RECONSTRUCTION)	TCS-3D
109	120+310	120+400	90.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1
110	120+400	120+420	20.00	BOTH SIDE FILL WITH PROTECTION (AS APPLICABLE)(RECONSTRUCTION)	TCS-2
111	120+420	120+470	50.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1
112	120+470	120+530	60.00	ONE SIDE CUT WITH ROCK	TCS-4

Sr. No.	Design Chainage		Design Length	TCS Detail	TCS Type
	From	To			
				BOLTING & ONE SIDE FILL WITH PROTECTION AS APPLICABLE(RECONSTRUCTION)	
113	120+530	120+600	70.00	BOTH SIDE FILL WITH PROTECTION (AS APPLICABLE)(RECONSTRUCTION)	TCS-2
114	120+600	120+770	170.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1
115	120+770	120+810	40.00	ONE SIDE CUT (Ht.>15m) & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1D
116	120+810	120+915	105.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1
117	120+915	121+275	360.00	MAJOR BRIDGE	MAJOR BRIDGE
118	121+275	121+370	95.00	BOTH SIDE FILL WITH PROTECTION (AS APPLICABLE)(RECONSTRUCTION)	TCS-2
119	121+370	121+560	190.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1
120	121+560	121+710	150.00	BOTH SIDE CUT WITH PROTECTION ON EITHER SIDE AS APPLICABLE (RECONSTRUCTION)	TCS-3
121	121+710	121+718	8.00	BOTH SIDE FILL WITH PROTECTION (AS APPLICABLE)(RECONSTRUCTION)	TCS-2
122	121+718	121+728	10.00	MINOR BRIDGE	MINOR BRIDGE
123	121+728	121+740	12.00	BOTH SIDE FILL WITH PROTECTION (AS APPLICABLE)(RECONSTRUCTION)	TCS-2
124	121+740	122+030	290.00	BOTH SIDE CUT WITH PROTECTION ON EITHER SIDE AS APPLICABLE (RECONSTRUCTION)	TCS-3
125	122+030	122+130	100.00	BOTH SIDE CUT WITHOUT PROTECTION WORK (CUT HEIGHT<2m)(RECONSTRUCTION)	TCS-3A
126	122+130	122+160	30.00	BOTH SIDE CUT WITH PROTECTION ON EITHER SIDE AS APPLICABLE (RECONSTRUCTION)	TCS-3
127	122+160	122+270	110.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1
128	122+270	122+310	40.00	BOTH SIDE CUT WITHOUT PROTECTION WORK (CUT HEIGHT<2m)(RECONSTRUCTION)	TCS-3A

Sr. No.	Design Chainage		Design Length	TCS Detail	TCS Type
	From	To			
129	122+310	122+670	360.00	BOTH SIDE CUT WITH PROTECTION ON EITHER SIDE AS APPLICABLE (NEW CONSTRUCTION)	TCS-3B
130	122+670	122+780	110.00	BOTH SIDE CUT (Ht.>15m)WITH PROTECTION ON EITHER SIDE AS APPLICABLE (NEW CONSTRUCTION)	TCS-3E
131	122+780	122+840	60.00	BOTH SIDE CUT WITH PROTECTION ON EITHER SIDE AS APPLICABLE (NEW CONSTRUCTION)	TCS-3B
132	122+840	122+920	80.00	BOTH SIDE FILL WITH PROTECTION (AS APPLICABLE)(NEW CONSTRUCTION)	TCS-2B
133	122+920	123+080	160.00	Viaduct	Vaiduct
134	123+080	123+090	10.00	BOTH SIDE FILL WITH PROTECTION (AS APPLICABLE)(NEW CONSTRUCTION)	TCS-2B
135	123+090	123+110	20.00	BOTH SIDE CUT WITH PROTECTION ON EITHER SIDE AS APPLICABLE (NEW CONSTRUCTION)	TCS-3B
136	123+110	123+230	120.00	BOTH SIDE CUT (Ht.>15m)WITH PROTECTION ON EITHER SIDE AS APPLICABLE (NEW CONSTRUCTION)	TCS-3E
137	123+230	123+310	80.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1
138	123+310	123+410	100.00	BOTH SIDE FILL WITH PROTECTION (AS APPLICABLE)(RECONSTRUCTION)	TCS-2
139	123+410	123+490	80.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1
140	123+490	123+530	40.00	ONE SIDE CUT(CUT HEIGHT<2m) & ONE SIDE FILL(EMBANKMENT HEIGHT<2m) WITHOUT PROTECTION WORK(RECONSTRUCTION)	TCS-1A
141	123+530	123+810	280.00	BOTH SIDE FILL WITH PROTECTION (AS APPLICABLE)(RECONSTRUCTION)	TCS-2
142	123+810	123+840	30.00	ONE SIDE CUT(CUT HEIGHT<2m) & ONE SIDE FILL(EMBANKMENT HEIGHT<2m) WITHOUT PROTECTION	TCS-1A

Sr. No.	Design Chainage		Design Length	TCS Detail	TCS Type
	From	To			
				WORK(RECONSTRUCTION)	
143	123+840	123+910	70.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1
144	123+910	124+060	150.00	BOTH SIDE CUT WITH PROTECTION ON EITHER SIDE AS APPLICABLE (RECONSTRUCTION)	TCS-3
145	124+060	124+120	60.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1
146	124+120	124+180	60.00	BOTH SIDE FILL WITH PROTECTION (AS APPLICABLE)(RECONSTRUCTION)	TCS-2
147	124+180	124+290	110.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1
148	124+290	124+320	30.00	BOTH SIDE FILL WITH PROTECTION (AS APPLICABLE)(RECONSTRUCTION)	TCS-2
149	124+320	124+350	30.00	BOTH SIDE FILL WITH NORMAL EMBANKMENT (HEIGHT.<2m)WITHOUT PROTECTION WORK(NEW CONSTRUCTION)	TCS-2C
150	124+350	124+770	420.00	BOTH SIDE CUT WITH PROTECTION ON EITHER SIDE AS APPLICABLE (NEW CONSTRUCTION)	TCS-3B
151	124+770	124+825	55.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(NEW CONSTRUCTION)	TCS-1B
152	124+825	125+065	240.00	MAJOR BRIDGE	MAJOR BRIDGE
153	125+065	125+100	35.00	BOTH SIDE FILL WITH PROTECTION (AS APPLICABLE)(NEW CONSTRUCTION)	TCS-2B
154	125+100	125+150	50.00	BOTH SIDE CUT WITH PROTECTION ON EITHER SIDE AS APPLICABLE (NEW CONSTRUCTION)	TCS-3B
155	125+150	125+350	200.00	BOTH SIDE CUT (Ht.>15m)WITH PROTECTION ON EITHER SIDE AS APPLICABLE (NEW CONSTRUCTION)	TCS-3E
156	125+350	125+380	30.00	BOTH SIDE CUT WITH PROTECTION ON EITHER SIDE AS APPLICABLE (NEW CONSTRUCTION)	TCS-3B

Sr. No.	Design Chainage		Design Length	TCS Detail	TCS Type
	From	To			
157	125+380	125+460	80.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(NEW CONSTRUCTION)	TCS-1B
158	125+460	125+500	40.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1
159	125+500	125+820	320.00	BOTH SIDE FILL WITH PROTECTION (AS APPLICABLE)(RECONSTRUCTION)	TCS-2
160	125+820	126+030	210.00	ONE SIDE CUT(CUT HEIGHT<2m) & ONE SIDE FILL(EMBANKMENT HEIGHT<2m) WITHOUT PROTECTION WORK(RECONSTRUCTION)	TCS-3
161	126+030	126+090	60.00	BOTH SIDE CUT (Ht.>15m)WITH PROTECTION ON EITHER SIDE AS APPLICABLE (NEW CONSTRUCTION)	TCS-3E
162	126+090	126+195	105.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-3
163	126+195	126+245	50.00	MINOR BRIDGE	MINOR BRIDGE
164	126+245	126+270	25.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-3
165	126+270	126+420	150.00	ONE SIDE CUT (Ht.>15m) & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-2
166	126+420	126+610	190.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1
167	126+610	126+770	160.00	ONE SIDE CUT (Ht.>15m) & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1D
168	126+770	126+910	140.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1
169	126+910	126+950	40.00	BOTH SIDE CUT (Ht.>15m)WITH PROTECTION ON EITHER SIDE AS APPLICABLE (NEW CONSTRUCTION)	TCS-3E
170	126+950	127+040	90.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS	TCS-1

Sr. No.	Design Chainage		Design Length	TCS Detail	TCS Type
	From	To			
				APPLICABLE(RECONSTRUCTION)	
171	127+040	127+110	70.00	ONE SIDE CUT (Ht.>15m) & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-2
172	127+110	127+150	40.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-3
173	127+150	127+240	90.00	BOTH SIDE CUT (Ht.>15m)WITH PROTECTION ON EITHER SIDE AS APPLICABLE (NEW CONSTRUCTION)	TCS-3E
174	127+240	127+280	40.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1
175	127+280	127+330	50.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-3
176	127+330	127+400	70.00	BOTH SIDE CUT (Ht.>15m)WITH PROTECTION ON EITHER SIDE AS APPLICABLE (NEW CONSTRUCTION)	TCS-3E
177	127+400	127+440	40.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-3
178	127+440	127+464	24.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1
179	127+464	127+524	60.00	Viaduct	Vaiduct
180	127+524	127+540	16.00	ONE SIDE CUT (Ht.>15m) & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-2
181	127+540	127+570	30.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1
182	127+570	127+610	40.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-3
183	127+610	127+680	70.00	BOTH SIDE CUT (Ht.>15m)WITH PROTECTION ON EITHER SIDE AS APPLICABLE (NEW CONSTRUCTION)	TCS-3E
184	127+680	127+710	30.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER	TCS-1

Sr. No.	Design Chainage		Design Length	TCS Detail	TCS Type
	From	To			
				SIDE AS APPLICABLE(RECONSTRUCTION)	
185	127+710	127+750	40.00	BOTH SIDE CUT (Ht.>15m)WITH PROTECTION ON EITHER SIDE AS APPLICABLE (NEW CONSTRUCTION)	TCS-3E
186	127+750	127+900	150.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1
187	127+900	127+930	30.00	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-3
188	127+930	127+970	40.00	BOTH SIDE CUT (Ht.>15m)WITH PROTECTION ON EITHER SIDE AS APPLICABLE (NEW CONSTRUCTION)	TCS-3E
189	127+970	128+040	70.00	BOTH SIDE FILL FOR TUNNEL APPROACH WITH PROTECTION (AS APPLICABLE)(NEW CONSTRUCTION)	TCS-5
190	128+040	128+070	30.00	BOTH SIDE CUT FOR TUNNEL APPROACH WITH PROTECTION ON EITHER SIDE AS APPLICABLE (NEW CONSTRUCTION)	TCS-6
191	128+070	128+110	40	MINOR BRIDGE	MINOR BRIDGE
192	128+110	128+155	45	TUNNEL Portal	TUNNEL Portal
193	128+155	138+518	10363	TUNNEL	TUNNEL
194	138+518	138+629	111	TUNNEL Portal	TUNNEL Portal
195	138+629	138+640	11	BOTH SIDE FILL FOR TUNNEL APPROACH WITH PROTECTION (AS APPLICABLE)(NEW CONSTRUCTION)	TCS-5
196	138+640	138+660	20	BOTH SIDE CUT WITH PROTECTION ON EITHER SIDE AS APPLICABLE (NEW CONSTRUCTION)	TCS-7
197	138+660	138+740	80	MAJOR BRIDGE	MAJOR BRIDGE
198	138+740	138+775	35	BOTH SIDE CUT FOR TUNNEL APPROACH WITH PROTECTION ON EITHER SIDE AS APPLICABLE (NEW CONSTRUCTION)	TCS-6
199	138+775	138+865	90	BOTH SIDE CUT WITH PROTECTION ON EITHER SIDE AS APPLICABLE (NEW CONSTRUCTION)	TCS-7
200	138+865	138+930	65	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-3B
201	138+930	138+988	58	BOTH SIDE FILL WITH	TCS-2B

Sr. No.	Design Chainage		Design Length	TCS Detail	TCS Type
	From	To			
				PROTECTION (AS APPLICABLE)(NEW CONSTRUCTION)	
202	138+988	140+333	1345	Viaduct	Viaduct
203	140+333	140+360	28	BOTH SIDE FILL WITH PROTECTION (AS APPLICABLE)(NEW CONSTRUCTION)	TCS-2B
204	140+360	140+550	190	BOTH SIDE CUT WITH PROTECTION ON EITHER SIDE AS APPLICABLE (NEW CONSTRUCTION)	TCS-3B
205	140+550	140+650	100	Viaduct	Viaduct
206	140+650	140+780	130	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(NEW CONSTRUCTION)	TCS-1B
207	140+780	140+960	180	BOTH SIDE CUT WITH PROTECTION ON EITHER SIDE AS APPLICABLE (NEW CONSTRUCTION)	TCS-3B
208	140+960	141+000	40	BOTH SIDE CUT WITHOUT PROTECTION WORK (CUT HEIGHT<2m)(NEW CONSTRUCTION)	TCS-3C
209	141+000	141+120	120	BOTH SIDE CUT WITH PROTECTION ON EITHER SIDE AS APPLICABLE (NEW CONSTRUCTION)	TCS-3B
210	141+120	141+240	120	BOTH SIDE FILL WITH PROTECTION (AS APPLICABLE)(NEW CONSTRUCTION)	TCS-2B
211	141+240	141+290	50	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(NEW CONSTRUCTION)	TCS-1B
212	141+290	141+460	170	BOTH SIDE CUT WITH PROTECTION ON EITHER SIDE AS APPLICABLE (NEW CONSTRUCTION)	TCS-3B
213	141+460	141+490	30	ONE SIDE CUT(CUT HEIGHT<2m) & ONE SIDE FILL(EMBANKMENT HEIGHT<2m) WITHOUT PROTECTION WORK(NEW CONSTRUCTION)	TCS-1C
214	141+490	141+590	100	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(NEW CONSTRUCTION)	TCS-1B
215	141+590	141+650	60	BOTH SIDE FILL WITH PROTECTION (AS	TCS-2B

Sr. No.	Design Chainage		Design Length	TCS Detail	TCS Type
	From	To			
				APPLICABLE)(NEW CONSTRUCTION)	
216	141+650	141+710	60	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(NEW CONSTRUCTION)	TCS-1B
217	141+710	142+010	300	BOTH SIDE CUT WITH PROTECTION ON EITHER SIDE AS APPLICABLE (NEW CONSTRUCTION)	TCS-3B
218	142+010	142+040	30	BOTH SIDE FILL WITH NORMAL EMBANKMENT (HEIGHT.<2m)WITHOUT PROTECTION WORK(NEW CONSTRUCTION)	TCS-2C
219	142+040	142+100	60	BOTH SIDE FILL WITH PROTECTION (AS APPLICABLE)(NEW CONSTRUCTION)	TCS-2B
220	142+100	142+170	70	ONE SIDE CUT(CUT HEIGHT<2m) & ONE SIDE FILL(EMBANKMENT HEIGHT<2m) WITHOUT PROTECTION WORK(NEW CONSTRUCTION)	TCS-1C
221	142+170	142+220	50	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(NEW CONSTRUCTION)	TCS-1B
222	142+220	142+410	190	BOTH SIDE FILL WITH PROTECTION (AS APPLICABLE)(NEW CONSTRUCTION)	TCS-2B
223	142+410	142+490	80	BOTH SIDE CUT WITHOUT PROTECTION WORK (CUT HEIGHT<2m)(NEW CONSTRUCTION)	TCS-3C
224	142+490	142+580	90	ONE SIDE CUT(CUT HEIGHT<2m) & ONE SIDE FILL(EMBANKMENT HEIGHT<2m) WITHOUT PROTECTION WORK(NEW CONSTRUCTION)	TCS-1C
225	142+580	142+730	150	BOTH SIDE FILL WITH PROTECTION (AS APPLICABLE)(NEW CONSTRUCTION)	TCS-2B
226	142+730	142+770	40	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(NEW CONSTRUCTION)	TCS-1B
227	142+770	142+960	190	BOTH SIDE CUT WITH PROTECTION ON EITHER SIDE AS APPLICABLE (NEW	TCS-3B

Sr. No.	Design Chainage		Design Length	TCS Detail	TCS Type
	From	To			
				CONSTRUCTION)	
228	142+960	142+975	15	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(NEW CONSTRUCTION)	TCS-1B
229	142+975	142+995	20	MINOR BRIDGE	MINOR BRIDGE
230	142+995	143+190	195	BOTH SIDE CUT WITH PROTECTION ON EITHER SIDE AS APPLICABLE (NEW CONSTRUCTION)	TCS-3B
231	143+190	143+320	130	BOTH SIDE FILL WITH PROTECTION (AS APPLICABLE)(NEW CONSTRUCTION)	TCS-2B
232	143+320	143+500	180	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(NEW CONSTRUCTION)	TCS-1B
233	143+500	143+530	30	BOTH SIDE FILL WITH PROTECTION (AS APPLICABLE)(NEW CONSTRUCTION)	TCS-2B
234	143+530	143+570	40	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(NEW CONSTRUCTION)	TCS-1B
235	143+570	143+750	180	BOTH SIDE CUT WITH PROTECTION ON EITHER SIDE AS APPLICABLE (NEW CONSTRUCTION)	TCS-3B
236	143+750	143+810	60	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(NEW CONSTRUCTION)	TCS-1B
237	143+810	143+960	150	BOTH SIDE CUT WITH PROTECTION ON EITHER SIDE AS APPLICABLE (NEW CONSTRUCTION)	TCS-3B
238	143+960	144+010	50	BOTH SIDE FILL WITH NORMAL EMBANKMENT (HEIGHT.<2m)WITHOUT PROTECTION WORK(NEW CONSTRUCTION)	TCS-2C
239	144+010	144+050	40	BOTH SIDE FILL WITH NORMAL EMBANKMENT (HEIGHT.<2m)WITHOUT PROTECTION WORK(RECONSTRUCTION)	TCS-2A
240	144+050	144+100	50	ONE SIDE CUT(CUT HEIGHT<2m) & ONE SIDE FILL(EMBANKMENT HEIGHT<2m) WITHOUT PROTECTION	TCS-1A

Sr. No.	Design Chainage		Design Length	TCS Detail	TCS Type
	From	To			
				WORK(RECONSTRUCTION)	
241	144+100	144+410	310	BOTH SIDE FILL WITH NORMAL EMBANKMENT (HEIGHT.<2m)WITHOUT PROTECTION WORK(RECONSTRUCTION)	TCS-2A
242	144+410	144+560	150	BOTH SIDE FILL WITH NORMAL EMBANKMENT (HEIGHT.<2m)WITHOUT PROTECTION WORK(NEW CONSTRUCTION)	TCS-2C
243	144+560	144+610	50	BOTH SIDE CUT WITHOUT PROTECTION WORK (CUT HEIGHT<2m)(NEW CONSTRUCTION)	TCS-3C
244	144+610	144+730	120	BOTH SIDE FILL WITH NORMAL EMBANKMENT (HEIGHT.<2m)WITHOUT PROTECTION WORK(NEW CONSTRUCTION)	TCS-2C
245	144+730	144+780	50	BOTH SIDE CUT WITHOUT PROTECTION WORK (CUT HEIGHT<2m)(NEW CONSTRUCTION)	TCS-3C
246	144+780	144+870	90	BOTH SIDE CUT WITH PROTECTION ON EITHER SIDE AS APPLICABLE (NEW CONSTRUCTION)	TCS-3B
247	144+870	144+930	60	BOTH SIDE CUT WITHOUT PROTECTION WORK (CUT HEIGHT<2m)(NEW CONSTRUCTION)	TCS-3C
248	144+930	145+020	90	BOTH SIDE FILL WITH NORMAL EMBANKMENT (HEIGHT.<2m)WITHOUT PROTECTION WORK(NEW CONSTRUCTION)	TCS-2C
249	145+020	145+070	50	BOTH SIDE CUT WITHOUT PROTECTION WORK (CUT HEIGHT<2m)(NEW CONSTRUCTION)	TCS-3C
250	145+070	145+150	80	BOTH SIDE FILL WITH NORMAL EMBANKMENT (HEIGHT.<2m)WITHOUT PROTECTION WORK(NEW CONSTRUCTION)	TCS-2C
251	145+150	145+280	130	BOTH SIDE FILL WITH NORMAL EMBANKMENT (HEIGHT.<2m)WITHOUT PROTECTION WORK(RECONSTRUCTION)	TCS-2A
252	145+280	145+330	50	BOTH SIDE FILL WITH	TCS-2

Sr. No.	Design Chainage		Design Length	TCS Detail	TCS Type
	From	To			
				PROTECTION (AS APPLICABLE)(RECONSTRUCTION)	
253	145+330	145+450	120	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1
254	145+450	145+490	40	ONE SIDE CUT(CUT HEIGHT<2m) & ONE SIDE FILL(EMBANKMENT HEIGHT<2m) WITHOUT PROTECTION WORK(RECONSTRUCTION)	TCS-1A
255	145+490	145+540	50	BOTH SIDE CUT WITHOUT PROTECTION WORK (CUT HEIGHT<2m)(RECONSTRUCTION)	TCS-3A
256	145+540	145+580	40	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1
257	145+580	145+660	80	BOTH SIDE FILL WITH PROTECTION (AS APPLICABLE)(RECONSTRUCTION)	TCS-2
258	145+660	145+720	60	BOTH SIDE CUT WITHOUT PROTECTION WORK (CUT HEIGHT<2m)(RECONSTRUCTION)	TCS-3A
259	145+720	146+230	510	BOTH SIDE FILL WITH NORMAL EMBANKMENT (HEIGHT.<2m)WITHOUT PROTECTION WORK(RECONSTRUCTION)	TCS-2A
260	146+230	146+290	60	BOTH SIDE FILL WITH PROTECTION (AS APPLICABLE)(RECONSTRUCTION)	TCS-2
261	146+290	146+520	230	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1
262	146+520	146+570	50	BOTH SIDE CUT WITH PROTECTION ON EITHER SIDE AS APPLICABLE (RECONSTRUCTION)	TCS-3
263	146+570	146+603	33	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1
264	146+603	146+613	10	MINOR BRIDGE	MINOR BRIDGE
265	146+613	146+680	67	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(RECONSTRUCTION)	TCS-1
266	146+680	146+750	70	ONE SIDE CUT(CUT HEIGHT<2m) & ONE SIDE FILL(EMBANKMENT HEIGHT<2m) WITHOUT PROTECTION	TCS-1A

Sr. No.	Design Chainage		Design Length	TCS Detail	TCS Type
	From	To			
				WORK(RECONSTRUCTION)	
267	146+750	146+890	140	BOTH SIDE CUT WITH PROTECTION ON EITHER SIDE AS APPLICABLE (RECONSTRUCTION)	TCS-3
268	146+890	147+200	310	ONE SIDE CUT(CUT HEIGHT<2m) & ONE SIDE FILL(EMBANKMENT HEIGHT<2m) WITHOUT PROTECTION WORK(RECONSTRUCTION)	TCS-1A
269	147+200	147+270	70	ONE SIDE CUT(CUT HEIGHT<2m) & ONE SIDE FILL(EMBANKMENT HEIGHT<2m) WITHOUT PROTECTION WORK(NEW CONSTRUCTION)	TCS-1C
270	147+270	147+370	100	BOTH SIDE FILL WITH NORMAL EMBANKMENT (HEIGHT.<2m)WITHOUT PROTECTION WORK(NEW CONSTRUCTION)	TCS-2C
271	147+370	147+490	120	ONE SIDE CUT(CUT HEIGHT<2m) & ONE SIDE FILL(EMBANKMENT HEIGHT<2m) WITHOUT PROTECTION WORK(NEW CONSTRUCTION)	TCS-1C
272	147+490	148+520	1030	BOTH SIDE FILL WITH NORMAL EMBANKMENT (HEIGHT.<2m)WITHOUT PROTECTION WORK(NEW CONSTRUCTION)	TCS-2C
273	148+520	148+560	40	BOTH SIDE FILL WITH PROTECTION (AS APPLICABLE)(NEW CONSTRUCTION)	TCS-2B
274	148+560	148+640	80	Viaduct Cum Bridge	Viaduct Cum Bridge
275	148+640	148+700	60	BOTH SIDE FILL WITH PROTECTION (AS APPLICABLE)(NEW CONSTRUCTION)	TCS-2B
276	148+700	148+870	170	ONE SIDE CUT(CUT HEIGHT<2m) & ONE SIDE FILL(EMBANKMENT HEIGHT<2m) WITHOUT PROTECTION WORK(NEW CONSTRUCTION)	TCS-1C
277	148+870	148+920	50	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(NEW CONSTRUCTION)	TCS-1B
278	148+920	148+960	40	ONE SIDE CUT(CUT HEIGHT<2m) & ONE SIDE FILL(EMBANKMENT HEIGHT<2m) WITHOUT PROTECTION WORK(NEW	TCS-1C

Sr. No.	Design Chainage		Design Length	TCS Detail	TCS Type
	From	To			
				CONSTRUCTION)	
279	148+960	149+010	50	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(NEW CONSTRUCTION)	TCS-1B
280	149+010	149+080	70	ONE SIDE CUT(CUT HEIGHT<2m) & ONE SIDE FILL(EMBANKMENT HEIGHT<2m) WITHOUT PROTECTION WORK(NEW CONSTRUCTION)	TCS-1C
281	149+080	149+110	30	BOTH SIDE FILL WITH NORMAL EMBANKMENT (HEIGHT.<2m)WITHOUT PROTECTION WORK(NEW CONSTRUCTION)	TCS-2C
282	149+110	149+678	568	ONE SIDE CUT & ONE SIDE FILL WITH PROTECTION ON EITHER SIDE AS APPLICABLE(NEW CONSTRUCTION)	TCS-1B
	Total Design Length		38611		

Note: Utility duct shall be laid with 300mm dia. HDPE pipe all along the project length as per applicable TCS given below and cross sectional in accordance with IS: 4984/14333 or any other relevant code with inspection chambers at acceptable interval as approved by Authority Engineer/ Employer.

Utility Shifting:- The details of utilities are as follows:

(i) Electrical utilities i.e., High Tension and Low-Tension Lines

Sl. No.	Type of Utility	Unit	Quantity	Remark
A	Electrical Utilities i.e., Sub-Transmission Division and JPDCL			The details are given in utility shifting plan. The actual as required based on the basis of detailed investigations shall be determined by the Contractor in accordance with the Specifications and Standards. Any variations in the specified in this Schedule B shall not constitute a Change of Scope.
1	Electrical poles & Conductor	Nos.	61	
2	Electrical cables	Meters	1800	
3	Crossings i.e., Overhead & U/g	No.	41	
3	Transformers	Nos.	1	

TC - Triple circuit, DC - Double circuit, SC - Single circuit

(ii) Public Health utilities (Water/Sewage Pipelines)

Sl. No.	Type of Utility	Unit	Length in m	Remark

1	PHE Jal Shakti to 100mm Dia Pipe under Kishtwar, Division	Meters	1500	The actual as required on the basis of detailed investigations shall be determined by the Contractor in accordance with the Specifications and Standards. Any variations in the specified in this Schedule B shall not constitute a Change of Scope.

(iii) Any Other Line

- (a) The type/spacing/size/specifications of poles/towers/lines/cables to be used in shifting work are as per the guidelines of utility owning department and it is solely between the Contractor and the utility owning department. No change of scope shall be eligible, or no cost shall be paid for using different type/spacing /size/specifications in shifted work in comparison to those in the existing or for making any overhead crossings to underground as per requirement of utility owning department/construction of project highway. The Contractor shall carry out joint inspection with utility owning department and get the estimates sanctioned from utility owning department. The assistance of the Authority is limited to giving forwarding letter on the proposal of Contractor to utility owning department whenever asked by the Contractor. The decision/approval of utility owning department shall be binding on the Contractor. No CoS or no cost shall, be eligible on any account.
- (b) The supervision charges at the rates/charges applicable between implementing agencies of MoRTH and utility owning department shall be paid directly by the Authority to the Utility Owning Entity as and when Contractor furnishing a demand of Utility Owning Department along with a copy of sanctioned estimate.
- (c) The credit of dismantled materials has been accounted for in the estimated cost. The dismantled material /scrap of existing Utility to be shifted/dismantled shall belong to the Contractor/Concessionaire who would be free to dispose-off the dismantled material as deemed fit by them. If the Contractor is forced to deposit the dismantled material to utility owning department, then the amount of credit for dismantled material indicated in the sanctioned estimates of utility owning department will be reimbursed to the Contractor after submitting the duly authenticated receipt of the dismantled material from utility owning department to the Authority.
- (d) The utilities shall be handed over after shifting work is completed to Utility Owning Department up to their entire satisfaction. The maintenance liability shall rest with the Utility Owning Department after handing over process is complete as far as utility shifting works are concerned.

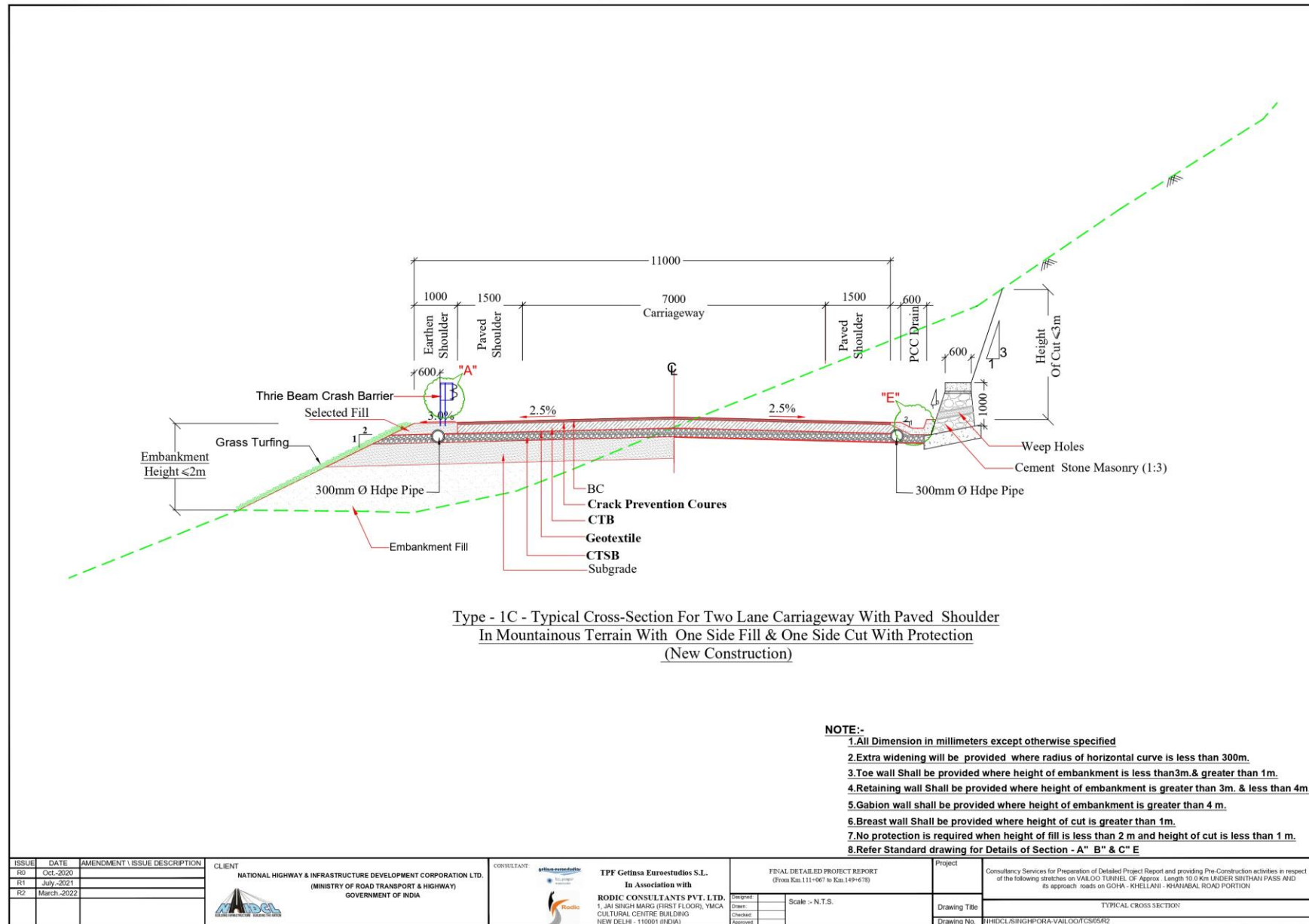
No change of scope shall be paid for any over-ground utilities. However, for any underground utilities not mentioned in Schedule B shall form change of scope, which shall be worked out as per the estimation of the concerned utility owning dept. and shall be payable to the contractor accordingly.

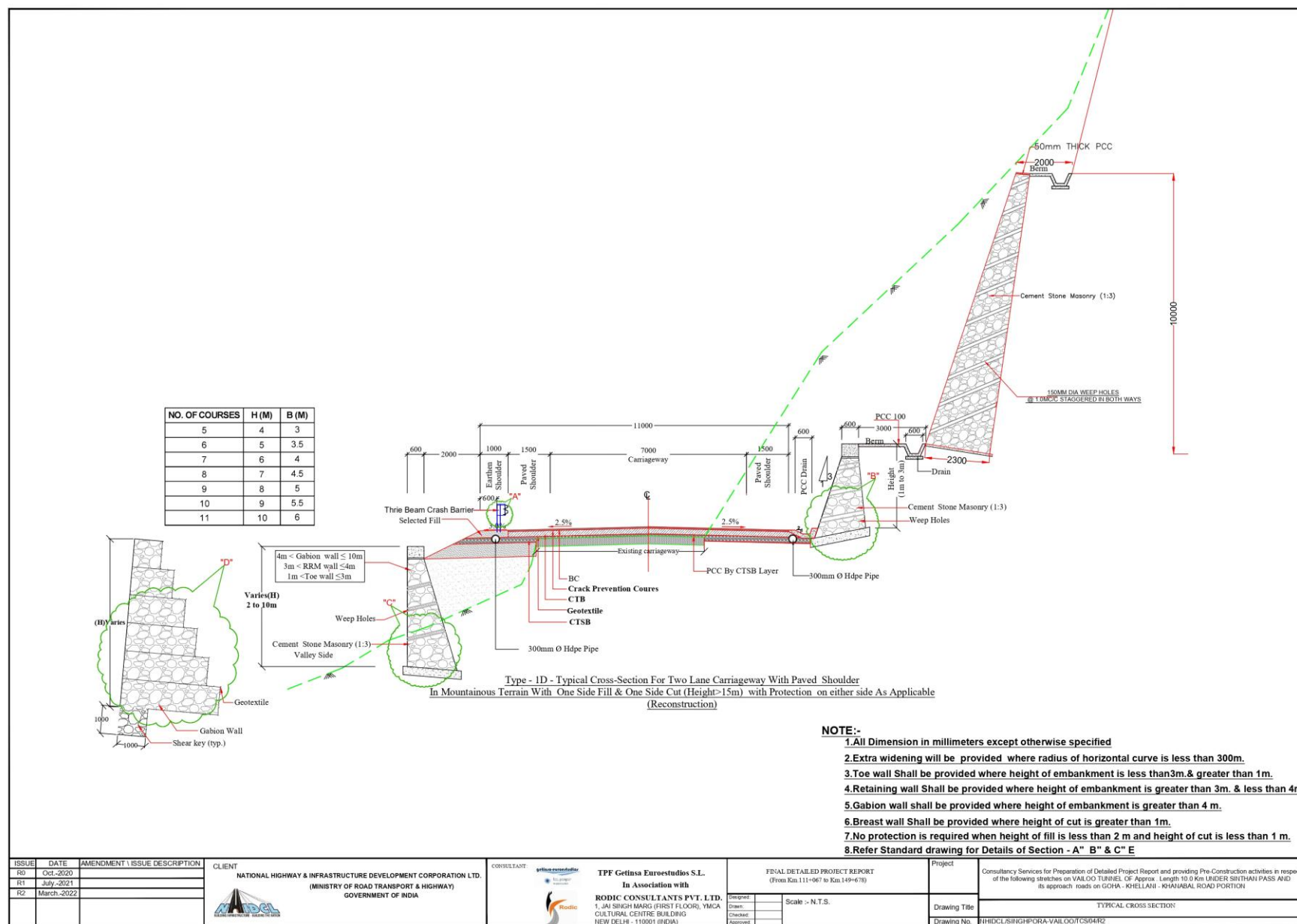
19. Power Supply for Tunnel and Tunnel Portals

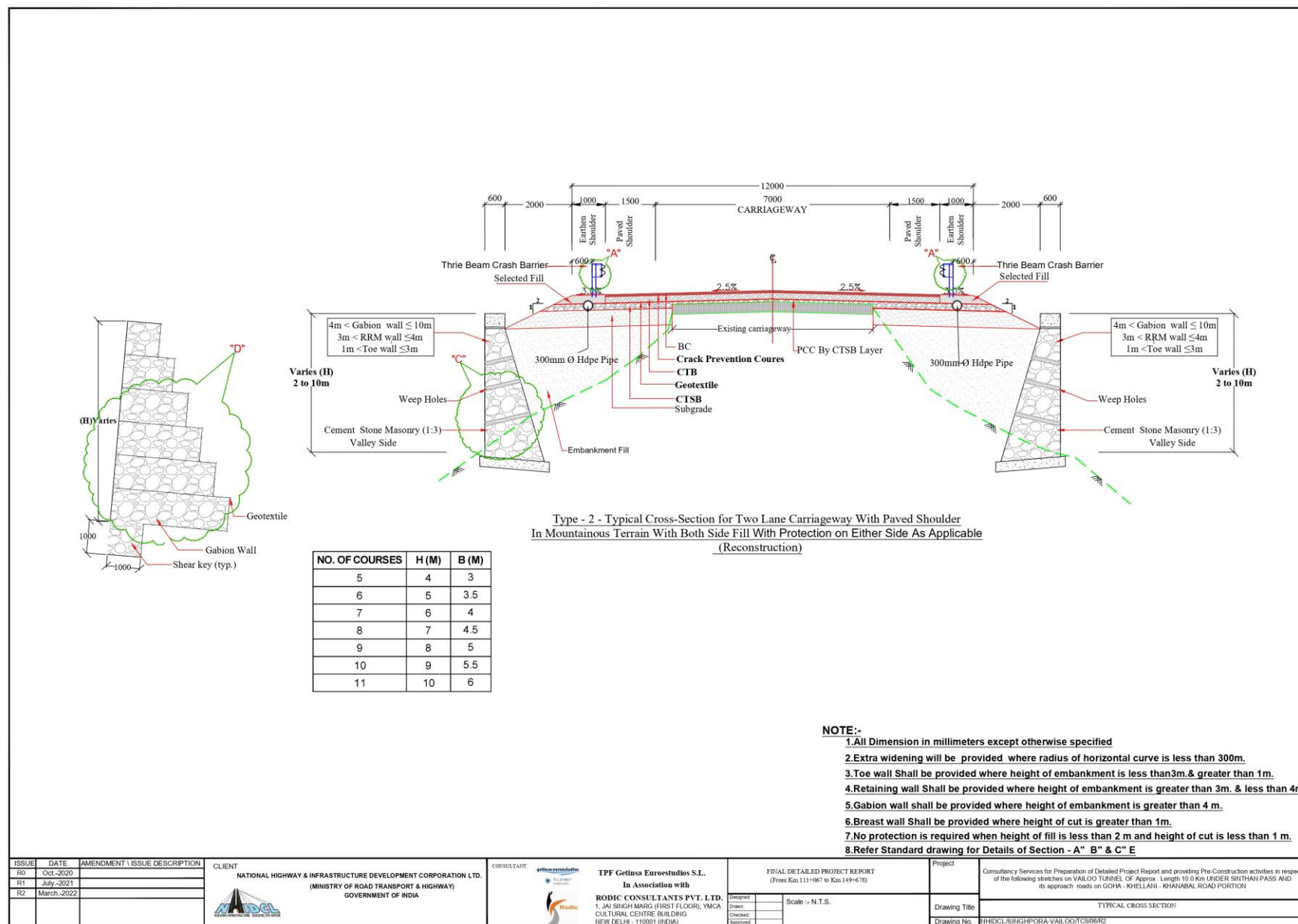
For power supply to the tunnel and tunnel portals it is required to lay power line and create Receiving Station. The Receiving Stations shall be created at no. of locations to cater the load of 6.624 MW and for Vailoo Tunnel.

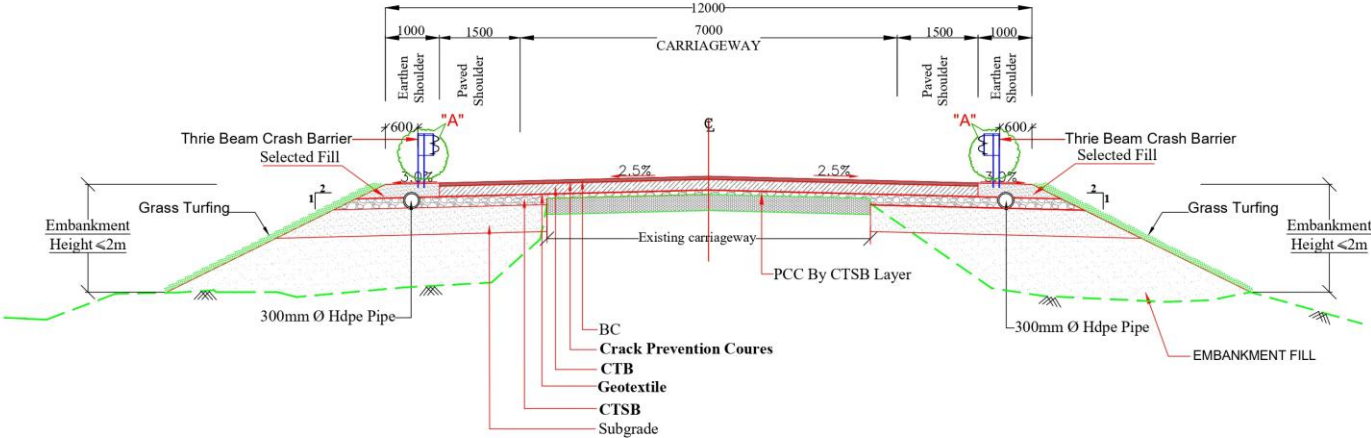
S.No	Description
East Portal	
1	12 Km long 33KV new Dadpeth line from 132/33 KV Katersamna grid to Bindraban tap
2	Bus-out arrangement at Dadpeth along with extension of control room building at Dadpeth station.
3	Creation of 10 MVA receiving station along with 35 Km long 33KV line from Dadpeth station.
West Portal	
1	Construction of 1x10MVA, 33/11KV Sub Stn. At Vailoo Tunnel
2	Construction of 27 Km long 33 KV line on 11m ST Poles with 100 sqm. ACSR
3	8 number of Gantry Structures at road crossings

The length of line will depend on the location of Receiving Station and may vary. The land for all the Receiving stations for the purpose of supplying power to the tunnel and tunnel portals shall be provided by the NHIDCL/competent authority.





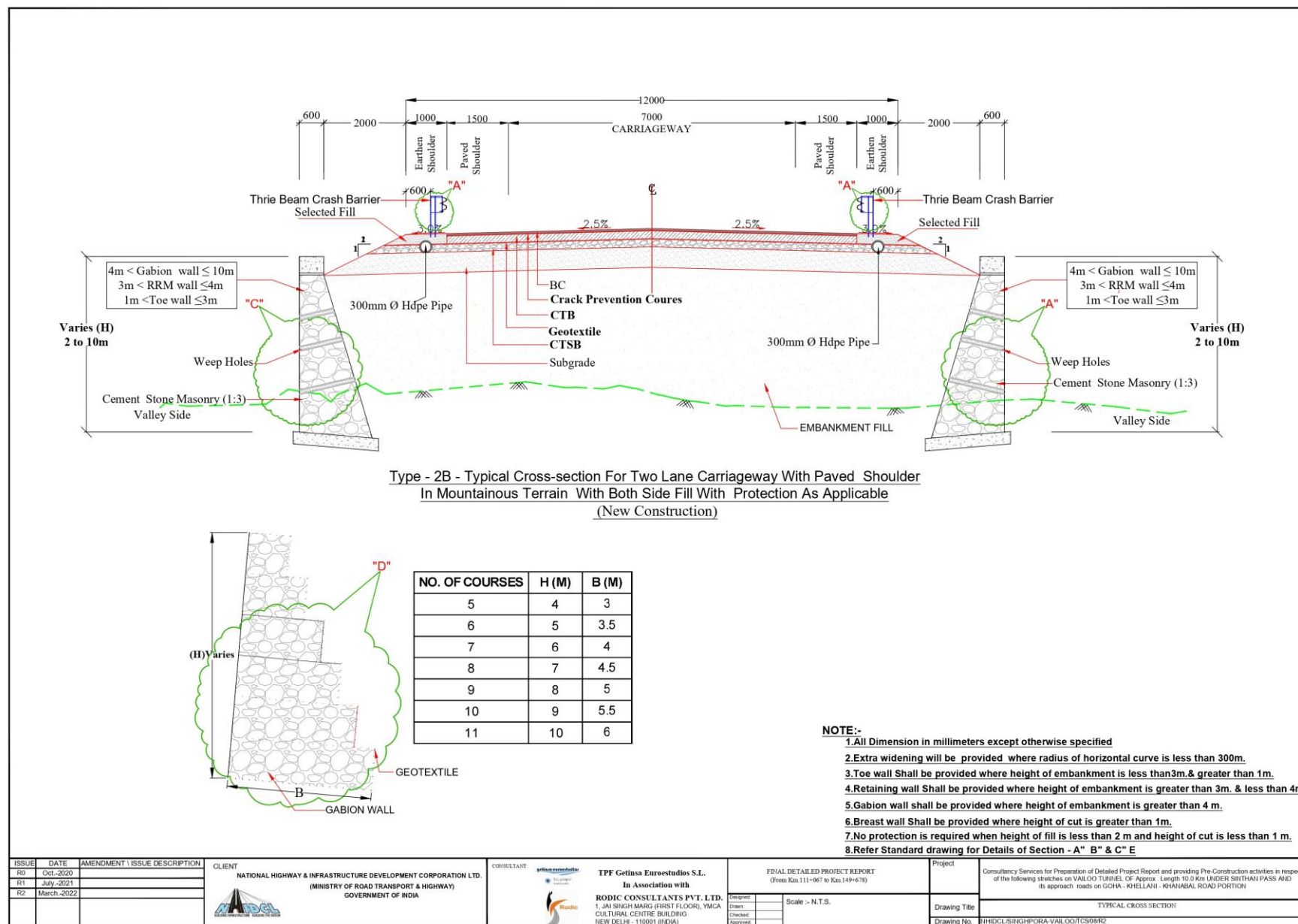


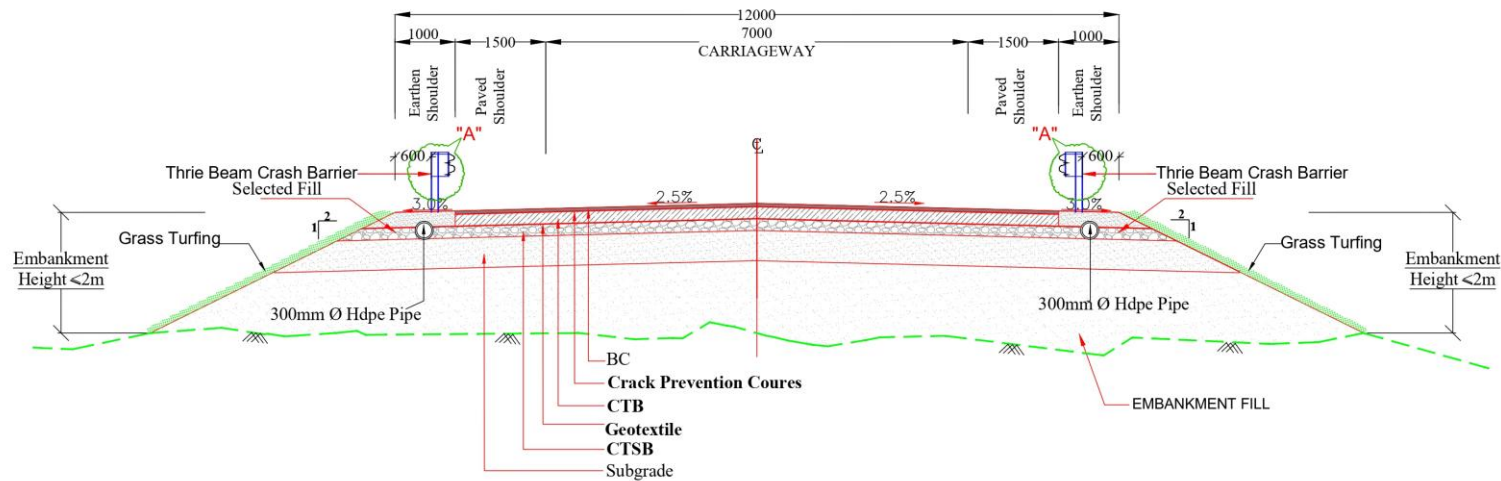


Type - 2A - Typical Cross-Section for Two Lane Carriageway With Paved Shoulder
In Mountainous Terrain With Both Side Fill With Embankment Height <2m
(Reconstruction)

- NOTE:-**
- 1. All Dimension in millimeters except otherwise specified
 - 2. Extra widening will be provided where radius of horizontal curve is less than 300m.
 - 3. Toe wall Shall be provided where height of embankment is less than 3m. & greater than 1m.
 - 4. Retaining wall Shall be provided where height of embankment is greater than 3m. & less than 4m.
 - 5. Gabion wall shall be provided where height of embankment is greater than 4 m.
 - 6. Breast wall Shall be provided where height of cut is greater than 1m.
 - 7. No protection is required when height of fill is less than 2 m and height of cut is less than 1 m.
 - 8. Refer Standard drawing for Details of Section - A" B" & C" E

ISSUE	DATE	AMENDMENT / ISSUE DESCRIPTION	CLIENT	CONSULTANT	PROJECT	DRAWING TITLE
R0	Oct-2020		NATIONAL HIGHWAY & INFRASTRUCTURE DEVELOPMENT CORPORATION LTD. (MINISTRY OF ROAD TRANSPORT & HIGHWAY) GOVERNMENT OF INDIA	TPF Getinsa Eurostudios S.L. In Association with RODIC CONSULTANTS PVT. LTD. 1, JAI SIKH MARG (FIRST FLOOR), YMCA CULTURAL CENTRE BUILDING NEW DELHI - 110001 (INDIA)	FINAL DETAILED PROJECT REPORT (From Km 111+067 to Km 149+678)	Consultancy Services for Preparation of Detailed Project Report and providing Pre-Construction activities in respect of the following stretches on VAILLOO TUNNEL OF Approx. Length 10.0 Km UNDER SRITHAN PASS AND its approach roads on GOHA - KHELLANI - KHANABAD ROAD PORTION
R1	July-2021					
R2	March-2022					
					Scale :- N.T.S.	TYPICAL CROSS SECTION
					Design: _____ Draw: _____ Checked: _____ Approved: _____	Drawing No. WHDCL/SINGH/PORA-VAILLOO/CS07/R2



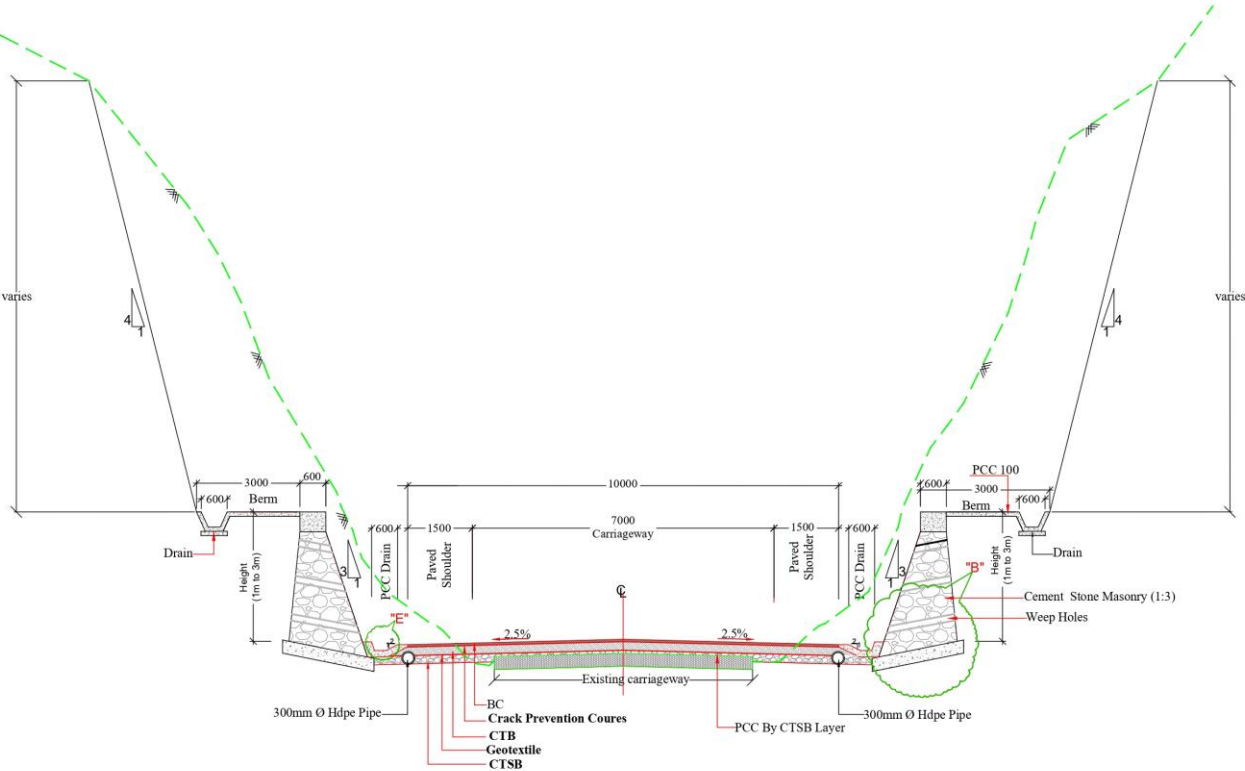


**Type - 2C- Typical Cross-section For Two Lane Carriageway With Paved Shoulder
In Mountainous Terrain With Both Side Fill With Embankment Height $\leq 2\text{m}$
(New Construction)**

NOTE:-

1. All Dimension in millimeters except otherwise specified
2. Extra widening will be provided where radius of horizontal curve is less than 300m.
3. Toe wall Shall be provided where height of embankment is less than 3m. & greater than 1m.
4. Retaining wall Shall be provided where height of embankment is greater than 3m. & less than 4m.
5. Gabion wall shall be provided where height of embankment is greater than 4 m.
6. Breast wall Shall be provided where height of cut is greater than 1m.
7. No protection is required when height of fill is less than 2 m and height of cut is less than 1 m.
8. Refer Standard drawing for Details of Section - A" B" & C" E

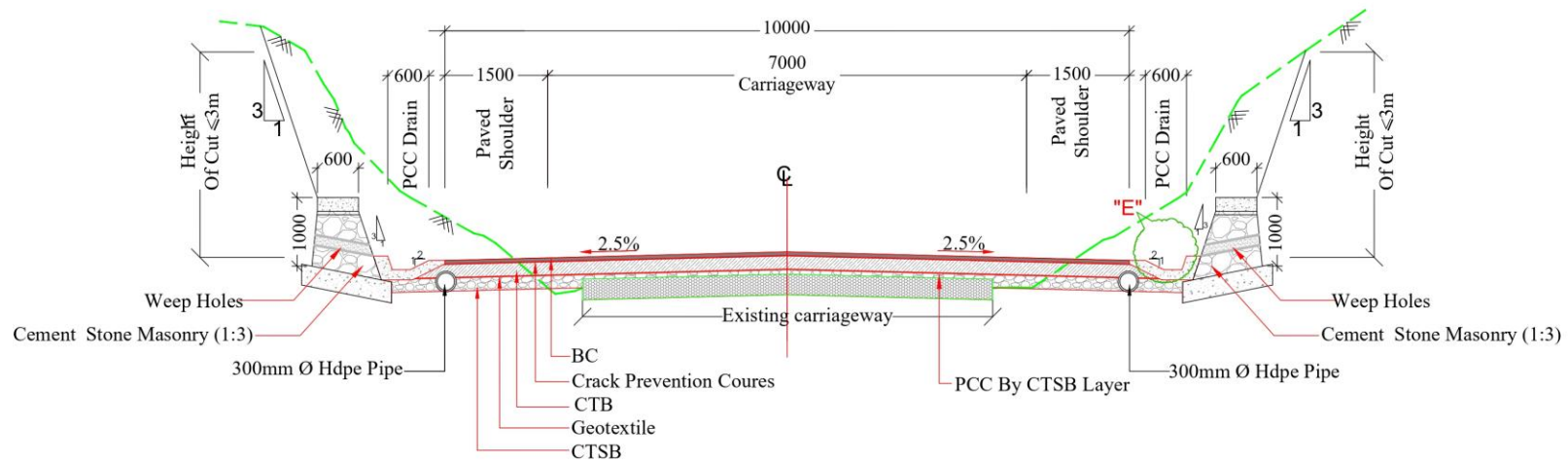
ISSUE	DATE	AMENDMENT / ISSUE DESCRIPTION	CLIENT	CONSULTANT	PROJECT
R0	Oct-2020		NATIONAL HIGHWAY & INFRASTRUCTURE DEVELOPMENT CORPORATION LTD. (MINISTRY OF ROAD TRANSPORT & HIGHWAY) GOVERNMENT OF INDIA 	TPF Getma Eurostudios S.L. In Association with RODIC CONSULTANTS PVT. LTD. 1, JAI SINGH MARG (FIRST FLOOR), YMCA CULTURAL CENTRE BUILDING NEW DELHI - 110001 (INDIA) 	Consultancy Services for Preparation of Detailed Project Report and providing Pre-Construction activities in respect of the following stretches on VAILLOO TUNNEL OF Approx. Length 10.0 Km UNDER SIKHAN PASS AND its approach roads on GOHA - KHELLAN - KHANABAD ROAD PORTION
R1	July-2021				Drawing Title
R2	March-2022				Drawing No.



Type - 3- Typical Cross-Section For Two Lane Carriageway With Paved Shoulder
In Mountainous Terrain With Both Side Cut With Protection on Either Side as Applicable
(Reconstruction)

- NOTE:-**
- 1. All Dimension in millimeters except otherwise specified
 - 2. Extra widening will be provided where radius of horizontal curve is less than 300m.
 - 3. Toe wall Shall be provided where height of embankment is less than 3m. & greater than 1m.
 - 4. Retaining wall Shall be provided where height of embankment is greater than 3m. & less than 4m.
 - 5. Gabion wall shall be provided where height of embankment is greater than 4 m.
 - 6. Breast wall Shall be provided where height of cut is greater than 1m.
 - 7. No protection is required when height of fill is less than 2 m and height of cut is less than 1 m.
 - 8. Refer Standard drawing for Details of Section - A" B" & C" E

ISSUE	DATE	AMENDMENT \ ISSUE DESCRIPTION	CLIENT	CONSULTANT	PROJECT
R0	Oct-2020		NATIONAL HIGHWAY & INFRASTRUCTURE DEVELOPMENT CORPORATION LTD. (MINISTRY OF ROAD TRANSPORT & HIGHWAY) GOVERNMENT OF INDIA	TPF Getinsa Eurostudios S.L. In Association with RODIC CONSULTANTS PVT. LTD. 1, JAI SINGH MARG (FIRST FLOOR), YMCA CULTURAL CENTRE BUILDING NEW DELHI - 110001 (INDIA)	Consultancy Services for Preparation of Detailed Project Report and providing Pre-Construction activities in respect of the following stretches on VAILLOO TUNNEL OF Approx. Length 10.0 Km UNDER SIKTHAN PASS AND its approach roads on GOHA - KHELLAN - KHANABAD ROAD PORTION
R1	July-2021				Drawing Title
R2	March-2022				Drawing No.

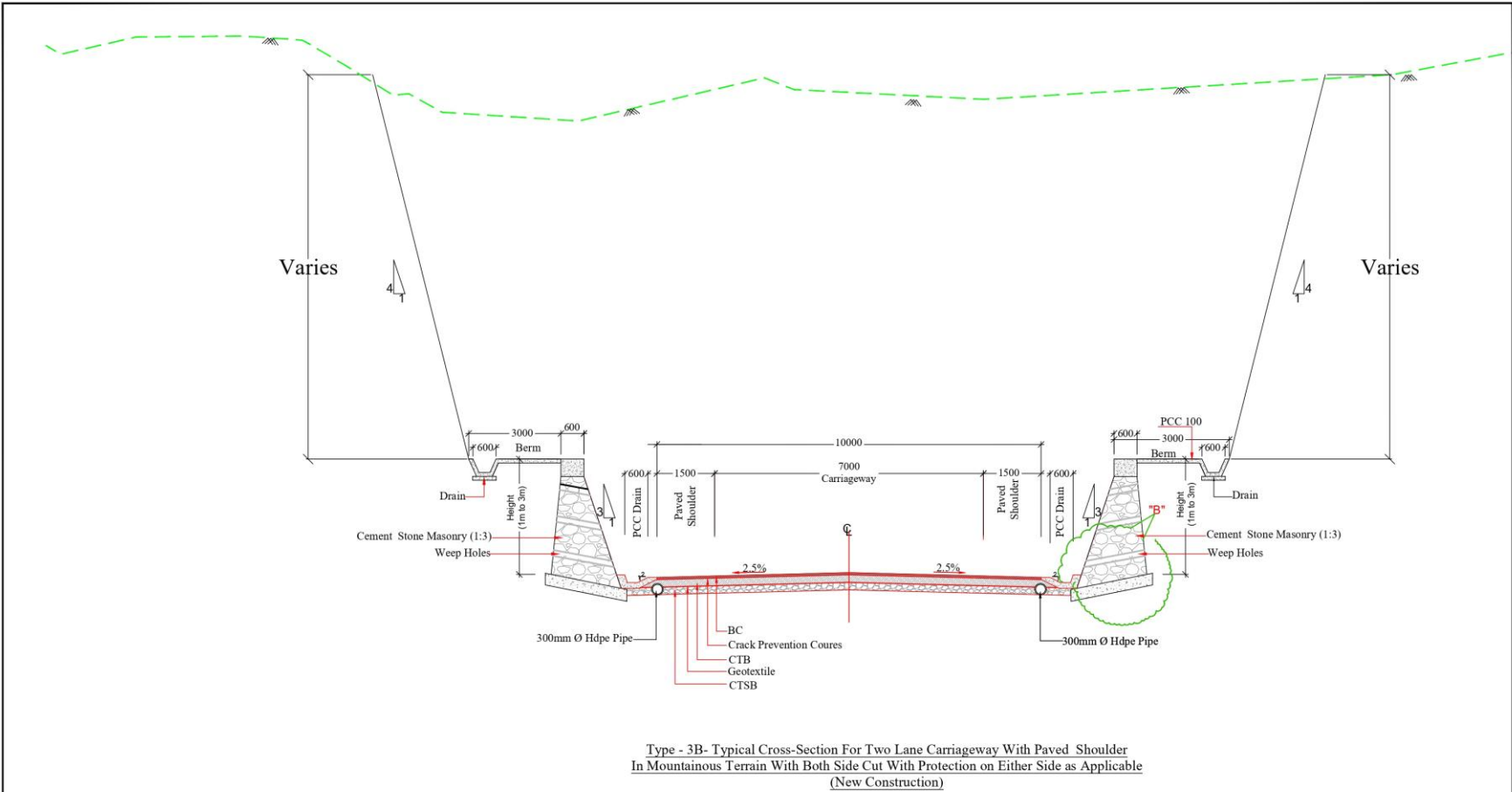


**Type - 3A- Typical Cross-Section For Two Lane Carriageway With Paved Shoulder
In Mountainous Terrain With Both Side Cut With Protection As Applicable
(Reconstruction)**

NOTE:-

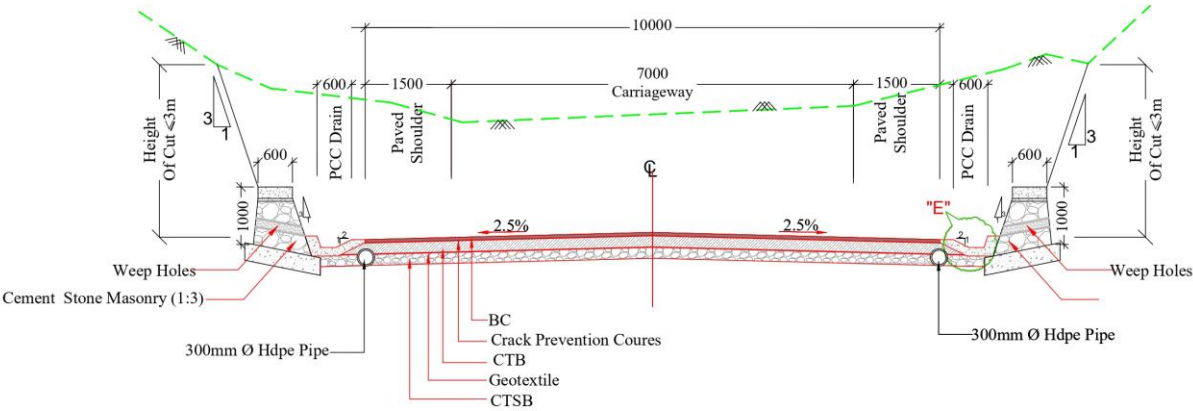
1. All Dimension in millimeters except otherwise specified
2. Extra widening will be provided where radius of horizontal curve is less than 300m.
3. Toe wall Shall be provided where height of embankment is less than 3m. & greater than 1m.
4. Retaining wall Shall be provided where height of embankment is greater than 3m. & less than 4m.
5. Gabion wall shall be provided where height of embankment is greater than 4 m.
6. Breast wall Shall be provided where height of cut is greater than 1m.
7. No protection is required when height of fill is less than 2 m and height of cut is less than 1 m.
8. Refer Standard drawing for Details of Section - A" B" & C" E

ISSUE	AMENDMENT / ISSUE DESCRIPTION	CLIENT	CONSULTANT	PROJECT	
R0	Oct-2020	 NATIONAL HIGHWAY & INFRASTRUCTURE DEVELOPMENT CORPORATION LTD. (MINISTRY OF ROAD TRANSPORT & HIGHWAY) GOVERNMENT OF INDIA	 TPF Getinsa Eurostudios S.L. In Association with  RODIC CONSULTANTS PVT. LTD. 1, JAI SIKH MARG (FIRST FLOOR), YMCA CULTURAL CENTRE BUILDING NEW DELHI - 110001 (INDIA)	Project	
R1	July-2021			Consultancy Services for Preparation of Detailed Project Report and providing Pre-Construction activities in respect of the following stretches on VAILLOO TUNNEL OF Approx. Length 10.0 Km UNDER SIKHTHAN PASS AND its approach roads on GOHA - KHELLAN - KHANABAD ROAD PORTION	
R2	March-2022				
				FEDERAL DETAILED PROJECT REPORT (From Km 111+067 to Km 149+678)	
		Scale :- N.T.S.		Drawing Title	
		Design: Drawn: Checked: Approved:		Drawing No.	
				WHDC/SH/CH/PORA-VAILLOO/CTS/11R2	
				TYPICAL CROSS SECTION	



- NOTE:-**
- 1. All Dimension in millimeters except otherwise specified
 - 2. Extra widening will be provided where radius of horizontal curve is less than 300m.
 - 3. Toe wall Shall be provided where height of embankment is less than 3m. & greater than 1m.
 - 4. Retaining wall Shall be provided where height of embankment is greater than 3m. & less than 4m.
 - 5. Gabion wall shall be provided where height of embankment is greater than 4 m.
 - 6. Breast wall Shall be provided where height of cut is greater than 1m.
 - 7. No protection is required when height of fill is less than 2 m and height of cut is less than 1 m.
 - 8. Refer Standard drawing for Details of Section - A" B" & C" E

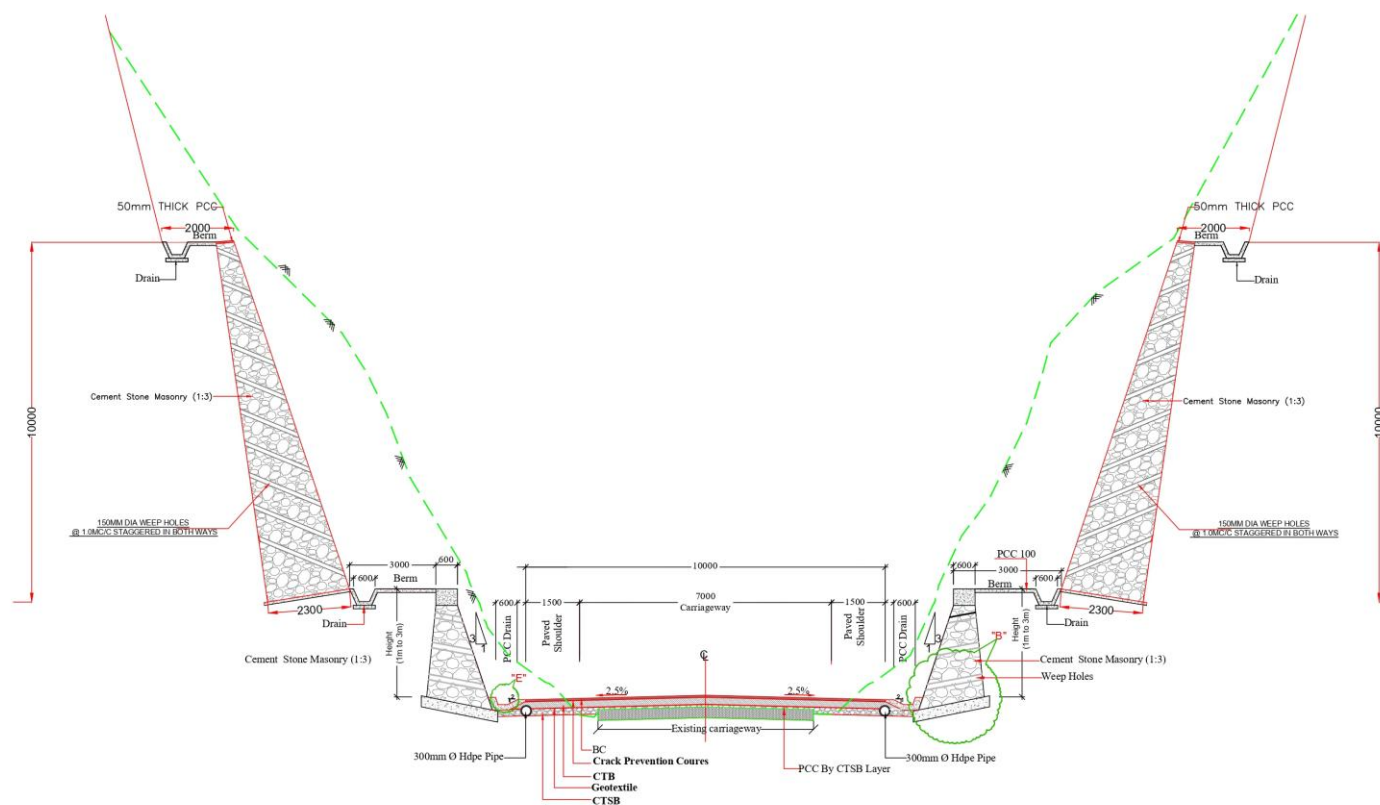
ISSUE	DATE	AMENDMENT / ISSUE DESCRIPTION	CLIENT	CONSULTANT	PROJECT	DRAWING TITLE	DRAWING No.
R0	Oct-2020		NATIONAL HIGHWAY & INFRASTRUCTURE DEVELOPMENT CORPORATION LTD. (MINISTRY OF ROAD TRANSPORT & HIGHWAY) GOVERNMENT OF INDIA	TPF Getinca Eurostudios S.L. In Association with RODIC CONSULTANTS PVT. LTD. 1, JAI SINGH MARG (FIRST FLOOR), YMCA CULTURAL CENTRE BUILDING NEW DELHI - 110001 (INDIA)	FINAL DETAILED PROJECT REPORT (From Km 111+067 to Km 149+678)	Consultancy Services for Preparation of Detailed Project Report and providing Pre-Construction activities in respect of the following stretches on VAILLOO TUNNEL OF Approx. Length 10.0 Km UNDER SRITHAN PASS AND its approach roads on GOHA - KHELLANI - KHANABAD ROAD PORTION	TYPICAL CROSS SECTION
R1	July-2021						
R2	March-2022						



Type - 3C- Typical Cross-Section For Two Lane Carriageway With Paved Shoulder In Mountainous Terrain With Both Side Cut With Protection As Applicable (New Construction)

- NOTE:-**
- 1. All Dimension in millimeters except otherwise specified
 - 2. Extra widening will be provided where radius of horizontal curve is less than 300m.
 - 3. Toe wall Shall be provided where height of embankment is less than 3m. & greater than 1m.
 - 4. Retaining wall Shall be provided where height of embankment is greater than 3m. & less than 4m.
 - 5. Gabion wall shall be provided where height of embankment is greater than 4 m.
 - 6. Breast wall Shall be provided where height of cut is greater than 1m.
 - 7. No protection is required when height of fill is less than 2 m and height of cut is less than 1 m.
 - 8. Refer Standard drawing for Details of Section - A" B" & C" E

ISSUE	DATE	AMENDMENT / ISSUE DESCRIPTION	CLIENT	CONSULTANT	PROJECT
R0	Oct-2020		NATIONAL HIGHWAY & INFRASTRUCTURE DEVELOPMENT CORPORATION LTD. (MINISTRY OF ROAD TRANSPORT & HIGHWAY) GOVERNMENT OF INDIA	TPF Getinsa Euroestudios S.L. In Association with RODIC CONSULTANTS PVT. LTD. 1, JAI SINGH MARG (FIRST FLOOR), YMCA CULTURAL CENTRE BUILDING NEW DELHI - 110001 (INDIA)	Consultancy Services for Preparation of Detailed Project Report and providing Pre-Construction activities in respect of the following stretches on VAILLOO TUNNEL OF Approx. Length 10.0 Km UNDER SIKHAN PASS AND its approach roads on GOHA - KHELLAN - KHANABAD ROAD PORTION
R1	July-2021				Drawing Title
R2	March-2022				Drawing No.

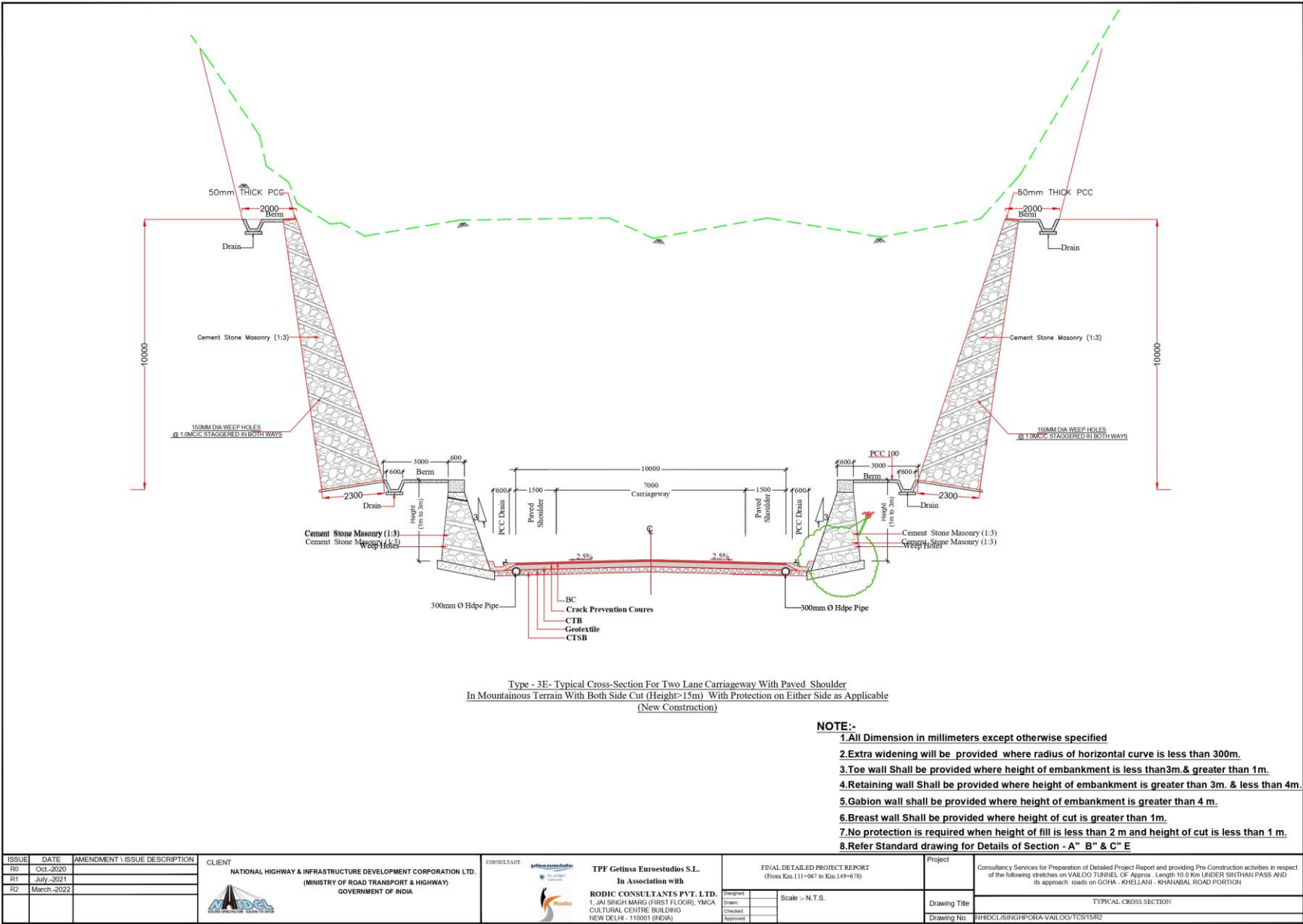


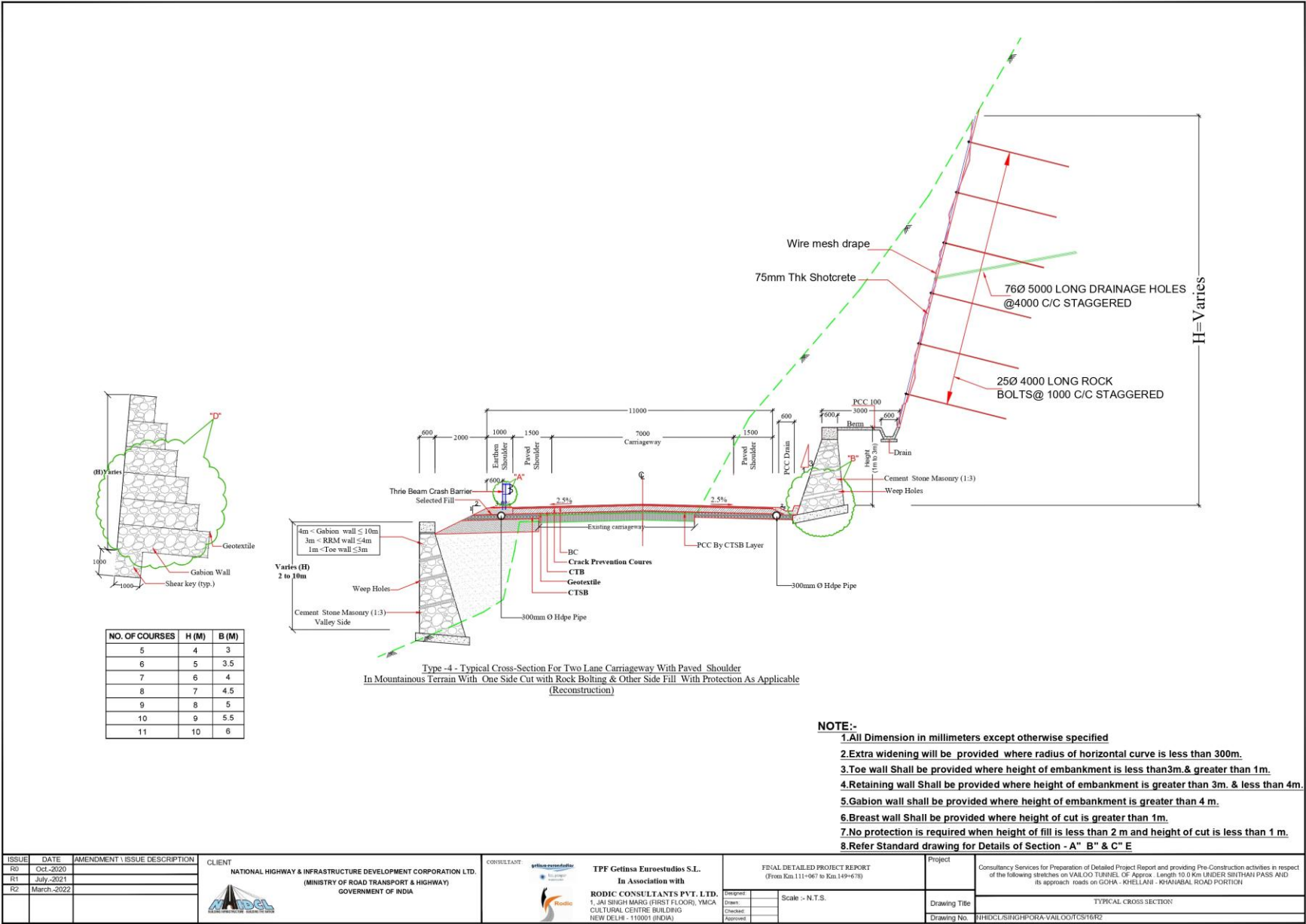
Type - 3D- Typical Cross-Section For Two Lane Carriageway With Paved Shoulder
In Mountainous Terrain With Both Side Cut (Height>15m) With Protection on Either Side as Applicable
(Reconstruction)

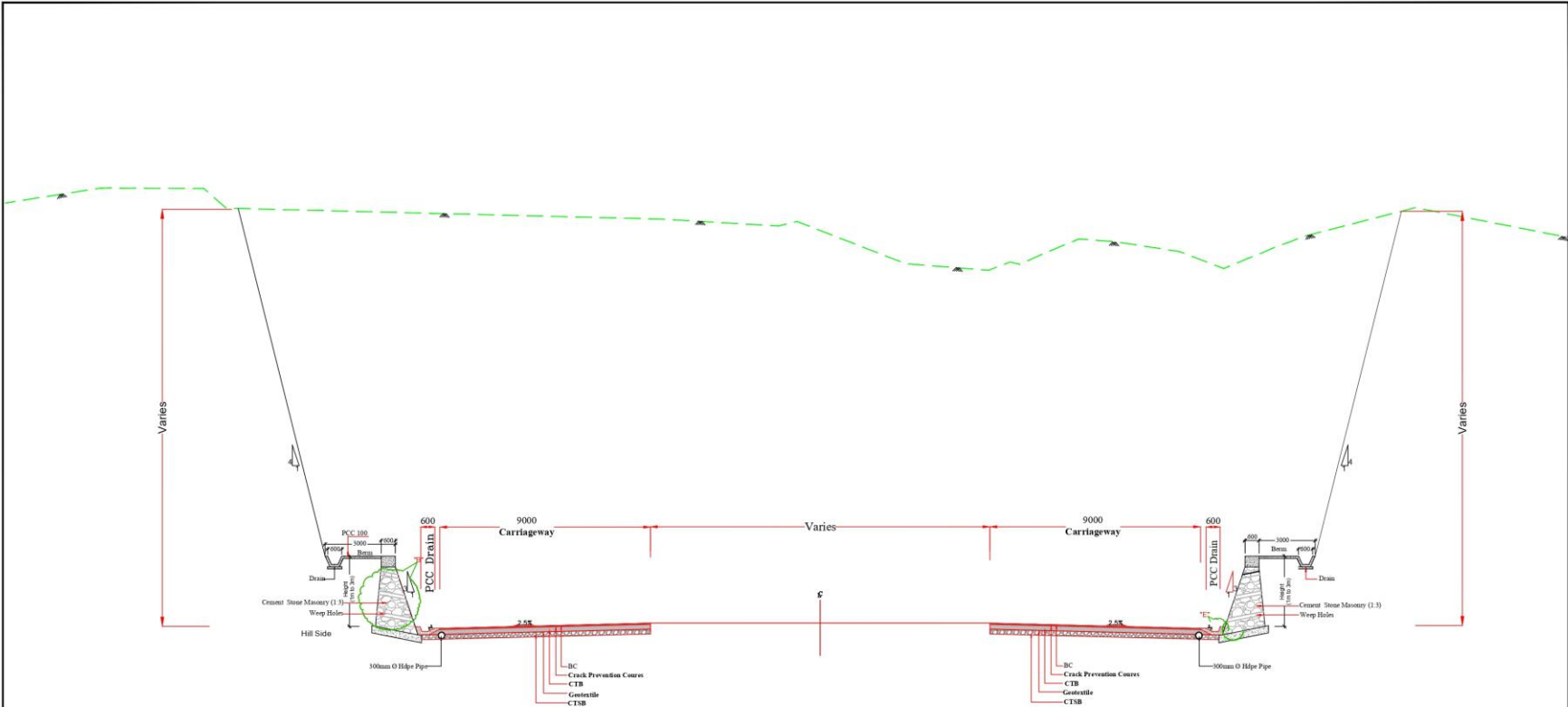
NOTE:-

1. All Dimension in millimeters except otherwise specified
2. Extra widening will be provided where radius of horizontal curve is less than 300m.
3. Toe wall Shall be provided where height of embankment is less than 3m. & greater than 1m.
4. Retaining wall Shall be provided where height of embankment is greater than 3m. & less than 4m.
5. Gabion wall shall be provided where height of embankment is greater than 4 m.
6. Breast wall Shall be provided where height of cut is greater than 1m.
7. No protection is required when height of fill is less than 2 m and height of cut is less than 1 m.
8. Refer Standard drawing for Details of Section - A " B " & C " E

ISSUE DATE		AMENDMENT		ISSUE DESCRIPTION		CLIENT		CONSULTANT		PROJECT		DRAWING NO.	
RD	02					NATIONAL HIGHWAY & INFRASTRUCTURE DEVELOPMENT CORPORATION LTD. (MINISTRY OF ROAD TRANSPORT & HIGHWAY) GOVERNMENT OF INDIA		 TPF Gelinas Eurostudios S.L. In Association with  RDC CONSULTANTS PVT. LTD.		FINAL DETAILED PROJECT REPORT (From Km.111-067 to Km.149-678) Scale = N.T.S.		Project Consultancy Services for Preparation of Detailed Project Report and providing Pre-Construction activities in respect of the following stretches on VALIOO TUNNEL OF Approx. Length 10 Km UNDER SITHIAN PASS AND its approach roads on GOHA - KHELLAR - KHAVALAR ROAD PORTION	
RT	July-2021											Drawing Title	
R2	March-2022											TYPICAL CROSS SECTION	
Drawing No. 01H001-SS03H000A-VALIOO TUNNEL CROSS400													



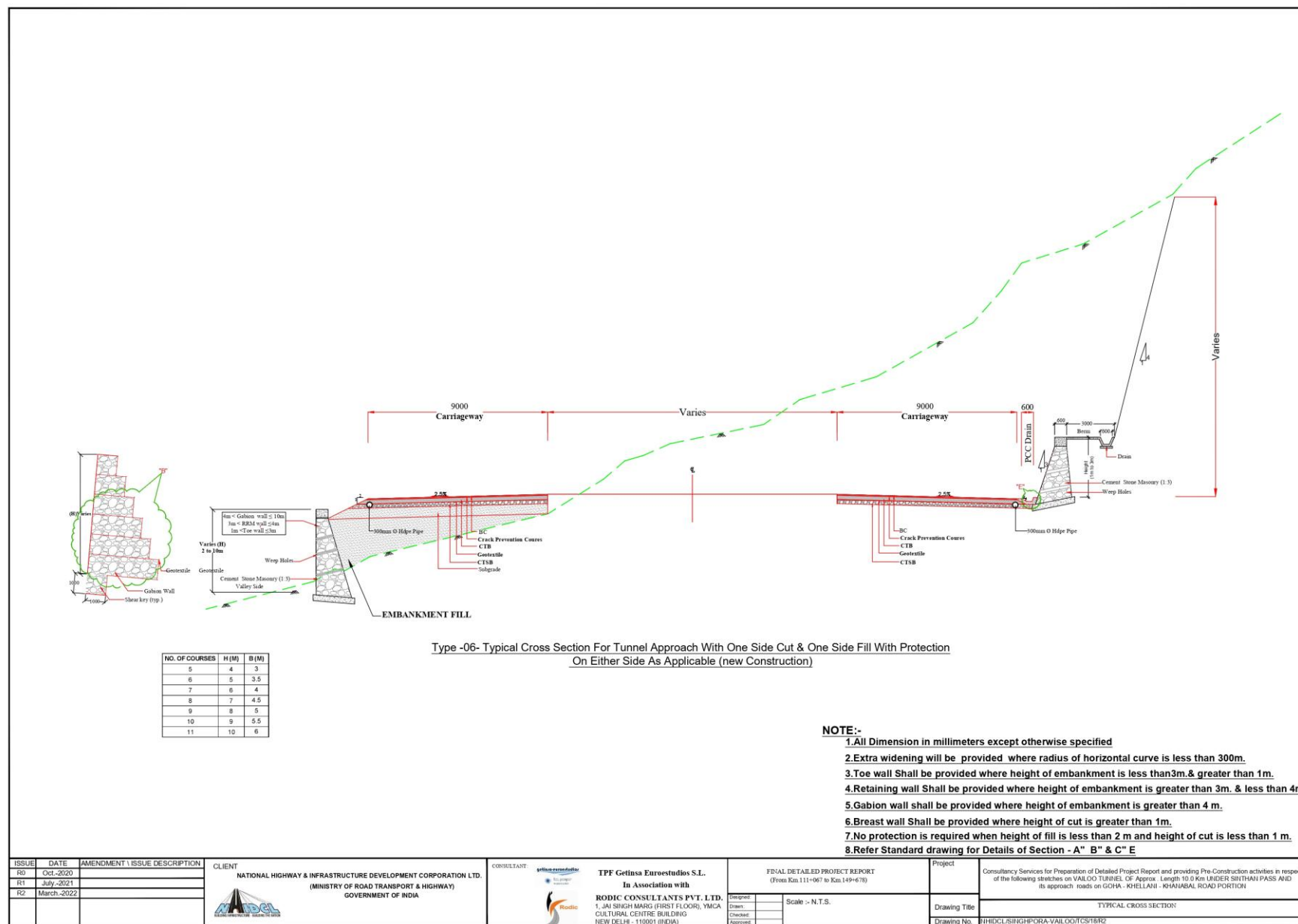


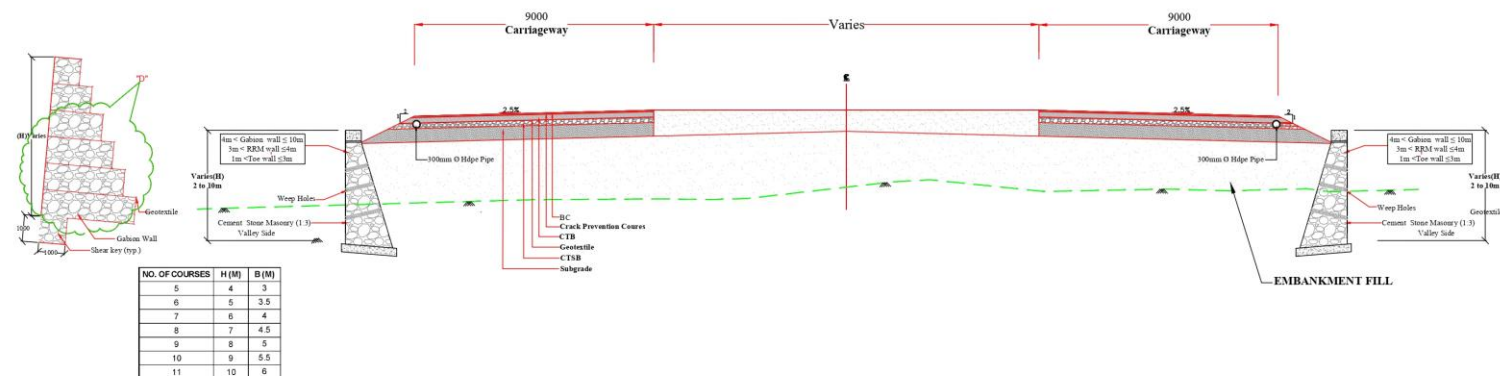


Type - 05 - Typical Cross Section For Tunnel Approach With Both Side Cut With Protection On Either Side As Applicable (New Construction)

- NOTE:-**
- 1. All Dimension in millimeters except otherwise specified
 - 2. Extra widening will be provided where radius of horizontal curve is less than 300m.
 - 3. Toe wall Shall be provided where height of embankment is less than 3m. & greater than 1m.
 - 4. Retaining wall Shall be provided where height of embankment is greater than 3m. & less than 4m.
 - 5. Gabion wall shall be provided where height of embankment is greater than 4 m.
 - 6. Breast wall Shall be provided where height of cut is greater than 1m.
 - 7. No protection is required when height of fill is less than 2 m and height of cut is less than 1 m.
 - 8. Refer Standard drawing for Details of Section - A" B" & C" E

ISSUE	DATE	AMENDMENT / ISSUE DESCRIPTION	CLIENT	CONSULTANT	PROJECT
R0	Oct-2020		NATIONAL HIGHWAY & INFRASTRUCTURE DEVELOPMENT CORPORATION LTD. (MINISTRY OF ROAD TRANSPORT & HIGHWAY) GOVERNMENT OF INDIA	TPF Getinsa Eurostudios S.L. In Association with RODIC CONSULTANTS PVT. LTD. 1, JAI SINGH MARG (FIRST FLOOR), YMCA CULTURAL CENTRE BUILDING NEW DELHI - 110001 (INDIA)	Project
R1	July-2021				Consultancy Services for Preparation of Detailed Project Report and providing Pre-Construction activities in respect of the following stretches on VAILLOO TUNNEL OF Approx. Length 10.0 Km UNDER SRITHAN PASS AND its approach roads on GOHA - KHELLAN - KHANABAD ROAD PORTION
R2	March-2022				Drawing Title
					Drawing No.



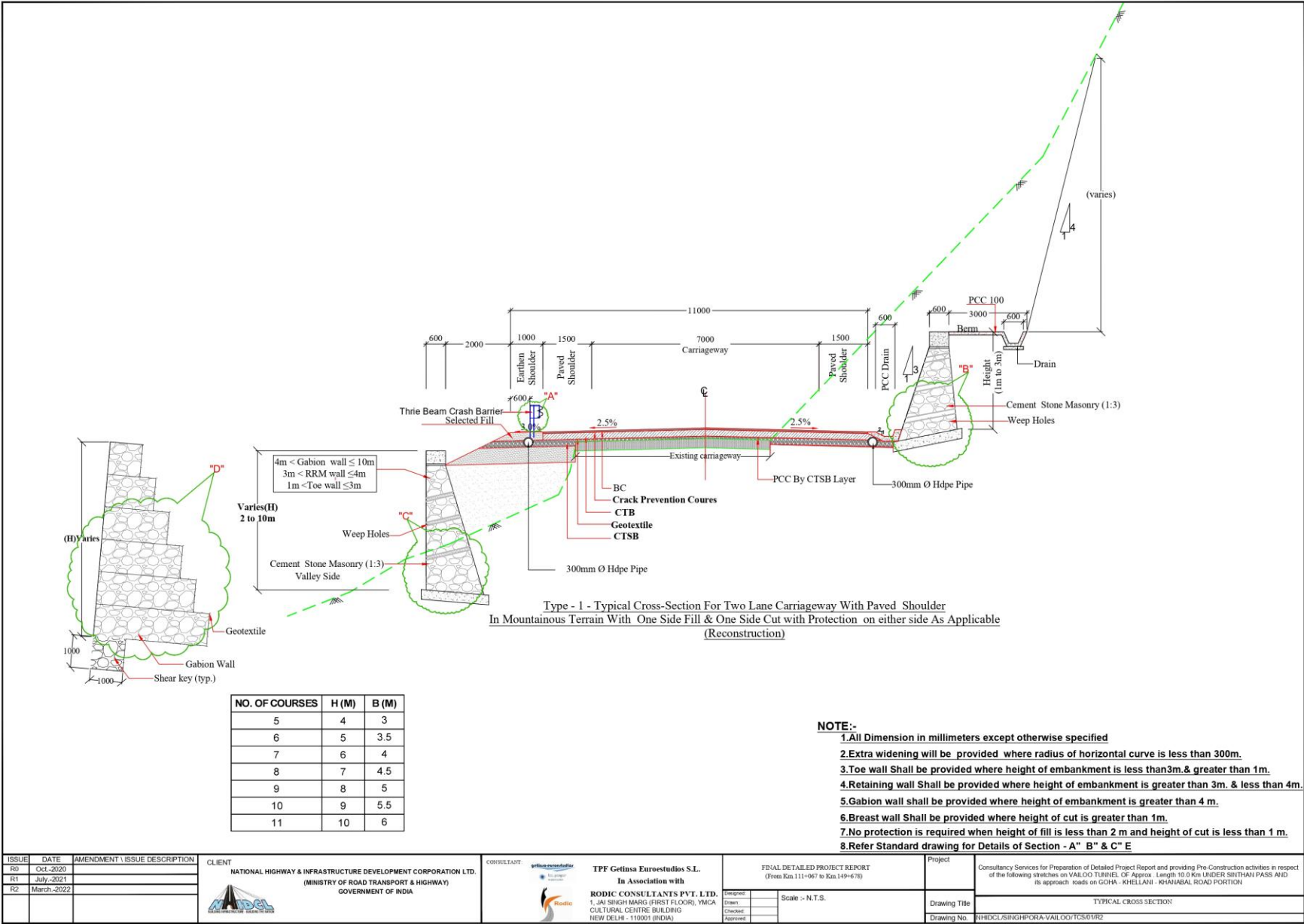


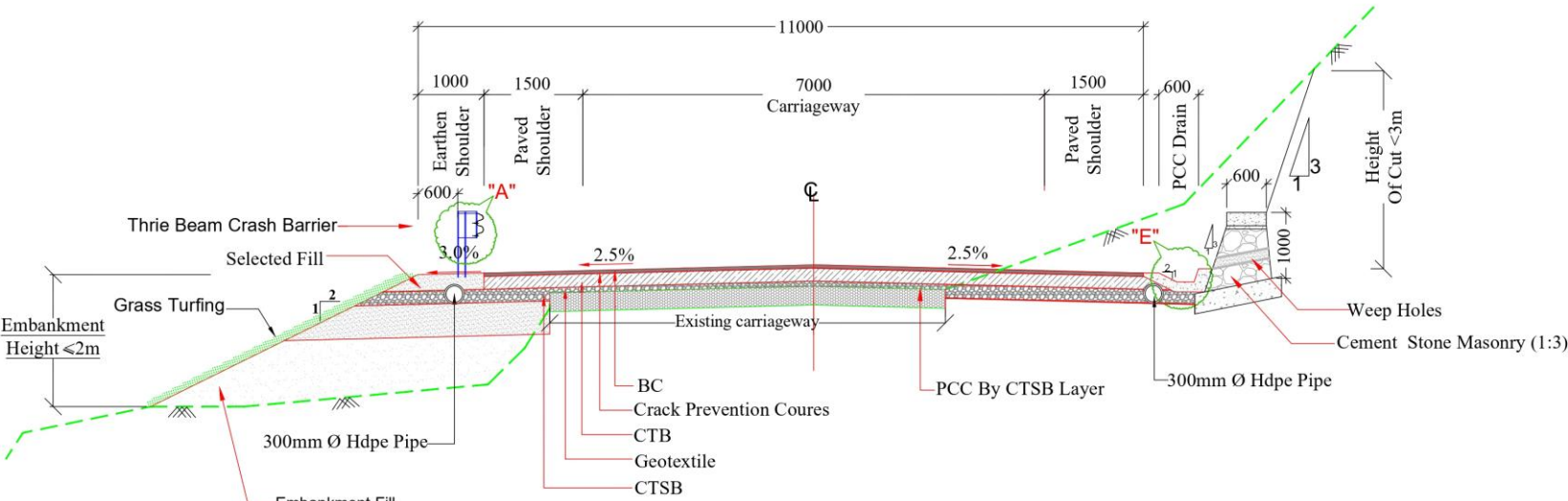
Type - 07-Typical Cross-section For Tunnel Approach With Both Side Fill With Protection As Applicable (New Construction)

NOTE:-

1. All Dimension in millimeters except otherwise specified
2. Extra widening will be provided where radius of horizontal curve is less than 300m.
3. Toe wall Shall be provided where height of embankment is less than 3m. & greater than 1m.
4. Retaining wall Shall be provided where height of embankment is greater than 3m. & less than 4m.
5. Gabion wall shall be provided where height of embankment is greater than 4 m.
6. Breast wall Shall be provided where height of cut is greater than 1m.
7. No protection is required when height of fill is less than 2 m and height of cut is less than 1 m.
8. Refer Standard drawing for Details of Section - "A" "B" & "C" E

ISSUE			DATE	AMENDMENT / ISSUE DESCRIPTION	CLIENT	CONSULTANT	PROJECT		
R1	Oct-2020				NATIONAL HIGHWAY & INFRASTRUCTURE DEVELOPMENT CORPORATION LTD. (MINISTRY OF ROAD TRANSPORT & HIGHWAY) GOVERNMENT OF INDIA 	 jetlin eurostudios  Rodic TPF Getma Eurostudios S.L. In Association with RODIC CONSULTANTS PVT. LTD. 1, JAN SINGH MARG (FIRST FLOOR), YMCA CULTURAL CENTRE BUILDING NEW DELHI - 110001 (INDIA)	FBDL DETAILED PROJECT REPORT (From Km111+067 to Km149+678)		Project Consultancy Services for Preparation of Detailed Project Report and providing Pre-Construction activities in respect of the following stretches: VAILO D TUNNEL OF APPROX. LENGTH 10.6 Km UNDER SIVHAN PASS AND its approach roads on GOHA - KHELLANI - KHAIBAHAD ROAD PORTION
R2	July-2021						Drawing Title TYPICAL CROSS SECTION		
R2	March-2022						Drawing No. 11HDCLSINGHPORA-VAILOOTCS19R2		



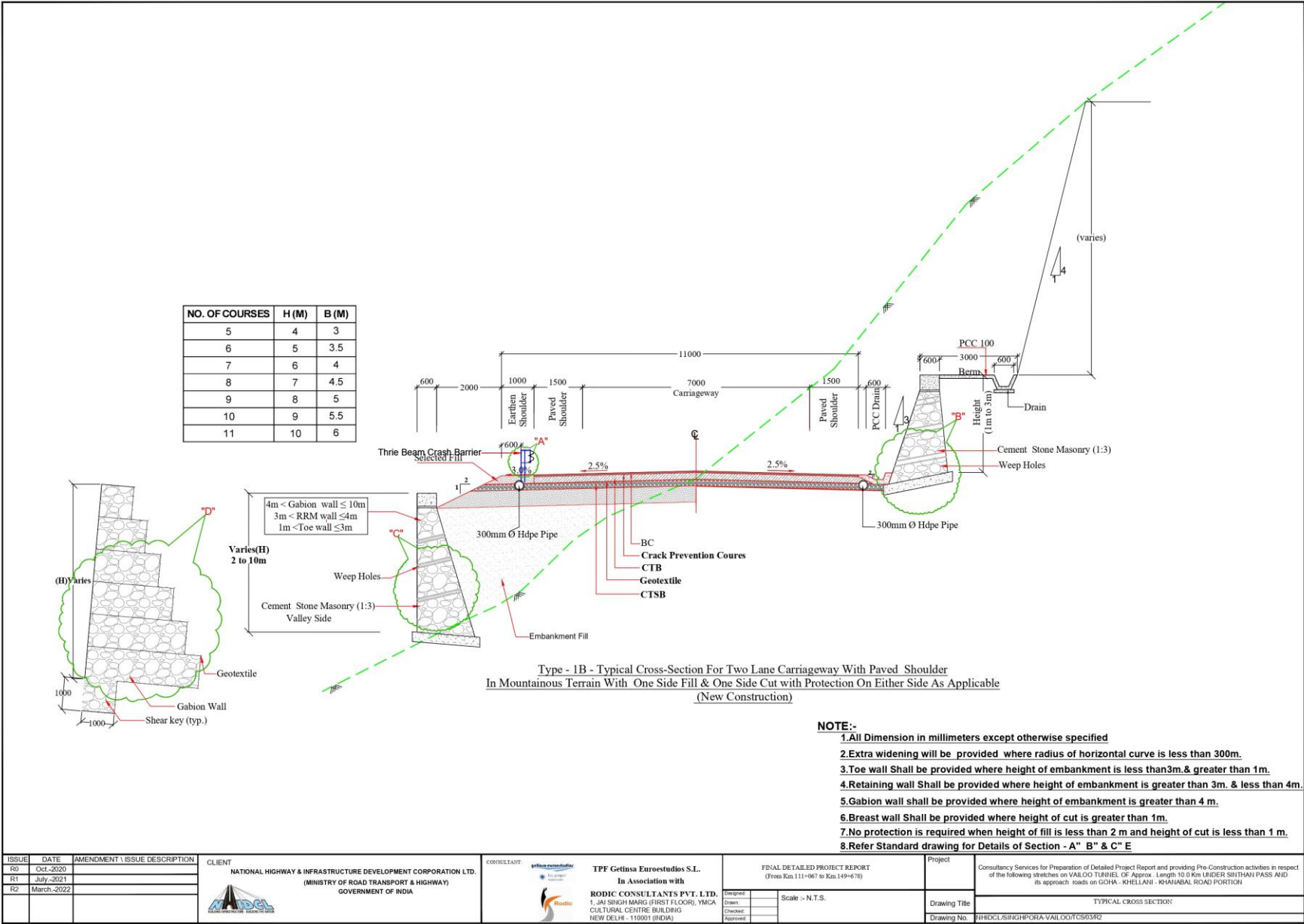


Type - 1A - Typical Cross-Section For Two Lane Carriageway With Paved Shoulder
In Mountainous Terrain With One Side Fill & One Side Cut With Protection
(Reconstruction)

NOTE:-

1. All Dimension in millimeters except otherwise specified
2. Extra widening will be provided where radius of horizontal curve is less than 300m.
3. Toe wall Shall be provided where height of embankment is less than 3m. & greater than 1m.
4. Retaining wall Shall be provided where height of embankment is greater than 3m. & less than 4m.
5. Gabion wall shall be provided where height of embankment is greater than 4 m.
6. Breast wall Shall be provided where height of cut is greater than 1m.
7. No protection is required when height of fill is less than 2 m and height of cut is less than 1 m.
8. Refer Standard drawing for Details of Section - "A" "B" & "C" E

ISSUE			DATE	AMENDMENT / ISSUE DESCRIPTION	CLIENT	CONSULTANT	PROJECT			Project
R0	Oct-2020				NATIONAL HIGHWAY & INFRASTRUCTURE DEVELOPMENT CORPORATION LTD. (MINISTRY OF ROAD TRANSPORT & HIGHWAY) GOVERNMENT OF INDIA 	 TPF Getma Eurostudios S.L. In Association with  RODIC CONSULTANTS PVT. LTD. 1, JAN SINGH MARG (FIRST FLOOR), YMCA CULTURAL CENTRE BUILDING NEW DELHI - 110001 (INDIA)	FBDL DETAILED PROJECT REPORT (From Km111+067 to Km149+678)		Consultancy Services for Preparation of Detailed Project Report and providing Pre-Construction activities in respect of the following stretches: VALDOO TURBINE OF APPROX. LENGTH 10.6 Km UNDER SIVHAN PASS AND its approach roads on GOHA - KHELLANI - KHAIBALI ROAD PORTION	
R1	July-2021						Detailed Drawn Checked Approved	Scale - N.T.S.	Drawing Title	TYPICAL CROSS SECTION
R2	March-2022							Drawing No.	11HDCLSINGHPORA-VALDOOTCROSS2R2	



Schedule - C

(See Clause 2.1)

Project Facilities**1. Project Facilities**

The Contractor shall construct the Project Facilities in accordance with the provisions of this Agreement. Such Project Facilities shall include:

- (a) toll plaza[s];
- (b) roadside furniture;
- (c) pedestrian facilities;
- (d) tree plantation;
- (e) truck lay-byes;
- (f) bus-bays and bus shelters;
- (g) rest areas; and
- (h) others to be specified

2. Description of Project Facilities

Each of the Project Facilities is described below:

a) Toll plaza

Sl. No.	Project Facility	Location	Design Requirements	Other essential details
1	Nil		-	-

b) Roadside Furniture

Traffic signs, kilometer stone (5th km, km and hectometer), Road marking, Road Delineator, Crash barrier, Road studs etc. shall be provided as per section 9 of manual.

c) Lighting

Street lighting shall be provided at the location interchange i.e., Major junction, Major Bridge, Inside VUP/VOP, Toll Plaza including High must lighting additional to the inside & outside of Tunnel location as per section 12 of the manual.

d) Highway traffic management system

Shall be provided in accordance with specifications and Standard.

e) Facilities for the Authority and the Authority Engineer

Facilities for the Authority and Authority's Engineer are to be provided within 06 months of appointed date as per Annexure-IA of Schedule-C.

f) Deleted**g) Deleted****h) Helicopter Services**

Contractor shall provide helicopter (Twin Engines) services from Jammu airport to project site and return for half day (Four Hours) twice a month on the request of the Authority. Additional or less usage of Helicopter service can be adjusted in subsequent months. The Contractor shall provide the Helicopter service within one month from the appointed date and shall be provided and maintained until issue of the Taking Over Certificate for the complete work.

i) Overhead Gantry signs:

- a) 1 nos.Start of Project
- b) 1 nos.Tunnel Portal(East)

c) 1 nos. Tunnel Portal (West)

d) 1 nos. End of the Project.

j) Other Facilities

As per the direction of Engineer-in-charge.

- Landscaping and Tree Plantation

Landscaping and Tree Plantation shall be provided in accordance with Manual of specifications and standards.

- Bus- Shelter-

Bus shelter have been proposed in the project road location may be fixed with the consultation with Authority Engineer and local authority. Tentative location is as given below:

Sl. No.	Design Chainage in km	Side
1	114+500	Both
2	115+430	Both
3	117+860	Both
4	118+760	Both
5	121+670	Both
6	123+760	Both
7	124+600	Both
8	125+975	Both
9	140+465	Both
10	142+015	Both
11	144+010	Both
12	145+910	Both
13	146+510	Both
14	147+810	Both
15	149+010	Both

Annexure-IA
(SCHEDULE- C)

1. Facilities for the Authority and the Authority's Engineer

The facilities to be provided for the Authority and the Authority's Engineer, comprehending the Site Offices and Accommodation shall be as follows:

Table 1: Facilities for the Authority and the Authority's Engineer to be provided by the Contractors

Offices	Accommodation for Authority Staff	Accommodation for Authority Engineer Staff
Core Office and Work Site offices	ED/GM: 2	Team Leader (T/L): 1
	Dy. General Manager (DGM).....2	Other Key Experts 7
	Manager /Site Engineer.....6	Sub-Professional Staff 7
	Office Supporting Staff.....9	Office Supporting Staff 9
	Visiting Officials 5	Visiting Experts 3

Note (1): Site Office: The layout shall be prepared by the Contractor and submitted for review and approval by the Authority's Engineer/ Authority. The locations shall be confirmed by the Authority's Engineer/ Authority.

Note (2): Accommodation: Depending upon the Authority's Engineer/ Authority's acceptance, rental of existing buildings by contractor for use of Authority and Authority Engineer will be allowed depending the proximity of the works to the nearby cities or towns, and comfortability.

1.1 Site Office for the Authority and the Authority's Engineer

1.1.1 Construction of Site Offices

The basic layout of each site office shall be prepared by the Contractor and submitted to the Authority's Engineer for review and respective acceptance.

The building shall comply with India's applicable specifications for architectural and structural works for buildings.

a. Basic Layout

The layout shall be prepared in accordance with the number of staff shown in Table-1 to accommodate properly the following (note: the plan area shown below is the minimum requirement to be considered):

(1) Core Office – Office Type 1:

Minimum Area: 400 sqm for Authority, 150 sqm Authority Engineer and 150 sqm common area.

The tentative area requirements are given below:

- (i) One office room for Team Leader 25 sqm
- (ii) Two office room for the ED/GM, NHIDCL.....25 sqm each
- (iii) Office room for DGM, NHIDCL.....20 sqm each
- (iv) Office room for Other Key Experts of AE 15 sqm
- (v) One office room for Manager/Site Engineer of Authority..... 50 sqm
- (vi) One office room for Sub-Professional Staff of AE 50 sqm
- (vii) One Meeting/Conference Room (Common).....40 sqm
- (viii) One reception/administration office room (Common).... 50 sqm

- (ix) One office room for working tables..... 20 sqm
- (x) 2 kitchen (Pantry) plan area well equipped with sink, draining board, cupboards, shelving, etc. 10 sqm each
- (xi) Male (3) and Female (1) toilets with shower and wash-hand basin facilities for the sole use of the Authority's representative, International Experts, National Experts, and administration staff (office manager and secretaries) 4 units
- (xii) Male (2) toilets for Sub-Professional and Supporting staff 2 units
- (xiii) Corridor for connecting all rooms (approx..60 sqm) 2m width
- (xiv) Parking for the vehicles used by the Authority and Authority's Engineer and visitor's vehicles 12 veh.

(2) Site Office – Office Type 2: (to be provided at all work sites i.e., both portals, three shaft locations and plant area)

b. Basic Requirements

- (i) The Contractor shall, not later than 15 days after the starting date, submit full details of the Design Drawings to the Authority's Engineer, including floor plans, elevations, construction principles and materials, before commencing the erection of the facilities.
- (ii) The Contractor shall be responsible for raising the ground (if necessary), grading and drainage in the vicinity of the building(s), with suitable access and walkways. The Contractor shall construct a covered hard-standing parking area, for the exclusive use of the Authority's Engineer and his visitors and respective access road to the parking area. The access road shall be paved and hard enough in order to be transited even during heavy rains. Outside lighting shall be installed around the buildings and the parking area, and appropriate signs shall be erected to indicate the purpose of the facilities.
- (iii) All facilities shall conform to current fabrication standards for the required types. The facilities described above shall represent the minimum requirements. The Contractor shall provide all additional incidentals and necessary items, so that the facilities will be completely adequate and satisfactory in every respect for their intended use. Painting both the exterior and the interior shall be as agreed with the Authority's Engineer.
- (iv) The building shall be complete with all services connected with clean water supply by water bowser (including elevated water tank and the tower for capacity of 3,000 liters for Office Type 1), electricity and sewerage. Each room shall be provided with at least four electrical outlet sockets. All power shall be 220V-240V, 50Hz except where otherwise agreed by the Authority's Engineer. All rooms shall be illuminated by fluorescent lighting. Each toilet shall be provided with a flushing toilet and warm water hand washing and shower facilities and extractor fans.
- (v) Telephone services (minimum 3 telephone lines and 6 extension lines completed with equipment for the office), including international direct dialing shall be provided. In addition, extra lines shall be provided for facsimile and internet connections. Each office shall be equipped with a telephone connected to the main reception telephone.
- (vi) Offices and meeting rooms shall be air-conditioned. The air-conditioning may be either individual units or a central ducted system and shall be adequate to maintain temperature of neither be more than 24°C (dry bulb) nor less than 15°C. The noise level of the air-conditioning while working should be sufficiently low to allow normal voice level discussions to take place.
- (vii) Office rooms shall be capable of providing at all times environmental conditions suitable for the operation of specified electronic office equipment.
- (viii) The building shall be weatherproof, fire protected, heat-insulated and secured. Windows shall give adequate light and ventilation and be protected with metal mosquito-proof gauze and have security bars and Venetian, or other approved sun blinds. Ceiling height above the floor level shall be at least 2.75 m. All internal walls shall be sound insulated. Floors shall be PVC tile covered. In

toilets and other washing areas the floors shall have drains to assist cleaning.

1.1.2 Maintaining and Servicing of the Offices

- (i) The construction of the new office building for the Authority's Engineer shall be completed within 60 days since the date of commencement of the Contract and shall be equipped and maintained by the Contractor to the satisfaction of the Authority's Engineer until 3 months after the issue of a Completion Certificate for the Works or such earlier time as instructed by the Authority's Engineer whereupon the furniture shall be removed and any internal partition walls modified as required by the Authority's Engineer.
- (ii) The Contractor shall provide all laborers, materials and equipment for maintaining and cleaning offices, furniture and fittings. The Contractor shall replace and/or restore, as directed, any facilities or parts thereof that become damaged, worn out, lost or stolen. The Contractor shall provide an adequate stock of all expendable and consumable items including refreshments, clean water supply and drinking water, paper towels, toilet rolls, soaps, washing up liquid, brooms/mops and shall ensure proper and continuing functioning of all components and parts of the facilities during the contract period.
- (iii) The Offices shall be provided with waste disposal material, and these shall be emptied and disposed of daily by the Contractor.

1.1.3 Equipment and Expenses for Running-Off the Offices

The Contractor shall provide the following furniture and equipment to be used by the Authority's Engineer at Site.

Table: Furniture and Equipment for Site Offices (each office)

Item	Unit	Quantity for Core office	Quantity for each of work site office	Remarks
Refrigerator (deodorizer and no-frost system)	unit	2	1	Office Type 1: 300liters' minimum capacity
Deep Freezer	Unit	1	-	
Water Dispenser (19 liters capacity including bottles and 6 spares bottles/gallon)	set	4	2	Office Type 1
Electric Kitchen Stove	unit	2	1	Size and model shall be discussed
Electric Kettle	unit	2	1	
Diesel Generator Set	unit	1	-	Office Type 1: 125 KVA

1.2 Accommodation for the Authority and the Authority's Engineer Staff

1.2.1 Accommodation

- (1) General
 - (i) Immediately after the date for Commencement of Works, during the first 3 months or until the permanent installations are prepared and approved, the Contractor shall provide rented houses as per the accommodation for all staff of the Authority's Engineer.
 - (ii) The accommodation shall be equipped with security grilles and mosquito netting, and shall be fully furnished and equipped with new items by the Contractor to the satisfaction of the Authority's

Engineer, including curtains, linen, blankets, glassware, cutlery, crockery and kitchen utensils.

- (iii) Each house shall be wired to permit the use of standby generators as well as mains for the supply of electricity. The generators shall be fitted with automatic starting switchgear if so directed by the Engineer. Covered, hard standing areas for positioning generators and storing fuel shall be provided.
- (iv) Each house designated for the Engineer's International Experts and National Experts shall be provided with one telephone line and internet connection. Telephone installation shall be made by the Contractor but the cost of calls shall be paid by the Authority's Engineer staff.
- (v) Each house shall be provided with a TV (including cable and satellite connection). The installation shall be made by the Contractor, but the cost of calls shall be paid by the Authority's Engineer staff.
- (vi) Each house shall be provided with hot and cold water in the kitchen and the bathrooms.
- (vii) The Contractor shall provide watchmen for security purposes to the approval of the Authority's Engineer.
- (viii) The accommodation shall be available and ready for occupation within the number of days approved by the Authority's Engineer after the Commencement Date.
- (ix) In the event that the Contractor fails to provide the required accommodation within the time specified or subsequently agreed by the Authority's Engineer, the Contractor shall provide, at no cost to the Employer, suitable hotel accommodation until such time as the accommodation is ready for occupation.
- (x) When a house is no longer required by the Authority's Engineer, all furniture, fittings and equipment provided by the Contractor for that house shall become the property of the Contractor.

(2) Housing Types

(A). House for the Authority near to Core Office (ED/ GM, NHIDCL)

Two residential accommodation, internal floor area approximately 100sqm comprising 1 x sitting room, 1 x dining room, 1 x bedroom with attached bathrooms, 1 additional bathroom, 1 x kitchen, 1 x office, 1 x veranda. Temperature control arrangements to the sitting room, dining room and bedrooms.

(B). Accommodation for the Authority near to Core Office (Other Staff: 1 per 1 person)

Bachelor's accommodation having internal floor area approximately 40 sqm (03 nos.) and other of 25 sqm with attached bathrooms.

(C). Team Leader (Authority's Engineer)

One residential accommodation, internal floor area approximately 100sqm comprising 1 x sitting room, 1 x dining room, 1 x bedroom with attached bathrooms, 1 additional bathroom, 1 x kitchen, 1 x office, 1 x veranda. Temperature control arrangements to the sitting room, dining room and bedrooms.

(D). Other Key Experts and Sub-Professional /Supporting Staff

Bachelor's accommodation having internal floor area approximately 25 sqm with attached bathrooms.

Note: (1) All the residential accommodation must have temperature control facility so that temperature is neither more than 24°C nor less than 15°C.

(3) Maintenance

- (i) The Contractor shall be responsible for supplying all utilities, including electricity (whether by mains or generator), water, timber for open fires, drainage and telephone services, and shall meet the cost of these services, except the cost of telephone calls.
- (ii) The Contractor shall maintain the accommodation, and all furniture, fittings and equipment, whether supplied by him or not, in good repair and to the satisfaction of the Authority's Engineer as long as such accommodation is occupied by the staff of the Authority & Authority's Engineer for the purposes of the Contract.

Schedule - D

(See Clause 2.1)

Specifications and Standards

1. Construction

The Contractor shall comply with the Specifications and Standards set forth in Annex- I & D1 of this Schedule-D for construction of the Project Highway.

2. Design Standards

The Project Highway including Project Facilities shall conform to design requirements set out in the following documents:

Manual of Specifications and Standards for 2-Laning of Highways IRC: SP: 73: 2018, referred to herein as the Manual.

Guidelines for road Tunnel IRC: SP:91- 2019, referred to herein as the Manual.

Annex – I
(Schedule-D)

Specifications and Standards for Construction

1. Specifications and Standards

All Materials works and construction operations shall conform to the Manual of Specifications and Standards for Two-Laning of Highways IRC: SP:73-2018, Hill Road Manual of IRC: SP: 48-1998 and Guidelines for Road Tunnel of IRC: SP:91-2019 referred to as the Manual, and MORTH Specifications for Road and Bridge Works. Where the specification for a work is not given, Good Industry Practice shall be adopted to the satisfaction of the Authority's Engineer.

2. Deviations from the Specifications and Standards

- (i) The terms “Concessionaire”, “Independent Engineer” and “Concession Agreement” used in the Manual shall be deemed to be substituted by the terms “Contractor”, “Authority's Engineer” and “Agreement” respectively.
- (ii) Notwithstanding anything to the contrary contained in Paragraph 1 above, the following Specifications and Standards shall apply to the Project Highway, and for purposes of this Agreement, the aforesaid Specifications and Standards shall be deemed to be amended to the extent set forth below:
- (iii) Deviations from the aforesaid Specifications and Standards shall be listed out here. Such deviations shall be specified only if they are considered essential in view of project-specific

Sl. No.	Item	Provisions	Deviation
1	Width of Structure	For open country/rolling terrain total width of the structure should be 18 m as per Clause 7.3(ii) of IRC: SP:73-2018(Fig.- 7.6). No width of structure /bridges for mountainous/hilly terrain.	Provided total width of structure/Viaduct cum bridge/Viaduct/bridges –10m (paved carriageway width 9m) and 12.5m (paved carriageway width 11.5 m).
2	Cross passages	Para 5 of Clause 2.2 (Annexure-B) in IRC: SP:91-2019 @500m C/C.	Provided @ every 330m spacing.
3	Refuge Parking	Note-1 (page no 107) point of Annexure B-1 (Page no 108) IRC: SP:91-2019 @500 m.	Provided @1650m C/C spacing in enlarged Cross Passages plus cross passages provided @330m c/c can also be used in case of emergency.
4	Raised footpath /inspection path	Annexure-B (Page no 104) Para 2e in IRC: SP:91-2019 (1.5m with railing)	Provided 1m raised footpath without railing.

As per IRC SP:48 1998 table no. 6.7& IRC 52 2019 (table no. 6.8), ruling minimum radius is 60m for steep terrain (snow bound area). Deviations from the aforesaid Specifications and Standards shall be listed out here.

Sr. No.	HIP Chainage (Km)	Radius (m)
HORIZONTAL CURVE DETAILS		
1	111127.8	50
2	112959.0	50
3	113170.4	50
4	113704.0	50
5	114385.7	50
6	117057.4	50
7	117245.8	50
8	117426.4	50
9	117818.5	50

Sr. No.	HIP Chainage (Km)	Radius (m)
HORIZONTAL CURVE DETAILS		
10	118282.7	50
11	118841.9	50
12	119309.5	50
13	120465.4	50
14	120730.3	50
15	121629.3	50
16	121850.4	50
17	121955.0	50
18	122724.4	50
19	123087.4	50
20	123549.2	50
21	123669.7	50
22	124440.1	50
23	125085.2	50
24	125419.2	50
25	125603.2	50
26	125809.4	50
27	126036.0	50
28	126293.2	50
29	127940.9	50
30	128056.2	50
31	143905.7	50
32	143996.4	50
33	144378.9	50
34	144933.2	50
35	143905.7	50
36	143996.4	50
37	144378.9	50
38	144933.2	50

**ATTACHMENT - DI - TECHNICAL
SPECIFICATIONS FOR ROAD TUNNELS & BRIDGE**

1. SCOPE OF WORK

The National Highways & Infrastructure Development Corporation Limited (NHIDCL) has been entrusted with the work of construction of Unidirectional Singhpura-Vailoo (under Sinthanpass) Tunnel and its approach roads.

2. GENERAL

These Technical Specifications define the technical and quality standards specifically for NATM tunnel construction works in all ground condition.

The construction works shall be executed by the Contractor according to the quality requirements defined in the Specification and to the satisfaction of the Employer's Representative. Any item of work arising from the execution of the works, not covered by the Technical Specification, shall be according to a Standard as agreed with the Employer's Representative and the Contractor.

It is the intent of this Specification to define standards for the tendering process as well as for the planning and execution of the work by the Contractor. This includes the definition of quality standards which must be followed and will be checked during construction by the Employer's Representative. Deviations from the Specification must be submitted in writing in the tender.

This Technical Specification is based on the "Specification for Tunnelling, Third Edition", British Tunnelling Society, Institution of Civil Engineers, 2010 and "MORTH Specification for Road and Bridge Works", Ministry of Road Transport and Highways, 2000.

2.1 Definition

Behaviour Type (BT) means general categories describing similar ground behaviour with respect to failure modes and displacement characteristics.

Contractor means the person(s) named as contractor in the Letter of Tender accepted by the Employer and the legal successors in title to this person(s).

Contractor's Representative means the person named by the Contractor in the Contract or appointed from time to time by the Contractor who acts on behalf of the Contractor.

Cost means all expenditure reasonably incurred (or to be incurred) by the Contractor, whether on or off the Site, including overhead and similar charges, but does not include profit.

Day means a calendar day.

Design drawing, final drawing, construction drawing, fit-for-constriction drawing means drawing of detailed design prepared by the Contractor and approved by Employer's Representative.

Employer means the person named as employer in Contract Data and the legal successor in title to this person.

Employer's Representative and Engineer means the person appointed by the Employer to act as Employer's Representative for the purposes of the Contract and named as such in the Contract Data, or other person appointed from time to time by the Employer and notified as such to the Contractor.

Framework plan means the summary of the Geotechnical Design, including relevant parameters used in the design, and application criteria for the assignment of excavation and support methods.

Ground behaviour means reaction of the ground to the excavation of the full profile without consideration of sequential excavation and support.

Ground Type (GT) means ground, soil or rock, with similar properties.

(Design) Line of excavation means the line of excavation within which no unexcavated ground material shall remain at any time. If due to additional displacements of the ground unexcavated material extend into the line of excavation the Employer's Representative may order to excavate this material at no additional costs.

Materials means things of all kinds (other than Plant) whether on the Site or otherwise allocated to the Contract and intended to form or forming part of the Works, including the supply-only Materials (if any) to be supplied by the Contractor under the Contract.

Overbreak means the excavation beyond the line of excavation.

Overbreak Line means the line to which Overbreak is allowed without any remedial work required.

Plant means the apparatus, machinery and vehicles intended to form or forming part of the Permanent Works.

Site means the places where the Permanent Works are to be executed and to which Plant and Materials are to be delivered, and where the Operation Service is to be provided, and any other places as may be specified in the Contract as forming part of the Site.

System Behaviour (ST) means behaviour resulting from the interaction between ground, excavation profile and support, separated in: system behaviour in the respective excavation section, system behaviour in the supported section and system behaviour in the final state.

Working Day means a day on which working is performed.

Works means the Permanent Works and Temporary Works or either of them as appropriate and the facility to be operated by the Contractor during the Operation Service Period.

2.2 Work during Bad Weather Condition

All works have to be continued during any weather condition. Difficulties due to low temperature or snow falls in winter times or heat, drought or heavy rain falls in summertime are compensated with the unit prices. No extension of construction time is derived.

The Contractor shall investigate the working areas required for the tunnel construction concerning avalanche risk before establishing site infrastructure.

2.3 Submittals

The Contractor shall provide description of all works prior to commencement of any work to the Employer's Representative for approval. The Contractor shall submit the documents in a way that sufficient time is left for approval of the submittals but latest 2 working weeks before start of the relevant works if not specified herein differently or directed by the Employer's Representative.

The description shall include but not limited to procedure, sequence, materials, equipment, laboratory etc. The Employer's Representative may request additional data and supplementation of the submittals at any time.

2.4 Standards and Units

Materials, equipment and methods shall comply with the Standards and Codes of Practice indicated using the versions that are current at the date for submission of tenders. The Contractor may propose the adoption of alternative standards and shall provide explanations with any proposals. The use of such standards shall be subject to the agreement of the Employer's Representative.

Some Indian, European and British Standards and Guidelines are listed in Clause 2.5. The list is provided for information only and does not illustrate all relevant Standards for the Works. All Work shall be in compliance with these Standards and Guidelines. First and foremost the compliance of Indian Standards is required unless defined otherwise in this Specification. International (in the first step European) Standards and Guidelines shall be accessed to when no Indian Standards/Guidelines are available for the specific matter.

References to sources for Standards, Guidelines and Recommendations cited in the contractual documents are provided in Table 1. The list is provided for information only.

Table 1: References to sources of Standards, Guidelines and Recommendation

Abbreviation	Name
ASTM	American Society for Testing and Materials, 100 Bar Harbor Drive West, Conshohocken PA 19429 - 2595, U.S.A.
BSI (BS)	British Standards Institute, 389 Chiswick High Road, London, W4 4AL UK.
DIN	Deutsches Institut für Normung e.V. Beuth Verlag GmbH, Burggrafenstrasse 6 D-10787, Berlin, Germany.
EFNARC	European Federation of Producers and Applicators of Special Building Products, Association House, 235 Ash Road, Aldershot, Hampshire, GU12 4DD, United Kingdom.
EN, ENV	European Committee for Standardisation, Central Secretariat, Rue de Stassart 36 B-1050, Brussels.
IRC	The Indian Road Congress, Jamnagar House, Shahjahan Road, New Delhi- 110011.
IS	Bureau of Indian Standards, Manak Bhavan, 9 Bahdur Shah Zafar Marg, New Delhi - 110002.
ISO	International Organization for Standardisation 1, rue de Varembe CP 56, CH-1211 Geneve 20, Switzerland.
ONORM:	Austrian Standard Institute, Heinestrasse 38, 1020 Wien, Austria

Abbreviation	Name
RVS (Austrian Code for Road Construction)	Austrian Association on Road, Rail and Transport (FSV), Karlsgasse 5, 1040 Wien, Austria
OGG	Austrian Society for Geomechanics, Bayerhamerstrasse 14, 5020 Salzburg, Austria

The units applied are those of Si-System according to ISO 1000. A full stop (.) is used as decimal delimiter. Additionally in the schedule of prices the following abbreviations are applied:

d	calendar day
each	each
ls	lump sum
wd	working day

2.5 Listing of Standards

The list is provided for information only.

2.5.1 Indian Standards

Table 2: Indian Standards

ID of Standard	Description
IS 10262-2009	Guidelines for concrete mix design proportioning
IS 1077-1992	Common Burnt Clay Building Bricks
IS 11171-1985	Dry-Type Power Transformers
IS 1199-1959	Methods of sampling and analysis of concrete
IS 12269-1987	53 grade ordinary Portland cement
IS 12330-1988	Specification for sulphate resisting Portland cement
IS 1248	Direct Acting Indicating Analogue Electrical Measuring Instruments and their Accessories
IS 1278-1972	Filler rods and wires for gas welding
IS 1343-1980	Code of Practice for Prestressed Concrete
IS 1542-1992	Sand for plaster
IS 1554-1988	(Part 1): PVC insulated (heavy duty) electric cables: Part 1 For working voltages upto and including 1 100 V
IS 1566-1982	hard-drawn steel wire fabric for concrete reinforcement
IS 1885-1993	Electro technical Vocabulary: Part 32 Electric cables
IS 1651-1991	Stationary cells and batteries, lead-acid type (with tubular positive plates)
IS 8130-1984	Conductors for insulated electric cables and flexible cords
IS 1786-2008	High strength deformed steel bars and wires for concrete reinforcement
IS 1791-1985	General Requirements for Batch Type Concrete Mixers
IS 1905-1987	Code of practice for structural safety of buildings; masonry walls
IS 2062-2011	Hot Rolled Medium and High Tensile Structural Steel
IS 2116-1980	Sand for masonry mortars
IS/IEC 60947-1-2007	Low-voltage Switchgear and Control gear :Part 1 General Rules
IS 2180-1988	heavy duty burnt clay building bricks
IS 2309-1989	Code of practice for the protection of buildings and allied structures against lightning
IS 2386-1963	(Part 1 & 8): methods of tests for aggregates for concrete
IS 2502-1963	Code of Practice for Bending and Fixing of Bars for Concrete Reinforcement
IS 2505-1992	Concrete vibrators - Immersion type - General requirements
IS 2514-1963	Concrete vibrating tables
IS/IEC 60947-2-2003	Low-Voltage Switchgear and Control gear - Part 2 : Circuit Breakers
IS 13118-1991	High-Voltage Alternating-Current Circuit-Breakers
IS/IEC 60947-3-1999	Low p voltage switchgear and control gear : Part 3 Switches, disconnectors, switch-disconnectors and fuse combination units
IS 269-1989	Ordinary and low heat Portland cement (33 GRADE)

ID of Standard	Description
IS 2705-1992	Current transformers
IS 2750-1964	Steel Scaffoldings
IS 2751-1979	Code of Practice for Welding of Mild Steel Plain and Deformed Bars for Reinforced Concrete Construction
IS 280-2006	Mild Steel Wire for General Engineering Purposes
IS13925-1-2012	Shunt capacitors for ac power systems having a rated voltage above 1000 V Part 1:General
IS 2961-1973	Chrome retain finished upper leather
IS 8130-1984	Conductors for insulated electric cables and flexible cords
IS 3043-1987	Code of practices for earthing
IS 3085-1965	Method of Test for Permeability of Cement Mortar and Concrete
IS 3156-1992	Voltage transformers
IS 3231-1986	Electrical relays for power systems protection
IS 3427-1997	A.C. Metal Enclosed Switchgear and Control gear for Rated Voltages Above 1 kV and Up to and Including 52 kV
IS 3443-1980	Crane rail sections
IS 3558-1983	Code of practice for use of immersion vibrators for consolidating concrete
IS 3597-1998	Concrete pipes - Methods of test
IS 5578-1984	Guide for marking of insulated conductors
IS 11353-1985	Guide for Uniform System of Marking and Identification of Conductors and Apparatus Terminals
IS 3764-1992	Code of safety for excavation work
IS 383-1970	Coarse and Fine Aggregates From Natural Sources For Concrete
IS 3954-1991	Hot Rolled Steel Channel Sections for General Engineering Purposes - Dimensions
IS 4031-1989	Methods of physical tests for hydraulic cement
IS 4032-1985	Method of chemical analysis of hydraulic cement
IS 4081-1986	Safety code for blasting and related drilling operations
IS 4138-1977	Safety code for working in compressed air
IS 432-1982	Mild Steel and Medium Tensile Steel Bars and Hard-Drawn Steel Wire for Concrete Reinforcement
IS 456-1978	Plain and Reinforced Concrete - Code of Practice
IS 457-1957	Code of Practice for General Construction of Plain and Reinforced Concrete for Dams and Other Massive Structures
IS 458-2003	Precast Concrete Pipes (with and without Reinforcement)
IS 4756-1978	Safety code for tunnelling work
IS 4880 (Part 1-7)	Code of practice for design of tunnels conveying water
IS 4925-2004	Concrete Batching and Mixing Plant
IS 4988-1968	(Part 1-5): Glossary of terms and classification of earth moving machinery
IS 5082-1998	Wrought aluminum and aluminum alloy bars, rods, tubes and sections for electrical purposes
IS 516-1959	Method of Tests for Strength of Concrete
IS 5525-1969	Recommendation for detailing of reinforcement in RCC
IS 5640-1970	Method of test for determining aggregate impact value of soft coarse aggregates
IS 5819-1970	Recommended Short-circuit Ratings of High Voltage PVC Cables
IS 5831-1984	PVC insulation and sheath of electric cables
IS 5878-1971	(Part 1-7): Code of Practice for Construction of Tunnels
IS 5892-2004	Concrete transit mixers & agitators
IS 6430-1985	Mobile air compressor for construction purposes
IS 6461-1972	Glossary of terms relating to cement concrete: Part I Concrete aggregates
IS 6461-1972	Glossary of Terms Relating to Cement Concrete - Part III : Concrete Reinforcement
IS 650-1991	Standard Sand for Testing of Cement
IS 694-2010	POLYVINYL CHLORIDE INSULATED UNSHEATHED AND SHEATHED CABLES/CORDS WITH RIGID AND FLEXIBLE CONDUCTOR FOR RATED VOLTAGES UP TO AND INCLUDING 450/750 V
IS 7098-1988	Crosslinked polyethylene insulated PVC sheathed cables: Part 1 For working voltage

ID of Standard	Description
	upto and including 1 100 V
IS 7245-1974	Concrete payers
IS 7251-1974	Concrete finishers
IS 7293-1974	Safety code for working with construction machinery
IS 7319-1974	perforated concrete pipes
IS 783-1985	Code of Practice for Laying of Concrete Pipes
IS 7861-1981	(Part 2): Code of practice for extreme weather concreting: Part II Recommended practice for cold weather concreting
IS 7861-1981	(Part 1): Code of practice for extreme weather concreting Part 1 Recommended practice for hot weather concreting
IS 800-2007	General Construction In Steel - Code of Practice
IS 8041-1990	Specification for rapid hardening Portland cement (2nd revision)
IS 8112-1989	High strength ordinary Portland cement (43 grade)
IS 814-2004	Covered Electrodes for Manual Metal Arc Welding of Carbon and Carbon Manganese Steel
IS 816-1969	Code of practice for use of metal arc welding for general construction in mild steel
IS 817-1992	(Part 1): Training of Welders - Code of Practice: Part 1 Manual metal arc welding
IS 818-1968	Code of Practice for Safety and Health Requirements in Electric and Gas Welding and Cutting Operations
IS 2062-2011	Hot Rolled Medium and High Tensile Structural Steel
IS 8623-1993	Low-Voltage Switchgear and Controlgear Assemblies
IS/IEC 60898 -2002	Electrical accessories - Circuit-breakers for overcurrent protection for household and similar installations : Part 1 Circuit-breakers for ac operation
IS 9012-1978	Recommended practice for shotcreting
IS 9103-1999	Concrete Admixtures
IS 9284-1979	Method of test for abrasion resistance of concrete
IS 9417-1989	Recommendations for welding cold worked bars for reinforced concrete construction

2.5.2 European Standards

Table 3: European Standards

Codes	Description
Eurocode 1	Basis of design and actions on structures
Eurocode 2	Design of concrete structures
Eurocode 3	Design of steel structures
Eurocode 5	Design of timber structures
Eurocode 7	Geotechnical design
Eurocode 8	Design of structures for earthquake resistance
BS EN ISO 62:2008	Plastics. Determination of water absorption
BS EN 196:2005	Methods of testing cement
BS EN 197-1:2011	Cement. Composition, specifications and conformity criteria for common cements
BS EN 197-1:2004	Cement - Part 1: Composition, specifications and conformity criteria for common cements
BS EN 206-1:2001	Specification, performance, production and conformity
BS EN 295-7:1996	Requirements for vitrified clay pipes and joints for pipe jacking
BS EN 338:2010	Structural timber. Strength classes
BS EN 450-1:2005	Fly ash for concrete - Part 1: Definitions, specifications and conformity criteria A1:2007
BS EN 471:2004	High-visibility warning clothing for professional use - Test methods and requirements
BS EN 480:2006	Admixtures for concrete, mortar and grout. Test methods
BS EN ISO 527-3:1996	Plastics. Determination of tensile properties. Test conditions for films and sheets
BS EN 681-2:2000	Elastomeric seals. Material requirements for pipe joint seals used in water and drainage applications. Thermoplastic elastomers
BS EN 771-3:2011	Specification for masonry units. Aggregate concrete masonry units (dense and light-weight aggregates)

Codes	Description
BS EN 772-2:1998	Methods of test for masonry units. Determination of percentage area of voids in masonry units (by paper indentation)
BS EN 791:1996	Drill rigs - safety
BS EN 815:1997	Safety of unshielded tunnelling boring machines and rodless shaft boring machines for rock
BS EN 932-6:1999	Tests for general properties of aggregates. Definitions of repeatability and reproducibility
BS EN 933-1:2012	Tests for geometrical properties of aggregates. Determination of particle size distribution. Sieving method
BS EN 934-2:2009	Admixtures for concrete, mortar and grout - Part 2: Concrete admixtures - Definitions and requirements, conformity, marking and labelling
BS EN 1008:2002	Mixing water for concrete - Specification for sampling, testing and assessing the suitability of water, including water recovered from processes in the concrete industry, as mixing water for concrete
BS EN 1011-1:2009	Welding - Recommendations for welding of metallic materials - General guidance for arc welding
BS EN 1011-2:2001	Welding. Recommendations for welding of metallic materials. Arc welding of ferritic steels
BS EN 1062-7:2004	Paints and varnishes. Coating materials and coating systems for exterior masonry and concrete. Determination of crack bridging properties
BS EN 1090-2:2008	Execution of steel structures and aluminum structures. Technical requirements for steel structures
BS EN 1097	Tests for mechanical and physical properties of aggregates
BS EN 1367	Tests for thermal and weathering properties of aggregates
BS EN ISO1461:2009	Hot dip galvanized coatings on fabricated iron and steel articles. Specifications and test methods
BS EN 1537:2000	Execution of special geotechnical work - rock anchors
BS EN 1542:1999	Products and systems for the protection and repair of concrete structures. Test methods. Measurement of bond strength by pull-off
BS EN 1562:2012	Founding. Malleable cast irons
BS EN 1563:2012	Founding. Spheroidal graphite cast iron
BS EN 1744	Tests for chemical properties of aggregates
BS EN 1849-2:2010	Flexible sheets for waterproofing. Determination of thickness and mass per unit area. Plastic and rubber sheets
BS EN 1928:2000	Flexible sheets for waterproofing. Bitumen, plastic and rubber sheets for roof waterproofing. Determination of water tightness
BS EN ISO 3506-2: 2009	Mechanical properties of corrosion-resistant stainless-steel fasteners - Nuts
BS EN ISO 4624:2003	Paints and varnishes. Pull-off test for adhesion
BS EN ISO 9001:2008	Quality management systems. Requirements
BS EN 10025:2004	Hot rolled products of structural steels
BS EN 10080:2005	Steel for the reinforcement of concrete. Weldable reinforcing steel.
BS EN 10164:2004	General Steel products with improved deformation properties perpendicular to the surface of the product - technical delivery conditions
BS EN 10226-1:2004	Pipe threads where pressure tight joints are made on the threads. Taper external threads and parallel internal threads. Dimensions, tolerances and designation
BS EN ISO 11925-2:2011	Reaction to fire tests. Ignitability of products subjected to direct impingement of flame. Single-flame source test
BS EN 12110:2002	Tunnelling machines - Air locks - Safety requirements
BS EN 12111:2002	Tunnelling machines - Road headers, continuous miners and impact rippers - Safety requirements
BS EN 12310-2:2000	Flexible sheets for waterproofing. Determination of resistance to tearing (nail shank). Plastic and rubber sheets for roof waterproofing
BS EN 12317-2:2010	Flexible sheets for waterproofing. Determination of shear resistance of joints. Plastic and rubber sheets for roof waterproofing
BS EN 12336:2005	Tunnelling machines - Shield machines, thrust boring machines, auger boring machines, lining erection equipment - Safety requirements
BS EN 12350	Testing fresh concrete

Codes	Description
BS EN 12390	Testing hardened concrete
BS EN 12504-1	Testing concrete in structures - Part 1: Cored specimens - Taking, examining and testing in compression
BS EN 12588:2007	Lead and lead alloys. Rolled lead sheet for building purposes
BS EN 12620:2002	Aggregates for concrete
BS EN 12878:2005	Pigments for the colouring of building materials based on cement and/or lime. Specifications and methods of test
BS EN 12889:2000	Trenchless construction and testing of drains and sewers
BS EN 13055-1:2002	Lightweight aggregates. Lightweight aggregates for concrete, mortar and grout
BS EN 13139:2002	Aggregates for mortar
BS EN 13263-1:2005	Silica fume for concrete - Part 1: Definitions, requirements and conformity criteria
BS EN 13492:2004(E)	Geosynthetic barriers - Characteristics required for use in the construction of liquid waste disposal sites, transfer stations or secondary containment
DIN EN 13670-1:2011	Execution of concrete structures
BS EN 13791:2007	Assessment of in-situ compressive strength in structures and pre-cast concrete components
BS EN 14487-1:2006	Sprayed concrete - Part 1: Definitions, specifications and conformity
BS EN 14487-2:2006	Sprayed concrete - Part 2: Execution
BS EN 14488-1:2005	Testing sprayed concrete - Part 1: Sampling fresh and hardened concrete
BS EN 14488-2:2006	Testing sprayed concrete - Part 2: Compressive strength of young sprayed concrete
BS EN 14488-3:2006	Testing sprayed concrete - Part 3: Flexural strengths (first peak, ultimate and residual) of fibre reinforced beam specimens
BS EN 14488-4:2005	Testing sprayed concrete - Part 4: Bond strength of cores by direct tension
BS EN 14488-5:2006	Testing sprayed concrete - Part 5: Determination of energy absorption capacity of fibre reinforced slab specimens
BS EN 14488-7:2006	Testing sprayed concrete - Part 7: Fibre content of fibre reinforced concrete
BS EN 14889-1:2006	Fibres for concrete - Part 1: Steel fibres. Definitions, specifications and conformity
BS EN 14889- 2:2006	Fibres for concrete - Part 2: Polymer fibres. Definitions, specifications and conformity
BS EN 15167-1:2006	Ground granulated blast furnace slag for use in concrete, mortar and grout - definitions, specifications and conformity criteria
BS EN 60204	Safety of machinery. Electrical equipment of machines
BS EN 61672-1:2003	Electroacoustics. Sound level meters. Specifications
DD CEN/TS 14416:2005	Geosynthetic barriers. Test method for determining the resistance to roots
PD CLC/TR 50426:2006	Assessment of inadvertent initiation of bridge wire electro-explosive devices by radio-frequency radiation. Guide

2.5.3 British Standards**Table 4: British Standards**

Codes	Description
BS 143 and 1256:2000	Threaded pipe fittings in malleable cast iron and cast copper alloy
BS 1134:2010	Assessment of surface texture. Guidance and general information
BS 4190:2001	ISO metric black hexagon bolts, screws and nuts. Specification
BS 4449:2005	Steel for the reinforcement of concrete - Weldable reinforcing steel - Bar, coil and decoiled product
BS 4482:2005	Steel wire for the reinforcement, of concrete products. Specification
BS 4483:2005	Steel fabric for the reinforcement of concrete
BS 4921:1988	Specification for sherardized coatings on iron or steel
BS 5228-1:2009	Code of practice for noise and vibration control on construction and open sites. Noise
BS 5228-2:2009	Code of practice for noise and vibration control on construction and open sites. Vibration
BS 5607:1998	Code of practice for the safe use of explosives in the construction industry
BS 5911-1	Concrete pipes and ancillary concrete products. Specification for unreinforced and reinforced concrete pipes (including jacking pipes) and fittings with flexible joints (complementary to BS EN 1916:2002)
BS 5975:2008	Code of practice for temporary works procedures and the permissible stress design of falsework
BS 6100	Building and civil engineering. Vocabulary. (various dates)
BS 6164:2011	Code of practice for health and safety in tunnelling in the construction industry
BS 6319	Testing of resin and polymer cement compositions for use in construction (various dates)
BS 6472:2008	Guide to evaluation of human exposure to vibration in buildings (1-80 Hz)
BS ISO 4866:2010	Mechanical vibration and shock. Vibration of fixed structures. Guidelines for the measurement of vibrations and evaluation of their effects on structures
BS 7385-2:1993	Evaluation and measurement for vibration in buildings. Guide to damage levels from ground borne vibration (Part 2)
BS 7668:2004	Weldable structural steels. Hot finished structural hollow sections in weather resistant steels. Specification
BS 7671:2011	Requirements for electrical installations
BS 7973-1:2001	Spacers and chairs for steel reinforcement and their Specification. Product performance requirements
BS 7973-2:2001	Spacers and chairs for steel reinforcement and their Specification. Fixing and application of spacers and chairs and tying of reinforcement
BS 7979:2001	Specification for limestone fines for use with Portland cement
BS 8102:2009	Code of practice for protection of below ground structures against water from the ground
BS 8500-1:2006	Concrete - Complementary British Standard to BS EN 206-1. Method of specifying and guidance for the specifier
BS 8500-2:2006	Concrete. Complementary British Standard to BS EN 206-1. Specification for constituent materials and concrete
BS 8666:2005	Scheduling, dimensioning, bending and cutting of steel reinforcement for concrete. Specification

2.5.4 International Standards**Table 5: International Standards**

Codes	Description
ASTM D 1777	Standard Test Method for Thickness
ASTM D 3776	Standard Test Methods for Mass Per Unit Area (Weight) of Fabric
ASTM D 4491a	Standard Test Method for Water permittivity
ASTM D 4751	Standard Test Method for Apparent opening size of a Geotextile
ASTM D 4632	Standard Test Method for Grab Breaking Load and Elongation of Geotextiles
ASTM D 3786	Standard Test Method for Bursting Strength of Textile Fabrics-Diaphragm Bursting Strength Tester Method
ASTM D 4833	Standard Test Method for Index Puncture Resistance of Geomembranes and Related Products
ASTM D 4533	Standard Test Method for Trapezoid Tearing Strength of Geotextiles
ASTM D 4632	Standard Test Method for Grab Breaking Load and Elongation of Geotextiles
ASTM D 4355	Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc Type Apparatus
ASTM D 3787	Standard Test Method for Bursting Strength of Textiles-Constant-Rate-of- Traverse (CRT) Ball Burst Test
ASTM D 4157	Standard Test Method for Abrasion Resistance of Textile Fabrics (Oscillatory Cylinder Method)
EFNARC-1996	European Specification for Sprayed Concrete
ASTM C-39	Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C-78	Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)
ASTM C-94/C	Standard Specification for Ready-Mixed Concrete
ASTM C-172/C	Standard Practice for Sampling Freshly Mixed Concrete
ASTM C-685/C	Standard Specification for Concrete Made by Volumetric Batching and Continuous Mixing
EFNARC Three Point Bending Test on Square Panel with Notch 2011	Testing Sprayed Concrete - Flexural tensile strength of fibre concrete on sprayed test specimen.
Austrian concrete society publications	Guide line on shotcrete and testing methods
Austrian concrete society publications	Inner lining concrete
JSCE -2004	Recommendation for design and construction of steel fibre reinforced concrete, Publications of Japan society of civil Employer's Representatives
DIN 67524 (Part1/02)	Lighting of street tunnels and underpasses
DIN 67524-2008	Tunnel illumination
DIN 5035	Artificial lighting
RABT (2006)	Guidelines for equipment and operation of road tunnels

2.6 Materials

All materials supplied to the Works shall conform to all of the following:

- This Specification.
- The appropriate Indian Standard, if no Indian Regulation is available the corresponding European or British Standard shall be adopted.
- Where an industry certification scheme is available, material shall be supplied in accordance with that scheme.
- Materials shall be supplied from a quality assured source, operating a Quality Assurance system in compliance with the relevant part of BS EN ISO 9001.

Where required in the particular Specification or where stated on the drawings, samples should be supplied, and the subsequent material shall conform to the samples.

Materials used on site shall be used in accordance with the manufacturer's recommendations and instructions.

All materials should be handled and stored in a way to maintain their integrity and to avoid damage and degradation.

Details of the level of inspection and testing to be adopted in respect of supplied materials shall be agreed with the Employer's Representative prior to commencement of work. Individual submissions are then restricted to those required by the Quality System.

2.7 Quality Management and Records

The project shall be administered using an accredited Quality Management System conforming to BS EN ISO 9001. The individual requirements for agreement by the Employer's Representative of materials and workmanship throughout this Specification shall be incorporated into agreed self-certification procedures.

The agreed Quality Control arrangements, including hold points and submission of records for the Employer's Representative's acceptance, shall be set out in agreed Inspection and Test Plans.

References to the agreement of materials, workmanship, methods etc. throughout this Specification shall be interpreted as requiring the agreement of the Employer's Representative.

The Contractor shall maintain all records necessary under this Specification, including quality records as appropriate. Electronic records shall be maintained and backed up on a daily basis to prevent loss of data in the event of failure of electronic data storage.

Copies of all site records shall be available to the Employer's Representative.

The Contractor shall supply the Employer's Representative with all information necessary for the Health and Safety File including as-built drawings and records, maintenance schedules, operation and maintenance manuals, within the time specified in the Contract, after substantial completion of the Works. Information shall be provided in the agreed format. The Health and Safety File shall be prepared by the party identified in the Contract.

3 SITE INSTALLATION

3.1 General

The Contractor shall be responsible for providing all necessary provisions for the execution of the construction works under this Contract. This includes plants, equipment, materials and laboratories.

The Contractor shall design, furnish, install, maintain and operate at the project area all temporary works and equipment such as Contractor's camp, offices, stores, workshops, warehouses, assembly areas, machinery, vehicles, material yards, health and safety measures, electric power, telecommunications, illumination, water supply system, concrete and aggregate processing plants, material testing laboratory, temporary construction roads etc.

28 days prior to commencement of any Works the Contractor shall submit layout plans at adequate scale showing the temporary construction facilities of the Contractor to the Employer's Representative and they shall include:

- the Contractor's camp, offices, parking space, workshop, warehouses and storage areas including explosive magazines
- water supply, electric power supply including illumination and communication system
- sewerage, sewage treatment and disposal
- construction roads
- concrete and material processing plant, cement and aggregate storage
- material testing laboratory
- temporary tunnel ventilation system
- survey plan
- security and safety arrangement plan, medical care services.

3.2 Contractor's Camp

The Contractor shall design, furnish, install, maintain and operate the Contractor's camp at the location and within the designated lines defined by the local Authorities or the Employer's Representative. The Contractor's

camp shall provide the housing, feeding and recreation of the Contractor's employees and those of his subcontractors. The Contractor's camp shall be designed for the maximum number of employees on the site.

All facilities shall be in compliance with the Indian Construction Workers Act 1996 on permanent and temporary housing of employees. Prior to any camp construction the Contractor's drawings and Specifications shall be approved by the Employer's Representative.

The Contractor shall provide additional adequate housings for the Employer's Representative staff.

3.3 Site Office, Stores

The Contractor shall design, furnish, install, maintain and operate all required offices, stores, warehouses and testing laboratories at the location and within the designated lines defined by the local Authorities or the Employer's Representative.

The Contractor shall provide and maintain a fully equipped site office for the Employer's Representative staff on each construction site.

3.4 Lighting & Ventilation during Construction

Lighting and ventilation during construction shall be in compliance with Clause 7.7 and 7.8 in this Specification.

3.5 Electrical Power Supply

3.5.1 General

The Contractor shall be responsible for obtaining an adequate electrical supply for all his Site operations during the whole construction period.

Installations shall comply with IEC 60204 Safety of machinery, electrical equipment of machines and IEC 60364 Electrical installations of buildings.

If so required by the Employer's Representative, the Contractor shall make a copy of all certificates prepared upon completion of electrical installations and prepared for all required periodic checks available.

The Contractor shall appoint a competent person to be solely responsible for ensuring the safety of all temporary electrical equipment on site.

The Contractor is to comply at all times with the Electricity at Work Regulations.

The Contractor shall furnish, install and keep operational throughout the duration of the Works standby generating facilities of such capacity as to be able to maintain minimum services such as illumination, ventilation, water supply, dewatering etc. necessary for the Project Area safety and security during a failure of the primary power source.

Oil filled transformers are not permitted in subsurface usage. Transformers shall be air-cooled and dry type.

Electrical heaters or radiators having exposed coils or elements shall not be permitted underground.

The lighting circuits shall be separated from the other sub-circuits.

The Contractor shall furnish, operate and maintain 100% standby diesel-driven generators or alternative source of power supply at each working portal. The generators or alternative supply shall be capable of operating the lighting system and the pumps required to flooding of the underground works besides operating all other systems so to allow the work function smoothly in event of main power system failure. The generators shall be tested by the Contractor weekly to ensure the full working capability.

Drawings showing the design of the electrical power distribution system within each area shall be submitted to the Employer's Representative for approval at least 28 days prior to installation. This shall at least include a single line diagram for the distribution systems within each area, protection schemes for the systems and description of the operation concept. The installation of the electrical distribution systems shall not be started unless the Employer's Representative has approved the submitted documents.

The client or representative of the client shall be allowed to access always all facilities of the construction site.

3.5.2 Earthing

All light fittings, electrical equipment and appliances shall be earthed electrically, and the Contractor's specialized personnel shall periodically check the effectiveness of such earthing. The earthing shall meet the requirements for plant and equipment given by Indian Standard 3043.

3.5.3 Cables

All exposed electrical cables installed within the tunnel shall comply with the following requirements:

- Flame retarding properties to IEEE 383,
- Toxicity level Acid evolution when burned 7%
- Flame propagation Oxygen index value 30% minimum
- Smoke density rating: 35% maximum

Supply cables at 3.3 kV or below shall be 3-core with the armouring used as the earth return in conditions where the cable is not subject to continues movement after installation or where the supply is to be a fixed point.

For supply to mobile or transportable equipment, where operation of the equipment subjects the cable to flexure, cables shall be sheathed in flame retardant LSFH.

3.6 Site Communication

The Contractor shall provide a suitable system for communication between the underground work site and workstations outside the tunnel and maintain such system in working order at all times. An underground station (including telephone socket with bell and indicator) shall always be within 50 m of the point where major work is being carried out and at 200 m intervals along the driven tunnel.

3.7 Water Supply

The Contractor shall provide water that is adequate for year-round use in his camps as well as for general construction use.

The Contractor shall furnish, install, operate and maintain all necessary equipment including pumps, piping, fittings, valves, storage tanks and disinfection for the water supply and distribution systems.

Special measures during low temperature periods shall be taken such as heating or thermal insulation of pipes to avoid freezing of water.

3.8 Concrete and Material Processing Plant

At each construction site, the Contractor shall install and erect all required materials processing plants of sufficient capacity to meet his planned peak requirements during construction. The plants shall be subject to approval by the Employer's Representative. All control and measuring shall be regularly serviced and calibrated.

The following plants shall be installed but not limited to:

- concrete aggregates processing plant (crushing and screening);
- concrete plant (batching and mixing);
- grouting plant

3.9 Testing Laboratory

The Contractor shall install, equip and maintain an adequate field laboratory for the sampling and testing of materials such as concrete, earth or any other materials as specified herein.

The laboratory shall be adequately lit, supplied with sufficient electrical power, water and heating. Adequate space for testing devices and storage areas shall be provided.

The equipment to be supplied and the methods of testing shall be in accordance with the referenced Standards in these Specifications. The proposed type and number of items of laboratory equipment shall be presented to the Employer's Representative and approved prior to purchase.

All facilities and services shall be available to the Employer's Representative as required. All sampling and testing to be undertaken shall be subject to the supervision of the Employer's Representative. The laboratory shall be run by Contractor's personnel experienced in sampling and testing of materials and be subject to quality control.

Specialised testing which may be required, and which cannot be performed in the Contractor's laboratory due to lack of time or equipment shall be assigned by the Contractor to an independent organisation approved by the Employer's Representative. The Contractor shall accept all test results and all instructions or restrictions

stipulated by the Employer's Representative based on such tests.

3.10 Removal

The Contractor's Camp shall be dismantled and removed subsequently to completion of the Works by the Contractor, unless otherwise specified or directed by the Employer's Representative.

All temporary installations must be completely removed after finalization of the relevant works. Rubbish, waste, debris and material must be removed.

Any disturbed area that will not be taken over for permanent use shall be restored at the completion of the Works to the original appearance as far as possible.

4 WORKING ENVIRONMENTS

4.1 Health, Safety and Welfare

The Contractor shall adopt safe systems of work which minimise the risk to health and safety. All persons working on the site shall be competent to carry out their tasks and duties safely and in a manner that will endanger neither their own health nor the health of others. Persons, who are employed on the site for the first time, shall be subject to appropriate pre-employment occupational health checks, instructed on the hazards inherent in the site, precautions to be taken, the form of construction, and emergency procedures and fire safety. Such instructions shall be given whenever there is a material change in the working arrangements. The Contractor shall maintain a record of all persons instructed and each person shall be required to sign such record confirming that instruction has been received. No person shall be permitted on site without being inducted as set out above. The Contractor shall prepare a written statement of Safe Systems of Working which shall be issued to all persons at site.

All parties shall comply with the requirements and recommendations of BS 6164, BS EN 815, BS EN 12336, BS EN 12110, BS EN 12111 and BS 7671.

The Contractor shall also comply with the requirements of the Employer's codes of practice for safe working and those of any authority or body where their services or property are affected by the works.

A person responsible for Safety shall be appointed by the Contractor and this person shall be conversant with corporate policy, management operational instructions, regulations, legislation and current best practice and how these relate to health, safety and welfare. Compliance with health and safety requirements is the responsibility of managers and individuals at each and every level.

The Contractor shall establish on site:

- Welfare and first aid facilities with appropriately trained personnel, both on the surface and underground, as required by the scale of the Works. Welfare facilities shall include toilet and washing facilities. Where water washing facilities cannot be provided, appropriate alternative means of hand cleaning shall be provided. Barrier creams etc. for skin protection shall also be provided.
- Occupational health facilities on the surface, staffed by appropriate occupational health professionals as required by the nature and scale of the Works.
- Equipment for the rescue and evacuation of persons underground with persons instructed in its use.
- All necessary equipment, safety barriers, notices and the like for the protection of persons.
- Procedures to ensure that all plant and equipment underground is fitted with on-board fixed fire-extinguishing equipment covering fluid tanks, motors or engine compartments and tyres along with the use of reduced flammability (HFDU) hydraulic fluid.
- Comprehensive fire detection and firefighting facilities.
- Sufficient chemical or compressed oxygen self-rescuer sets for all persons underground in accordance with HSE guidance.
- A competent safety officer shall be appointed by the Contractor who shall be conversant with the hazards associated with the form of construction to be undertaken and who shall be responsible for ensuring compliance with all management directives, rules and regulations concerning occupational health and safety.
- Subject to any legal requirement or requirement of the Employer and the size and nature of the Works, the Contractor may appoint a visiting competent safety officer under item above. He shall visit the site at the

start of operations and for changes in methods of working, but in any event his visits shall not be at greater intervals than one month.

4.2 Noise & Vibration

4.2.1 General

The Contractor shall minimise occupational exposure to noise and vibration, the amount of noise emitted to the environment and the environmental vibration levels generated by his work activity.

The Contractor shall select and utilise methods of working and items of plant and control in his Works so as to minimise noise and vibration levels, including occupational noise and vibration exposure of the workforce, and not to exceed maximum permitted noise and vibration levels specified in the Contract or defined by local Authorities.

The adherence to any vibration levels specified in the Contract does not relieve the Contractor of his obligations with respect to structural or other property damage.

4.2.2 Temporary Fencing and Barriers

Where required the Contractor shall erect and maintain throughout the construction period temporary fencing of appropriate height taking account of the need for this fencing to act as a noise barrier around all working areas. The fencing shall be dismantled and re-erected as the progress of the Works requires.

The line of the fencing shall be uniform, and the exterior face of the fencing shall be treated with a durable finish. Where required, in order to prevent reflection of noise, the Contractor shall line the inside of fencing with sound-absorbent material with accepted acoustic absorption properties. The material shall be fire and water resistant.

Local fencing barriers or shelters shall be erected as necessary to shield particular activities, such as those involving the use of pneumatic or hydraulic techniques, and all stationary plant.

4.2.3 Plant & Equipment

The Contractor shall select and use plant, equipment and working practices which minimise occupational exposure to noise and vibration and minimise emissions of noise and vibration to the environment.

All plant shall be properly maintained, and relevant service records completed. All plant shall be provided with effective silencers and vibration-dampening devices and shall be operated according to the manufacturer's recommendations in such a manner as to avoid causing any excessive noise emission or vibration. The noise emitted by an item of plant shall not exceed the relevant values quoted in the Contract or defined by local Authorities.

4.2.4 Noise & Vibration Monitoring

Where monitoring is required the Contractor shall provide, calibrate, operate according to the manufacturer's recommendations appropriate equipment for monitoring construction noise and vibration throughout the construction period.

The Contractor shall arrange for adequate standby equipment.

The Contractor shall notify the Employer's Representative immediately whenever the specified noise or vibration limit has been exceeded, and agree measures to avoid repetition.

Any items of plant causing excessive noise or vibration levels shall be removed from the site and substituted by alternative compliant equipment.

The Employer's Representative may instruct the Contractor to devise and use an alternative process if a construction method is causing unnecessary disturbance.

4.3 Access & Egress

The Contractor shall make all arrangements and assume full responsibility for transportation to the Site of all construction plant, materials and supplies needed for the proper execution of the Works.

Where designated access routes are indicated in the Contract, the Contractor shall use no other without the agreement of the Employer's Representative.

4.3.1 Maintenance of Routes

All public and private highways and roads which are being used by the Contractor's, Subcontractors' or

Suppliers' vehicles for the construction of the Works shall be kept clean and free of dirt and mud arising from the Works. The Contractor, unless otherwise provided for in the Contract, shall provide, maintain and use as necessary suitable equipment including mechanical road sweepers, throughout the course of the Works where and as agreed with the highway authority.

The Contractor shall provide, maintain and use mechanical wheel washers and high-pressure hosing facilities at work sites and at such additional locations as required under the Contract.

The Contractor shall be responsible for all maintenance in all respects of all site roads.

Any area of public highway which is closed because of the Works shall not be reopened until appropriate safety and traffic management measures have been completed and until the Employer's Representative confirms that it is in a suitable condition for use by the public.

The Contractor shall protect the public from the Works by secure fencing and gates and shall control access through the gates as required under the Contract.

4.3.2 Access for Others

The Contractor shall always meet the full requirements for access for fire, ambulance and other emergency services and maintain liaison with them in that respect.

The Contractor shall always maintain access for the authorised representatives of utility providers and allow emergency operations to be carried out on any utility or service facilities within the Site.

The Contractor shall not use public or private rights of way for depositing or storing plant or materials. The Contractor shall maintain those parts of the public or private rights of way not temporarily occupied by the Works in a clean, passable and safe condition always.

The Contractor shall execute the Works in such a manner that safe pedestrian access, including disabled person access, to all properties is always maintained.

Unless otherwise provided in the Contract, methods of construction and programming of the Works shall be such that vehicular access to properties affected by the Works is not restricted.

4.3.3 Traffic Safety and Management

Where work is carried out on or adjacent to a trafficked highway the Contractor shall ensure that personnel shall, always, wear high-visibility fluorescent garments which shall comply with BS EN 471.

All proposals, details, execution, maintenance, removal and necessary reinstatement associated with traffic safety and management and temporary decking and other temporary structures on, or subways beneath, the highway shall be subject to the approval of the appropriate authorities. The Contractor shall supply all information required, for consultation with the appropriate authorities including the local authority, police and other authorities with jurisdiction or interest.

The Contractor shall agree a traffic management plan with the Employer's Representative based on consultation and agreement with highway authorities. This shall show the scheme of traffic safety and management measures including the provision of safety zones and traffic signing. The plan shall include the requirements of emergency services for access into and through the site.

Fenced storage areas, gantries, loading bays, skips and other temporary structures on the public highway shall be provided and maintained to the conditions of a licence issued by the local authority.

All traffic safety and management measures necessitated by the Works shall be fully operational before the Contractor commences any work which affects the public highway.

The Contractor shall devise and put into effect traffic management procedures, including appropriate speed limits, within the site including on haul roads and temporary access roads, which are to an equivalent standard to those for a public highway unless directed otherwise by the Employer's Representative.

4.3.4 Signing, Signalling & Lighting

The Contractor shall provide suitable entry and exit signs, at the points of access to and from the site, for vehicles and plant engaged on the Works. As far as possible, vehicles and plant shall enter and exit the site in a forward direction.

Unless otherwise specified, the Contractor shall make all necessary arrangements including notices to relevant authorities for the provision, erection, maintenance, repositioning, covering and uncovering and final removal of all traffic signs as the progress of the Works requires.

The Contractor shall devise and put into operation traffic management arrangements to separate pedestrian and vehicular traffic. Pedestrian access shall be clearly signed and provided with barriers of adequate strength.

The temporary traffic Contractor shall be responsible for the design, provision and maintenance of all signals and associated equipment unless otherwise given in the Contract.

Where required during the execution of the Works, the Contractor shall provide and maintain temporary lighting for the highways. Temporary lighting shall provide the same level of illumination as that of the existing street lighting, which it replaces. Temporary lighting shall be provided and approved prior to the removal of any existing street lighting.

4.3.5 Survey & Reinstatement

Prior to commencing the Works, the Contractor shall carry out a condition survey of all roads and footways adjacent to the site. The survey record shall be available to the Contractor.

Unless stated otherwise, the Contractor shall reinstate all roads and footways affected by the Works to the extent, lines and levels that existed prior to the commencement of the Works and to standards that are at least equivalent to those that existed prior to the commencement of the Works.

Unless stated otherwise, the Contractor shall reinstate all surface water drainage systems (including but not restricted to gullies, channels, catch pits, pipe runs, manholes and covers and the like) affected by the Works. The Standard of reinstatement shall be at least equivalent to that existing prior to the Contract commencing.

4.3.6 Access within Works

The Contractor shall provide safe access in and about, the site and underground workings.

All shafts shall have a ladder access in addition to any mechanical means.

The Contractor shall always provide a safe designated pedestrian access in the tunnel and throughout the site area. This shall have a firm, level, slip-resistant and continuous surface and shall be suitable for use in emergencies when lighting may be unavailable.

The Contractor shall segregate pedestrian and vehicular access routes.

The Contractor shall always maintain a clear means of egress from each tunnel face. Such means of egress through or past equipment, trains and similar obstructions shall meet the minimum dimensions in BS EN 12336.

The Contractor shall establish, maintain and operate a system whereby the presence of personnel underground is recorded, together with their location where appropriate.

4.4 Disposal of Spoil & Water

The Contractor shall prepare a Site Waste Management Plan (SWMP), which sets out in detail how spoil and all waste is to be categorised, disposed of and monitored, the programme for disposal and how legislation is to be complied with. This plan will address all waste matters at the site and have specific documented mechanisms for adopting a 'reduce, reuse, recycle' approach to waste minimisation for dealing with all wastes. The SWMP will be reviewed by the Employer's Representative and accepted or approved as required by the Contract.

4.4.1 Solid Waste Disposal

The Contractor shall remove all excavated material, spoil, surplus materials and rubbish from whatever source on site and shall, except where otherwise specified in the Contract, make his own arrangements for their disposal and provide all thenecessary facilities to achieve this. The Contractor shall also comply with any legal or local authority requirements applying to the handling and disposal of any contaminated spoil.

The Contractor shall set up a system to control and monitor the transport of spoil from site to the tip site, in accordance with the current legislation and requirements of the local Authorities. The system shall be agreed with the Employer's Representative and will provide evidence that each load has been deposited at a licensed tip site.

The Contractor shall retain auditable records of waste removed from site. Waste Transfer Notices should be collated and submitted to the Employer's Representative. Transfer and Consignment notes shall be kept in the site file.

The Contractor shall comply with all statutes and statutory instruments relating to spoil disposal.

4.4.2 Liquid Waste Disposal

Before discharging any surplus water, the Contractor shall obtain the prior approval of the owner of the sewer

or water-course and of the Environment Agency.

The Contractor shall ensure that the condition of any discharged water complies with permitted limits. The parameters to be monitored include pH values, temperature and suspended solids.

5 DEWATERING ARRANGEMENT

5.1 General

The Contractor shall design, furnish, maintain and remove temporary works for protecting the Works under construction against flood flows in rivers and creeks, and design, furnish, operate, maintain and dismantle the temporary dewatering facilities required to remove water from construction activities and from natural surface flow or groundwater seepage from working areas on the surface as well as in the tunnel.

The Contractor's working methods and systems shall be designed to control ground and surface water to permit the construction of shafts, tunnels, breakouts and portal structures.

Where dewatering operations are used they shall be kept to the minimum necessary for the execution of the Works. If, at any time, during construction, the inflow of water increases more than the installed pumping capacity, the Contractor shall be required to install additional pumping facilities and perform additional sealing as required by the Employer's Representative. The dewatering system shall include a system for identifying ingress of soil material during the dewatering operation.

In planning temporary pumping systems, the Contractor shall take due consideration of water quality, pressure, quantity and variations in water levels.

Settlement ponds and other measures shall be provided so as to ensure that potentially contaminated or polluted matter from the execution of the Works is nowhere released into creeks, rivers or the ground.

The Contractor will be held responsible for all damage caused by his dewatering procedures or the lack of such, and he shall reinstate or repair disturbed ground or structures to their original condition or as otherwise approved.

Plant shall be delivered to site and maintained in good working order. Plant and pipe work shall be fitted with appropriate valves, controls and gauges. Each dewatering well shall be capable of individual adjustment and being shut down and isolated from the rest of the system. Appropriate standby equipment and spares shall be maintained on site at all time.

5.2 Construction Site

The Contractor shall perform all works necessary to drain the surface construction sites of rain, groundwater and service water. The work shall include, but not be limited to the following:

- design and construction of drainage, ditches, pits, pump sumps and settlement ponds with oil separators
- design, furnish, operate and maintain dewatering equipment and conduits
- relocation of dewatering facilities required for the performance of other works
- diversion of creeks where required by construction of any permanent or temporary structure, including spoil and stockpile areas
- all auxiliary work required for the safe and continuous dewatering of the surface construction sites

The Contractor shall perform all work necessary to collect and drain construction water and infiltrating groundwater, convey it to main conduits and convey it out from tunnel work to discharge points. The work shall include, but not be limited to, the following:

- design and construct pits, trenches and drainage measures along the tunnel invert
- design, furnish, operate and maintain dewatering equipment (including pumps and power supply) and conduits
- relocate dewatering facilities as required for the unhindered performance of the tunnel work
- design, construct and operate settlement ponds, with oil separators, at the portals or elsewhere, with discharge into creeks and rivers, as approved
- all auxiliary work required for the safe and continuous dewatering of the underground working areas

The Contractor shall design and install complete facilities for the drainage of the temporary and permanent

portal areas and the muck disposal areas.

Drainage ditches shall be excavated along the top of excavated slopes and on the berms. Such ditches shall be kept well back from the excavation edges. In loose materials the ditches shall be lined with concrete or with rock paving set in mortar immediately after completion of excavation. The ditches shall be regularly cleaned out of accumulated silt and other matter so that water may flow freely at all times.

Rivers, creeks and intermittent streams in the vicinity of temporary or permanent works shall be diverted into culverts of lined ditches. Erosion must be prevented. Sediment laden water must be diverted through settling ponds or basins according to the environmental regulations.

5.3 Tunnel

The Contractor shall perform all necessary works to collect and drain construction and ground water in all tunnel drifts at all headings. All required drainage measures including collection and pumping of any ground water in inclined tunnel drifts must be included in the given prices. The water shall be drained out of the tunnel with minimum impact on ground stability and construction works. This includes, but not limited to:

- pits, trenches and drainage along the tunnel floor
- dewatering equipment including pumps
- pipes along tunnel side wall
- collecting local inflows directly from tunnel perimeter before and after installation of primary support
- collect inflowing water with dimpled sheets along the tunnel perimeter
- settlement ponds or basins with oil separators before discharge into rivers

Mountain water due to tunnel construction shall be collected and drained. Excavation areas shall be drained of all construction water and ground water. Water appearing at the face shall be drained to the longitudinal drainage system as soon as possible.

Dewatering arrangement must be considered for falling and rising gradient of the excavation, a softening and damaging of the bench shall be avoided. The water drainage length shall be kept at a minimum. In case of falling gradient temporary pump sumps must be max 5m behind the excavation face (top heading, bench, temporary and permanent invert).

The Contractor shall provide adequate pumping capacity where required, including a sufficient number of standby pumping units and standby power, to handle all water entering any portion of the tunnel works. These units shall be connected to the power supply and dewatering systems in such a way that proper and uninterrupted drainage will be ensured throughout the construction period.

Heavy mountain water may occur and therefore additional drainage system to the longitudinal drainage system may be required. In such zones systematic drainage drillings ahead of the tunnel face may be required and ordered by the Employer's Representative.

If required, drainage drillings (placement, direction and length according to local conditions) shall be constructed with no delay. Instrumentation, for measuring the pore pressure, may be required by the Employer's Representative.

In tunnel sections with ground material sensitive to water (softening or swelling ground condition) particular care has to be taken concerning water drainage. The inflowing water shall be collected as soon as possible and conveyed in pipes not to allow contact to the tunnel floor. Construction water must be reduced to a minimum and collected and pumped immediately into pipes.

Water entering a working face from another part of the tunnel must be deviated not to affect construction works such as bench/invert excavation or concreting.

Unless otherwise specified, all water emanating from the tunnel excavation shall be discharged into settlement ponds, designed so as to meet the requirements of the prevailing Indian regulations. The outflow from each settlement pond shall be arranged in a way to prevent any oil from leaving the pond irrespective of the volume of water entering the pond.

Dimpled sheet membrane shall be of HDPE with a sheet thickness of 1.0 mm. The drainage capacity shall be 10 l/s/m. The compressive strength shall be 150 kN/m².

Strip drains shall consist of dimpled sheet membrane as defined above, wrapped in a nonwoven het bonded

geotextile. The geotextile shall comply with Clause 12.2.

5.4 Measurement and Monitoring

The Contractor shall install, operate, maintain and relocate the necessary devices for flow measurements. These measuring devices shall be checked and approved by the Employer's Representative before usage.

Gauging stations shall be installed, and measurement of the total discharge shall be made as follows:

- Heading Zone: Measurement shall be performed during excavation and supporting work at a point not less than 50 m and not more than 100 m behind the heading face. Transfer of the measuring station in drill and blast advances shall be done in 100 m steps or as approved by the Employer's Representative.
- Rear Zone: Flow measurements at the portal or at the outlet of installed pump lines shall be performed during the entire excavation and supporting work.

Measurement of water flow shall be performed once a day jointly by the Employer's Representative and the Contractor or as otherwise agreed upon.

All pumping rates must be recorded and the Contractor shall keep full and detailed records of all monitoring carried out. Copies of such records shall be available to the Employer's Representative.

The Contractor shall monitor all springs and wells which may be influenced by the lowering of the ground and mountain water table due to the tunnel construction. The zero readings must be done prior to any excavation.

5.5 Final Tunnel Dewatering Arrangement

5.5.1 Ground Water

A minimum gradient of 0.5% of the drainage pipes shall be provided in each tunnel cross section.

If not otherwise specified by the detailed design drawings or the Employer's Representative, the following ground water drainage pipes with the given diameters shall be installed at the lines given in the detailed design drawings.

- Side wall drainage: ≥ 250 mm
- Sub-base drainage: ≥ 150 mm
- Ground water collecting pipe: ≥ 400 mm

Perforated pipes shall be made of slotted Polypropylene (PP) or polyvinyl chloride (PVC) or any other equivalent material in agreement with the Employer's Representative. The upper section of the pipe shall be longitudinal corrugated and slotted, with the bottom section closed. The width of slots shall not exceed 1.0 mm. The total area of the slots for water intake shall exceed 50 cm² per metre length of pipe.

The bedding shall consist of dry lean concrete in compliance with Clause 10.2.

The pipe shall be embedded in no-fines concrete in compliance with Clause 10.3.

5.5.2 Carriageway Water

The carriageway water shall be collected and drained in a separate drainage system.

The collection shall be continuous by a slot channel or punctual with a minimum interval of 65 m. Slot channels shall be made of water impermeable concrete with plastic fibre reinforcement.

The slot channel diameter shall be minimum 250 mm. A minimum longitudinal gradient of 0.5% shall be provided.

6 OPEN EXCAVATION

6.1 General

In these specifications, the following works are covered:

- surface excavation in soil or rock (Cut) for the temporary and permanent tunnel
- portals, the tunnel portal structures, control building, muck dump areas, ditches, drains,
- surface fill (Fill) with soil and rock material for the platform of the tunnel portal structures and buildings, muck dump areas or roads,
- erosion protection of embankment slopes with gabions, mattresses, rip-rap, etc.

- sub surface drainage
- backfill of structures
- water proofing of structures before refill

The existing ground surface area below which open excavation is required shall be cleared of trees, brushes, shrubs, embedded logs, fallen timber and surface litter and shall be grubbed of vegetation, roots and stumps. Cleared and grubbed material shall be disposed of in the designated spoil disposal areas.

No unexcavated material is permitted inside the design lines of the excavation.

14 days prior to commencement of any surface excavation the Contractor shall submit all detailed drawings and/or descriptions of his proposed excavation methods, sequences and equipment to the Employer's Representative for approval.

28 days prior to dumping of any spoil, the Contractor shall submit all detailed drawings and/or descriptions of his proposed method for laying, compacting and protection against erosion of the muck dump material including information of dumping sequences and equipment. The muck dump areas shall be within the areas so designated by the Local Authorities or the Employer's Representative and in compliance with Clause 4.4.1.

At least 28 days prior to placing of any fill material, the Contractor shall submit detailed drawing and/or descriptions of the construction procedure, mixing, treatment and compaction procedures, topsoiling, slope stabilisation and surface erosion protection, and other completion works for approval, for construction of embankments. All data of working methods, equipment and provisions for the stability of the construction as well as temporary and permanent drainage of these areas shall be included. Details of volumes, material types, heights and grades shall be provided.

The Contractor shall forward information of the progress of surface excavation including information on excavated volumes, ground type, ground support installed, water inflows and difficulties encountered to the Employer's Representative at an interval in agreement with the Employer's Representative.

6.2 Standards

Open excavation works shall be in compliance with the following Standards and Guidelines unless otherwise defined in these Specifications.

- Specification for Road and Bridge Works (Fifth Revision) printed in April 2013 issued by MoSRT&H and published by IRC.
- IS 2720: Methods of test for soils — applicable parts
- IS 4532: Method of test for stabilized soils
- ASTM D3282: Classification of soils and soil-aggregates mixtures for highway construction purposes
- Eurocode 7: Geotechnical design

6.3 Cut

The excavation requirements and limits shown on the drawings have been established on the basis of the results of subsurface exploration by the Designer. The Employer's Representative will examine the conditions exposed at the actual excavated surfaces and, if the conditions are deemed unacceptable for the intended purpose, will relocate the excavation design lines locally outside of the excavation design lines shown on the Drawings.

If, in the opinion of the Employer's Representative, the necessity for excavation outside of the excavation design lines has been caused by negligence on the part of the Contractor or by ineffective executed excavating or blasting operations by the Contractor, the volume of additional excavation shall be backfilled with concrete or other material as required by the Employer's Representative. Such additional excavation and backfilling shall be done at no additional cost to the Employer.

Unclassified material and rock excavated outside of the excavation design lines for the Contractor's own purposes shall be replaced with concrete or other material as required by the Employer's Representative. Such additional excavation and backfilling shall be done at no additional cost to the Employer.

All initial support measures as given in the detailed design drawings or directed by the Employer's Representative e.g. sprayed concrete, pre-stressed anchors, wire mesh etc. shall be in compliance with Clause 9 of this Specification.

The Contractor shall draw his own conclusions from site inspection, from the logs of rock cores, test pits, test

trenches, test tunnels, test chambers and surface exposures and from other site investigation data made available to the Contractor, as to the excavation method that will be best suited for the satisfactory removal of materials to be excavated and as to the behaviour of unclassified material and rock in situ, during and after excavation.

Excavation shall include all items of work, equipment, facilities and material with respect to the proper excavation as specified, including mucking, dumping and transport of excavated materials in stockpile or disposal areas approved by the Local Authorities.

The Contractor shall apply, as approved by the Employer's Representative, excavating, drilling and blasting techniques, which will produce a smooth final profile, i.e. smooth blasting resulting in minimum over break as well as - minimum detrimental effect beyond the design lines for excavation in compliance with Clause 7.3.3. Explosives and detonating systems shall be used by the Contractor to produce a smooth final excavated surface.

The Contractor shall adopt excavation procedures such that the stability of surfaces in open excavations is not impaired. The Contractor shall be responsible for the stability and safety of all excavations until final acceptance of the Works and shall install such instrumentation in the excavations, in addition to the instrumentation required by the Employer's Representative, that the Contractor considers necessary to measure deformation and to establish that unstable conditions do not develop. The Contractor shall execute all remedial work required in excavations to ensure that the excavated surfaces are maintained in a sound and stable condition. The Contractor shall submit to the Employer's Representative all readings taken the instruments he installs not more than 1 working day after taking the readings.

During excavation, and at any time during the Work, all material which is unsafe or appears to endanger persons, the Works or the property of others, shall be immediately scaled and removed from the excavations. The fact that such scaling and removal may enlarge the excavation beyond the excavation pay lines shall not relieve the Contractor from the necessity of doing such scaling and removal of such materials. If it is not possible to remove loose rock by normal barring and wedging, then rock support, shotcrete or chain link mesh or any combinations of each, shall be applied to secure and prevent the loose rock from falling or becoming unstable.

Notwithstanding the provisions specified herein, the Employer's Representative may require the Contractor to take such action as the Employer's Representative deems necessary to assure the safety of the excavations and the Contractor shall immediately comply with such requirements. Nothing in these Specifications shall be construed to relieve the Contractor from the sole responsibility for safety.

If drilling and blasting operations is required, these shall be carried out in such way that they do not interfere with the work of others nor cause any damage to adjacent structures.

Snow and ice shall be removed when necessary to ensure the safe and effective performance of the Work.

If slides occur in excavated slopes, all materials affected shall be excavated and removed to the designated spoil disposal areas. The slopes shall then be further excavated to a safe, stable and neat condition or to the lines, slopes, dimensions and elevations required by the Employer's Representative. If, in the opinion of the Employer's Representative, any slide was caused by negligence on the part of the Contractor, all remedial work shall be done at no additional cost to the Employer.

The Contractor's excavation operations and schedule shall allow for interruption while the geological conditions exposed at the excavated rock surfaces are mapped and assessed by the Employer's Representative. Local areas shall be cleaned off where required by the Employer's Representative to expose a fresh undisturbed surface. Such interruption and assistance shall be at no additional cost to the Employer.

Construction traffic shall only be routed over suitably protected parts of the excavated surfaces.

6.4 Excavation Classification

Surface excavation shall be classified according to the excavation method as:

- Loose excavation
- Rock excavation

Loose excavation means all excavation which may be performed without continuous and systematic drilling and blasting. Clearing and grabbing of trees, shrubs and plants, stockpiling of topsoil layer, digging, ripping and occasional blasting may be required.

Rock excavation means excavation which requires continuous and systematic drilling and blasting for loosening, including measures for smooth blasting methods. The Contractor shall solely adapt blasting hole

diameters, distance, charging and detonating delay of holes to form a smooth, sound surface along the excavation design lines. The distance between blasting holes shall not exceed 10 times of the blasting hole diameter.

6.5 Excavation Material Disposal

The disposal of excavation material shall be in accordance to Clause 4.4.1 of this Specification.

Excavation material suitable to be utilised in the Works shall be stockpiled separately from materials to be disposed. The use of excavation material in the Works shall be in agreement with the Employer's Representative.

Suitable materials shall, wherever possible, be transported directly from the required excavation to the various designated final locations.

Excavated materials, not suitable for or in excess of the construction requirements, shall be disposed of in spoil areas designated by the Local Authorities or the Employer's Representative. Unless otherwise provided for, spoil areas shall be built up in layers, with a maximum layer thickness of 0.6 m, and evenly compacted by the traffic of the construction equipment, aimed at minimizing future differential settlement. Final sloping and shaping of surfaces shall be as indicated on the Drawings. Other details of the work such as stabilisation and drainage measures are shown on the Drawings.

All activity by the Contractor at spoils areas shall be confined to the limits designated by the Local Authorities or the Employer's Representative. The limits shall be clearly marked and, where directed barricaded to prevent traffic in areas outside the limits.

6.6 Fill and Embankment

The Contractor shall construct all compacted earthfill or rockfill embankment as shown on the Drawings or as otherwise directed by the Employer's Representative.

This work shall include such work as selection of suitable material, transporting, spreading, adjusting moisture content, compacting to specified minimum dry density and completion in all respects, all in accordance with this Specification.

The embankment shall extend to the design lines as given in the drawings.

All permanent and long term temporary slopes shall generally be stabilised and erosion protected by planting of vegetation and greens similar to the typical local vegetation of the area. Additional measures such as bolts, anchors, shotcrete for cut slopes or gabions, rip-rap, geo-textile for embankment slopes must be applied as designed or ordered by the Employer's Representative.

The Contractor shall construct all sub-surface drainage measures in cuts or embankments as shown on the Drawings or as otherwise directed by the Employer's Representative. This work shall include such work as excavation, selection of suitable material, transporting, placing, and completion in all respects, all in accordance with this Specification.

The material beneath the road sub-base shall have CBR values. The testing procedure shall be in accordance to AASHTO T193 and fulfil the requirements shown in the detailed design drawings and Indian Standards.

Trees, shrubs, grass, humus/topsoil shall be removed from the existing ground surface and stockpiled for later reinstatement if required by the Employer's Representative prior to any placing of embankment.

The prepared surface shall be benched in vertical and horizontal cuts to provide a shear key with the embankment material.

The material of the embankment shall be placed and compacted layers with a thickness not exceeding 300 mm loose before compaction.

The moisture content of the material to be compacted shall be as wet or just wetter than optimum moisture content determined by laboratory testing.

All embankment material shall be compacted to a dry density not less than 95 per cent of the maximum laboratory dry density in accordance with IS 2720, Part 8.

6.7 Back Fill

Backfill shall be placed to the specified type of the lines, grades and dimensions in the locations shown on the

detailed design drawings by the Contractor or directed by the Employer's Representative.

All material proposed by the Contractor to be used as backfill shall be approved by the Employer's Representative prior to any placing of backfill material. The material to be used as backfill shall be as far as possible obtained from required excavation for Underground Excavation Works.

Backfill material shall be homogeneous without layers, pockets and lenses and may not consist of any organic component. Each load of material shall be distributed well and operation of equipment shall be restricted in the area near permanent structures to avoid any kind of damage. The Employer's Representative may reject full loads of backfill material that contain unacceptable percentage of organic component.

Backfilling may not be done before reaching full load capacity of adjacent structures and only after approval of Employer's Representative. The placing of the backfill shall be done simultaneously and with similar method, procedure and material at the different sides of a structure to avoid differential earth pressure. The work may not be done at low temperatures and frozen backfill material is not permitted.

Back fill material shall consist of well graded granular material containing 35% or less by weight passing a 0.075 mm sieve, as specified in ASTM D3282 and with a maximum particle size of 300mm.

Back fill material shall be placed and compacted layers with a thickness not exceeding 300 mm loose before compaction and shall be compacted to a dry density not less than 95 per cent of the maximum laboratory dry density in accordance with IS 2720, Part 8.

The moisture content of the material to be compacted shall be as wet or just wetter than optimum moisture content determined by laboratory testing.

Backfill material shall be tested every 300 m³ or 600 m² or 1 test per shift, whichever is less, or as directed by the Employer's Representative. Proctor test procedures shall be done in random backfill and impervious backfill; whereas the relative density testing of IS: 2720 shall be done for free-draining backfill.

6.8 Gabions

The foundation for each gabion and mattress shall be prepared by the Contractor to the satisfaction of the Engineer. Irregularities in the foundation shall be excavated or tightly filled with gravel to produce a surface which has no protrusions or cavities in excess of 100 mm and the surface shall be covered with a geotextile fabric.

Gabions and mattresses shall consist of double twisted woven mesh gabions with coated, polymer sheathed wires or equivalent in agreement with the Employer's Representative.

The construction working procedures of gabions and mattresses shall be in compliance with the manufacturer's recommendations and instructions.

6.9 Rip-Rap Layers

Rip-rap layers shall be furnished and placed by the Contractor on permanent embankments as erosion protection layer as shown on the detailed design drawings of as directed by the Employer's Representative.

Prior to any placing of rip-rap layers the source of the material shall be approved by the Employer's Representative. Rip-rap material shall consist of hard, dense and durable rock. Material from Underground Excavation Works may be used.

The minimum rock size shall not be less than 500 mm and shall not be greater than that which can be encompassed in the specified layer thickness.

Rip-rap layers shall not be placed on earth, gravel or weathered rock foundation when not agreed with the Employer's Representative. When the underground is not suitable for bedding of rip-rap layers, the rip-rap shall be placed on a 300 mm thick continuous layer of gravel, sand or rock fragments in agreement with the Employer's Representative.

6.10 Water Proofing Membrane

The water proofing membrane shall cover all backfilled structures from water and moisture and is similar to the tunnel water proofing membrane as specified in 12.5.

7 UNDERGROUND EXCAVATION

7.1 General

The Contractor shall be responsible for the safety and security of excavations at all times during the execution

of the Contract.

The geological/geotechnical information presented in the tender documents represents the state of knowledge of the geological/geotechnical conditions along the tunnel alignment based on available information at this stage.

Tunnel works to be executed are based on the New Austrian Tunnelling Method, hereafter referred to as NATM, with observance of all principles related to the application of this method.

Mechanised techniques for excavation shall be used wherever practicable to eliminate or reduce health and safety risks.

The excavation material shall be classified in compliance with Clause 6.4 of this Specification. Different and adequate excavation methods shall be considered for rock excavation and loose excavation by the Contractor.

A detailed description, defined by the Contractor, of all excavation methods including equipment, location of headings, benches and pilot tunnels, drilling and blasting, controlled perimeter blasting, ripping, mucking, loading, hauling, temporary support systems, scaling, ventilation, lighting, pumping, safety measures, schedules, excavation cycles, simultaneous working of faces and sequence of operations he plans to follow in each excavation area to complete the work shall be included in the offer or submitted to the Employer's Representative prior to commencement for review. Additionally, details concerning installation of pumping, ventilation and lighting systems shall be forwarded to the Employer's Representative for review. The Employer's Representative shall be provided with all submissions in sufficient time ahead of the construction works or at such dates as mutually agreed upon. No excavation shall be started in any excavation area until permission has been received in writing from the Employer's Representative.

The approval given by the Employer's Representative to the Contractor's methods and equipment does not relieve the Contractor of his full responsibility for proper and safe execution of tunnel excavations, or of liability for injuries to persons or fatal accidents, or any obligations under this Contract.

Manufacturer's certificates of compliance shall be submitted certifying that the materials and equipment proposed to be used meet Specification requirements. During excavation, and at any time during the work, all ground material which is unsafe or appears to endanger persons, the Works or the property of others, shall be immediately scaled and removed from the excavations. The fact that such scaling and removal may enlarge the excavation beyond the line of excavation shall not relieve the Contractor from the necessity of doing such scaling and removal of such materials. If it is not possible to remove loose rock by normal barring and wedging, then rock support, shotcrete or steel mesh or any combinations of each, shall be applied to secure and prevent the loose rock from falling or becoming unstable.

Excavation shall be carried out in a uniform and controlled manner and over-cutting shall be kept to a minimum consistent with the need to maintain the necessary clearance for construction of the Works.

Drilling and blasting operations shall be carried out in such way that they do not interfere with the work of Others nor cause any damage to adjacent structures.

The Contractor's excavation operations and schedule shall allow for interruption while the geological conditions exposed at the excavated rock surfaces are mapped and assessed by the Employer's Representative. Local areas shall be cleaned off where required by the Employer's Representative to expose a fresh undisturbed surface. Such interruption and assistance shall be at no additional cost to the Employer.

The excavation invert shall not be damaged due to construction works. Hence the invert of the tunnel shall be protected against damage and deterioration which may be caused by construction traffic. Any other surfaces which deteriorate or are damaged shall be made good to a standard agreed with the Employer's Representative.

Excavation shall be carried out in sections limited to such lengths, depths and widths as may be safely executed having regard to all the circumstances and as appropriate to the ground conditions and the equipment and method of construction being used.

In water-bearing strata the Contractor shall use such methods and take such steps as are necessary to control flows and maintain the stability of the excavation.

Additional excavation, not shown on the drawings, but the Contractor considers being required for his own purpose such as cross passages, mucking pits, turning cavern or spaces for site installation may only be carried out in agreement with the Employer's Representative. Such excavations are done at no additional cost for the Employer and shall be backfilled to the excavation line.

7.2 Overbreak

The overbreak-line is defined with 30 cm for tunnel sections with drill and blast excavation and 20 cm for

tunnel sections with excavation by excavator of road header.

Overbreak shall be secured with determined measures in agreement with the Employer's Representative and according to the local conditions. Loose rock mass shall be removed. Any voids formed during the excavation process by overbreak and temporary works shall be backfilled completely with grout, concrete, sprayed concrete or other approved durable material.

Accepted geological overbreak in tunnel excavation is defined as a local overbreak which occurs while the following four conditions are simultaneously fulfilled:

- overbreak extends beyond the "overbreak"-line;
- the overbreak occurs above the tunnel invert;
- the Employer's Representative is immediately notified and given the opportunity for inspection, while both the cause and the extent of the overbreak are clearly visible; and
- appropriate working methods were used, and adequate rock reinforcement and support was installed in due time, and properly applied by the Contractor.

The Contractor shall survey and plot cross sections at sufficient intervals to allow for a reasonably accurate estimate of the volume of overbreak which he claims to be due to geological conditions.

Voids created by overbreak extending beyond the "overbreak"-line in tunnel excavations shall, as directed, be backfilled up to the "overbreak"-line as required by the Employer's Representative.

In the event of excessive geological overbreak, support shall be installed immediately as required to stabilize the ground. The Employer's Representative shall be informed immediately of such conditions. Remedial works shall be in agreement with the Employer's Representative. The design of the remedial works shall be done by the Contractor and approved by the Employer's Representative. Remedial works shall be executed before further advance of the face unless otherwise directed by the Employer's Representative.

The void formed by the geological overbreak shall be measured in-situ. Individual voids of less than 1 m³ shall be discarded for measurement purposes. The materials required to complete the repair shall be quantified and approved by the Employer's Representative and certified for payment.

Where forepoling is required no separate remuneration for the additional overbreak will be made, i.e. the additional overbreak shall be included in the excavation costs.

7.3 Tunnel Excavation

7.3.1 General

Tunnel excavation in any kind of ground shall be performed in accordance with modern blasting and excavating practice, using methods and techniques that will reduce overbreak to a minimum outside of the line of excavation (payline), and which will preserve, in the soundest possible condition, the structural integrity of the rock beyond the line of excavation.

Excavations shall not be advanced until the pattern ground support for the previous round has been installed and the profile of the previous round has been checked and all rock remaining inside the line of excavation has been removed. The Employer's Representative may stop the work for removal of undercuts at any time if undercutting is observed.

Tunnel excavation shall not be started until the exposed rock faces in its portal excavation have been stabilized with rock support and shotcrete and drainage measures have been installed as given in the drawings.

The Contractor shall maintain accurate records of all blasting and excavating operations and at the end of each shift he shall provide the Employer's Representative with two copies of the records, together with such additional data as the Employer's Representative may request. The forms shall bear the signatures of the Contractor's and the Employer's Representative certifying that records are accurate and complete and include but not limited to the following:

- length of tunnel excavated, and theoretical volume of solid material excavated
- quantity of any rock support installation
- occurred rock falls, zones of instability and logs of pilot holes
- water inflow at the head and rate of discharge at the tunnel portal

- Unusual occurrences and all delays with reasons for these.

Holes drilled in swelling ground shall be conducted without water.

7.3.2 Geotechnical Design

The procedure of ground characterisation during construction sequence is based on the Austrian “Guideline for the Geotechnical Design of Underground Structures with Conventional Excavation” by the Austrian Society for Geomechanics.

Rock mass classes are determined based on the rock at the excavation face of the tunnel before the commencement of the respective excavation sequence.

7.3.2.1 General

A continuous updating of the geotechnical model and an adjustment of excavation and support to the actual ground conditions during construction is required.

The rock mass characterisation shall be determined according to the following steps, which are summarized and presented in Figure 1.

- Step 1: Determination of the encountered Ground Type (GT) and prediction of ground characteristics
- Step 2: Assessment of system behaviour in excavation area
- Step 3: Determination of excavation and support measures and prediction of System Behaviour in supported section
- Step 4: Verification of system behaviour

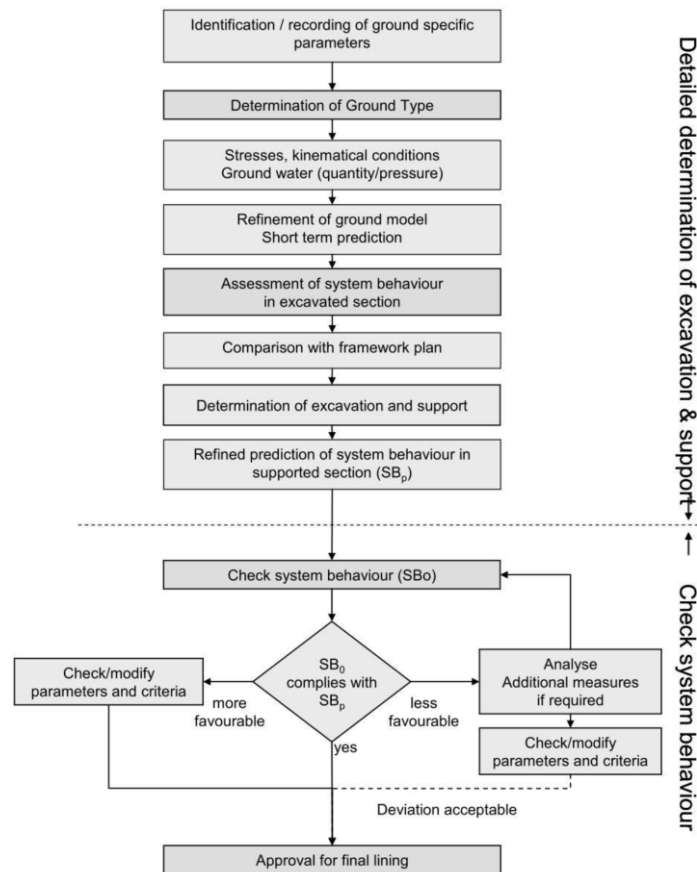


Figure 1: Basic procedure of determination of construction measures and check of system behaviour during construction (SB_p = predicted system behaviour, SB₀ = observed system behaviour) from Austrian “Guideline for the Geotechnical Design of Underground Structures with Conventional Excavation” by the Austrian Society for Geomechanics

Step 1: The geological conditions during construction shall be monitored as defined in Section 7.3.4 to collect and record the relevant parameters specified in the design. Based on the geological conditions the

Ground Type (GT) shall be determined. Additional observations, like indications of overstressing, deformation and failure mechanisms as well as results from probing ahead and the evaluation of the geotechnical monitoring shall be used to update the ground model and predict the conditions ahead of the face.

Step 2: Based on the predicted ground conditions, the system behaviour in the section ahead shall be assessed under consideration of the influencing factors and compared to the framework plan. Particular attention must be paid on potential failure modes.

Step 3: To determine the appropriate excavation class and support category, the criteria laid out in the framework plan must be followed. Consequently, it must be checked if the actual ground conditions (Ground Type, system behaviour) comply with the prediction. The additional data obtained during construction form the basis for the determination of the applied excavation and support methods.

The system behaviour must be predicted for the next excavation section, considering ground conditions and the chosen construction measures. This process is to be done during the daily review meeting as per Clause 8.4. Records of this meeting shall be kept and signed of all attended parties in compliance with Clause 8.4.

Step 4: The system behaviour shall be monitored (visually and by measurements) in compliance with Clause 8 of this Specification and the criteria defined in the geotechnical safety management plan. When differences between the observed and predicted behaviour occur, the parameters and criteria used during excavation for the determination of the Ground Type and the excavation and support must be reviewed. When the displacements or support utilization are higher than predicted, a detailed investigation into the reasons for the different system behaviour must be conducted, and if required mitigation measures (like increase of support) ordered. In case the system behaviour is more favourable than expected, the reasons must be analysed as well and the used parameters modified, if appropriate. This allows for a continuous improvement and refinement of the method for assignment of excavation and support methods.

7.3.2.2 Determination of Actual Ground Type

Key parameters shall be defined in agreement with the Employer's Representative for the identification of each Ground Type, considering that those can be recorded during construction. If directed by the Employer's Representative, additional parameters shall be monitored, which the Employer's Representative deems necessary for determination of the system behaviour.

Each of the key parameters shall be categorized. Whenever feasible, numerical values shall be used preferably than descriptive data, like spacing, joint opening, strength, etc. Due to practical reasons, some of the required parameters can only be described qualitatively.

Using predefined criteria the parameters are weighted and combined, allowing the appropriate Ground Types to be identified. A correlation matrix shall be used.

Data collection on site shall be concentrated on collecting relevant geological and geotechnical data and on observing and recording the ground structure. The collected data are recorded in prepared forms. With the criteria defined during the design the Ground Type is determined. In heterogeneous ground conditions, the ground shall be divided into several sections, and the appropriate key parameters shall be collected for each section separately.

The geological and geotechnical data collected and evaluated on site are the basis for the extrapolation and prediction of the ground conditions. The geological work is not limited to recording the face conditions, but also shall involve prediction of the conditions in the volume of rock that controls the ground response.

7.3.2.3 Assessment of System Behaviour in the Excavation Area

In addition to the parameters required to determine the Ground Type(s), influencing factors, like ground water conditions, ground structure, estimated stress situation and kinematical conditions as well as observations of the system behaviour in the excavation area shall be recorded by the Contractor.

The reaction of the ground to the excavation and support are observed by the Contractor using an appropriate monitoring system in compliance with Clause 8 of this Specification.

The predicted ground structure in combination with the on-site observations and monitoring results shall be used for prediction of the ground behaviour for the sections to be excavated subsequently.

7.3.2.4 Determination of Excavation and Support and Prediction of System Behaviour

For the final determination of the excavation and support method, it must be checked if the ground conditions and system behaviour observed on site conform to the design assumptions. When the observed conditions conform to the predicted ones, stipulations in the framework plan must be followed when determining the construction measures.

In case of a deviation exceeding the specified tolerance in the framework plan, the designer has to be informed to allow for an adaptation of the prediction, based on new findings. The designer shall agree with the required additional measures in due time and update the framework plan accordingly.

The final decisions on the applied construction measures are based on the design and additional information gained during construction and shall be done during the daily review meeting as per Clause 8.4 of this Specification. The goal is a safe and economical construction. The decisions must be coherently explained and documented, for example in an appendix to the required excavation and support sheet (RESS) in compliance with Clause 8.6 of this Specification.

The prediction of the system behaviour shall contain the following but is not limited to:

- Expected magnitude and orientation of the tunnel displacements, and the surface (if applicable), including the displacements spatial and time dependent development
- Expected utilization factor of the support

7.3.3.5 Check of System Behavior

The actual system behaviour in the supported area and in the final stage shall be compared to the predicted system behaviour, and checked, whether the behaviour is within the specified limits of the warning criteria. Additional measurements or evaluations may be required on direction by the Employer's Representative to determine for example the utilization of the lining.

Deviations between the expected and the observed behaviours have to be analysed and documented by the Contractor and discussed with the Employer's Representative in the daily review meeting as per Clause 8.4.

The reasons for the deviation in behaviour have to be analysed. In case the assumptions regarding the influencing factors are inappropriate, the parameters have to be modified. The modifications have to be supported by appropriate data and analyses and documented in an updated framework plan.

In case the ground quality is better than predicted, the geotechnical model has to be revised. In case of a significant deviation, the criteria for the determination of excavation and support have to be modified.

In case the ground quality is worse than predicted and warning levels exceeded, contingency measures according to the safety management plan have to be implemented, and excavation and support shall be adjusted accordingly. This can be done for example by additional bolting, installation of a temporary invert, etc. In some cases, the installation of a stronger support in the following rounds may be sufficient to achieve the target. All additional support measures are defined in the daily review meeting and presented in the RESS in agreement with the Employer's Representative.

In case of significant deviations, the geotechnical model has to be revised and the criteria for the determination of excavation and support have to be modified. This generally requires that the framework plan is updated.

7.3.3.6 Updating of Design

Due to limited information available during design, a number of assumptions and simplified models have to be used to arrive at a design, which is the basis for the framework plan and the tender documents.

A continuously update of the geotechnical design with the increasing level of information shall be done. This applies to the determination of the Ground Types, the assignment and calibration of key parameters and criteria as well as for the determination of the system behaviour. The refinement of parameter categories, the introduction of additional criteria, etc. help in improving the geotechnical model.

The tunnel engineer on site has to report to the designer in case of significant deviations of the actual geological/geotechnical situation or system behaviour from the predicted ones, as outlined in the framework plan. A detailed report, containing all relevant information and coordinated with the site geologist and the Employer's Representative and the Contractor, has to be prepared and submitted. After consideration of the facts the designer has to update the framework plan. This must be documented in a supplement to the geotechnical report.

7.3.3 Blasting

7.3.3.1 General

Not less than 40 days prior to commencement of rock excavation in each area, the Contractor shall submit, for review by the Employer's Representative, details of the drilling and blasting methods which he intends to use in that area. If, at any time in a specific area, a plan which has been previously adopted does not produce conditions at the excavated rock face that conform to the requirements of these Specifications, the Contractor

shall submit a revised plan to the Employer's Representative before continuing excavation in adjacent areas.

The Contractor shall develop controlled blasting techniques, which will satisfy the excavation requirements specified herein. In each different type of rock conditions, the Contractor's initial blasts shall be performed as trials, and the burden, drill hole pattern and depth, explosive type and quantity, blasting sequence and drill delay pattern shall be modified to achieve the requirements specified herein.

Blasting means must follow the licensing requirements and orders as well as the manufacturer's instructions.

Blasting operations shall be carried out only under the direction of an experienced operator. The Contractor shall appoint one competent person to be responsible for the security of explosives.

Blasting shall be carried out carefully so as to avoid loosening or shattering rock beyond the required line of excavation, and loose or shattered rock (where it does not contribute to stability of the excavation) shall be removed by scaling down or other means before personnel will be permitted to restart operations after blasting.

Notices of blasting operations shall be posted on site. Before each firing, the Contractor shall give audible warning, clear the area and shall take positive measures to prevent personnel from entering the danger area.

The Contractor shall monitor the results of blasting closely and, where it is proper to do so, shall propose changes to his blasting operation for the agreement of the Employer's Representative.

Under no circumstances shall any holes be charged until completion of all drilling operations at the face.

After each blasting operation the tunnel drive shall be sufficiently ventilated to remove any nitrous gases and the atmospheric conditions shall be constantly checked prior to personnel accessing the excavated face in compliance with Clause 7.7.

No person shall be allowed to approach the face and no face operation shall commence until the Contractor's authorised person in charge of the operation has given permission after blasting round.

As soon as practicable after blasting and without undue delay, the Contractor shall erect such support as may be necessary to safeguard the excavation and personnel.

The shot-firer must keep a record of the number of shots fired, their time of firing, type and weights of explosives used, and the type and number of detonators used, together with a record of the post-blast situation for each and every location. A copy of the record shall be available to the Employer's Representative at the end of every shift on which shots are fired.

7.3.3.2 Controlled Perimeter Blasting

Controlled perimeter blasting techniques shall be used to produce rock faces conforming to the required excavation lines, slopes, elevations and dimensions shown on the drawings with a minimum of disturbance to the rock at, or outside of, the excavation pay lines.

Drill holes for controlled perimeter blasting shall not be less than 42 millimetres in diameter and shall be a single row of closely spaced holes drilled to a maximum depth of one round length along the excavation paylines and a spacing of 0.4 to 0.6 m depending on the ground condition. The spacing of the perimeter holes may be modified based on results obtained and in agreement with the Employer's Representative.

All blast holes within a distance of 5 meters normal to the excavation pay lines shall be less than 75 millimetres in diameter and shall be loaded in a manner and detonated in a sequence to ensure that a minimum of damage will result to the face when the main charge is fired.

7.3.3.3 Explosives

The Contractor shall use explosives only in circumstances where it is safe to do so having due regard to the safety of persons, third-party property and the safety of the Works. Explosives shall not be used without the agreement of the Employer's Representative.

The Contractor shall obtain all necessary licences and consents and shall provide secure storage facilities for all explosives and equipment in accordance with Indian or International Standards Code of practice for the safe use of explosives in the construction industry and the requirements of the local Authorities and the Employer's Representative.

Explosives shall be handled and used only by the Contractor's duly authorised personnel. The names and qualifications of such personnel shall be submitted to the Employer's Representative in writing in advance of any possible use of explosives.

At an early stage, in advance of the proposed use of explosives, the Contractor shall notify the Employer's Representative, third parties, statutory authorities and services which have an interest in or are likely to be affected by blasting operations, of the general nature of the operation. The Contractor shall subsequently give a minimum of 14 days' notice to the Employer's Representative and others described above of the proposed use of explosives. With this notification the Contractor shall submit to the Employer's Representative a detailed method statement on all aspects of the proposed use of explosives, including the treatment of misfires.

The Contractor shall comply with the following documents in respect of the use of explosives:

- Indian Explosives Act 1884
- Indian Explosive Rules 1983
- The Manufacture and Storage of Explosives Regulations 2005
- BS 5607:1998 Code of practice for the safe use of explosives in the construction industry
- Control of Explosives Regulations 1991
- Carriage of Explosives by Road. Road Traffic (Carriage of Explosives) Regulations 1996
- PD CLC/TR 50426:2004 Assessment of inadvertent initiation of bridge wire electro-explosive devices by radio- frequency radiation. Guide Quarries (Explosives) Regulations 1988, as far as it is relevant to tunnel works.

7.3.3.4 Blasting Vibrations

For structures in the proximity of blasting, the peak particle velocity shall be measured at the locations immediately adjacent to the structure nearest to the face being blasted or any other location where it is necessary to limit vibration.

Vibration monitoring proposals shall be submitted to the Employer's Representative for his agreement.

The measurement of peak particle velocity shall be obtained from instruments capable of measuring along three orthogonal axes, one of them shall be aligned parallel to the centre line of the excavation and another shall be vertical. The Contractor has to provide supports for the measuring instrument if so required by the manufacturer's instructions.

The measurements of the particle velocities shall be the responsibility of the Contractor. Copies of the readings in an agreed form shall be supplied to the Employer's Representative.

Prior to the commencement of blasting in any location, the Contractor shall demonstrate by the use of test firings, or by other means, that neither the peak particle velocities given in the particular Standards and Specifications will be exceeded.

The maximum allowable blasting vibrations shall be defined by the Contractor for every influenced structure with reference to the applicable Standards and Specifications for the relevant structure. The allowable blasting vibrations shall be approved by the Employer's Representative prior to any blasting operations.

7.3.4 Geological Mapping

Geological mapping shall be performed by the Contractor's qualified geologist to provide a documentation of rock and rock mass condition encountered during excavation. Additionally all exposed rock surfaces of the open and underground excavations shall be washed down by the Contractor for inspection and geological mapping by the Employer's Representative if he deems to do so. Exposed rock surfaces at the required excavation, pay lines shall be mapped after preparation but before shotcrete application. Tunnel and other underground faces shall be mapped just before the start of drilling. The Contractor shall allow in his construction procedure and schedule for the geological mapping of each tunnel face not less than 30 minutes.

The geological mapping shall include but not limited to the following information:

- excavation face
- tunnel meter
- geological unit
- intact rock:
 - rock type and lithology description

- weathering and alteration degree
- uniaxial and unconfined compressive strength (from point load tests)
- rock mass:
 - jointing degree
 - geometry, orientation (strike and slip) and properties of discontinuities
 - face condition (homogeneous or heterogeneous)
 - water inflow
 - over breaks (separated in geological and non-geological)
 - ground response
 - suspected pervious zone
- the GSI value and the corresponding excavation class
- groundwater appearance

The Contractor shall provide lights, ladders, platforms and free access and shall assist the Employer's Representative to carry out inspection and geological mapping. Tunnel Face shall properly be cleaned with the help of water/air jet.

In case of sudden and unexpected changes of the geological conditions the Employer's Representative shall be informed immediately by the Contractor.

7.3.5 Exploratory Drillings

Long exploratory drillings with full core recovery shall be carried out when deemed necessary and required by the Employer's Representative. Based on the geological mapping and the exploratory drillings the Employer's Representative may require rock mechanic laboratory tests.

7.4 Shaft Excavation(if applicable)

7.4.1 General

Prior to excavation, the shaft area shall be thoroughly checked for existing pipes, cables or structures and the appropriate measures taken in agreement with the Employer's Representative.

7.4.2 Safety

At all times shafts shall be provided with safe primary and secondary means of access and egress.

Should heavy plant and heavy loads have to be located in close proximity to any shaft, the Contractor shall take into account the effects of these loads as well as any ground loads when designing the shaft.

The Contractor shall guard against distortion of shaft lining during construction and the possibility of shaft settlement or uplift at an intermediate stage of construction.

7.4.3 Temporary Shafts

Full details of temporary shafts required by the Contractor's working methods shall be submitted to the Employer's Representative for his agreement. Such shafts shall be adequately sized for all operations required for the execution of the Works.

Backfill for temporary working shafts shall comprise material agreed by the Employer's Representative.

Where the Contractor wishes to recover temporary shaft linings the structure shall be removed in safe stages as backfilling proceeds, taking care to maintain the safety and structural integrity of the remaining lining. No part of Temporary Works shall be left in the ground within 2 m of the designed final surface level.

7.4.4 Construction

Shaft sinking shall be carried out by a method suitable for all the particular circumstances of the site including ground parameters, groundwater, depth and final purpose.

Where work is done by underpinning, only that ground which may be safely excavated for the installation of one ring or one unit of support shall be carried out. Until that depth is properly secured by permanent or

temporary shaft lining, no further excavation shall take place. In the case of pre-formed rings, securing shall include grouting.

Where work is done by a caisson operation, a cutting edge shall be fitted to the leading ring. The Contractor's details for bolting caisson rings shall avoid working at height where practicable.

The cutting edge shall be maintained at an even level all round during shaft sinking. Jacking arrangements or kentledge shall be adequate for the work. The Contractor's arrangements shall ensure the stability of any kentledge. A lubrication space shall be maintained completely filled with the lubricating material around the full shaft periphery during sinking. On completion of sinking the lubricating material shall be displaced with grout.

Concrete walls installed by slurry trench or secant piling techniques shall comply with best practice. The Contractor's proposals shall be submitted to the Employer's Representative for his agreement.

Where low-pressure compressed air is used to assist shaft construction, air decks and locks shall be designed by the Contractor to give adequate margins of safety against the air pressures to be used in the shaft. The Contractor's proposals shall be submitted to the Employer's Representative for his agreement.

Excavation in rock shall generally be carried out by methods outlined in Section 7. Where explosives are used, full-width shaft covers and blasting mats shall be installed during blasting. Blasting shall be carried out in compliance with Clause 7.3.3.

Full details of Temporary Works required by the Contractor's method of working for the construction of tunnel or pipe jack eyes in the shaft lining shall be submitted to the Employer's Representative for his agreement.

Shaft bases shall be concreted as shown on the drawings. In the case of Temporary Works shafts the Contractor shall submit his proposals for the shaft base structure taking account of ground and groundwater forces and sealing the shaft against water entry. Water pressure shall not be allowed to build up under shaft bases until the shaft has sufficient resistance to prevent flotation. The construction sequence shown on the drawings shall be followed unless agreed with the Employer's Representative.

Shafts shall be sunk to a maximum divergence of 1:300 from the design centre line at any depth.

7.5 Control Survey

The Contractor shall be entirely responsible for the accuracy of the control survey and the plotting and periodic checking thereafter. Location and positioning of all survey control stations, reference pillars, benchmarks etc. must be presented in coordinates and in a map (scale 1:1000) and approved by the Employer's Representative before the start of any works.

The Contractor shall install all necessary above ground survey stations and reference points well in advance of the commencement of excavation works so as to allow the Employer's Representative sufficient time to check the initial control survey and subsequent setting out for the alignment and levels of the respective tunnels.

Survey stations, centre lines, benchmarks and grade lines shall be clearly marked in paint on the tunnel walls, chainages at 10 metre intervals or as otherwise agreed by the Employer's Representative. The Contractor shall appoint and employ the necessary qualified and experienced staff to carry out the required survey and setting out. The Contractor shall provide all necessary instruments, equipment, record books, level books measuring devices etc. required for survey and setting out. The Employer's Representative shall have use of any of the survey equipment required for the checking of survey work and setting out throughout the period of the Contract. Chainmen and transport shall be provided by the Contractor for checking purposes at the request of the Employer's Representative.

All additional work found to be necessary because of negligence in/or incorrect setting out, shall be carried out immediately by the Contractor as directed by the Employer's Representative at no additional costs.

7.6 Excavation Cross Section Check

7.6.1 General

Tunnels and shafts shall be constructed to the centre lines as defined herein and subsequently agreed on site with the Employer's Representative. Average deviation of the tunnel centreline from the design centreline, along a 100 m length of any tunnel section, shall not exceed 30 mm. If deviations in tunnels excavated exceed the specified tolerance, the Contractor shall be required to adapt his working methods so that the specified tolerances are achieved.

Immediately after excavation and before support installation the cross section of the actual round has to be

checked to avoid unexcavated ground reaching into the excavation area as per excavation and support category. The check must be done with proper instrumentation, either with free positioned theodolite or with temporarily installed monitoring device for profile check.

When all ground material inside the excavation area is removed the support installation shall start earliest.

In case of partial excavation, the similar procedure shall be executed for each partial excavation area.

For checking the primary lining cross sections refer to 9.12.

7.6.2 Definitions

The theoretical excavation line means the line of excavation within no unexcavated ground material shall remain at any time. If due to additional displacements of the ground unexcavated material extends into the line of excavation, the Employer's Representative may order to excavate this material at no additional costs.

The practical excavation line shall compensate for radial displacements and construction tolerances according to the actual ground conditions and Support Categories and shall consider allowances for deformation and practical constructability. The values defined in the Bill of Quantities and on related drawings are paying item values. These documents are developed based on the theoretical line of excavation. The displacements must be predicted during detailed design and construction works. Practical excavation line may be adjusted by Contractor to suit actual deformations and excavation techniques used as experience is gained during excavation. Adjustments shall be approved by the Employer's Representative.

All additional quantities due to tolerances and displacements must be included in the item prices which are based on theoretical line of excavation.

In the following the basic geometrical conditions for the definition of line of excavation are given.

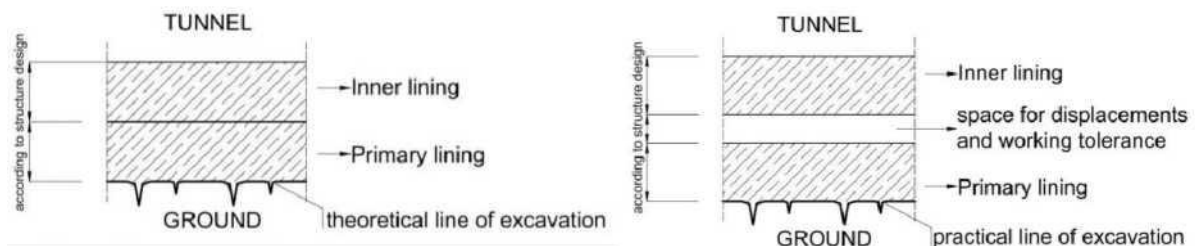


Figure 2 Schematic sketch of the geometrical condition for the definition of the line of excavation

7.7 Temporary Ventilation System

7.7.1 General

Pits, shaft tunnels and headings shall always be kept ventilated to maintain an atmosphere fit for respiration and free from oxygen deficiency, potentially explosive or noxious gases and dust, whether present naturally or otherwise. Ventilation shall also be used to maintain a safe working temperature.

Underground works shall be ventilated in accordance with all applicable regulations. Details of the proposed ventilation system shall be submitted to the Employer's Representative, for review, not less than 40 days prior to the start of commencement.

Where more than one pollutant is present any adverse interaction between them shall be identified and mitigated.

All diesel engines used in the underground works shall be provided with means, which shall be maintained in efficient order, of cooling exhaust gases and reducing the concentration of toxic gases to acceptable levels, filtering particulates and preventing emission of flames or sparks.

In underground workings and in confined spaces the air breathed by persons shall contain not less than 19% of oxygen by volume, and shall not contain concentration of gases, vapours or dust greater than is safe for the health or workmen, having regard to the effects of time, temperature, humidity and the combined effects contaminants.

Smoking is forbidden in tunnels, headings, pits or shafts and all confined spaces.

In rock excavation all drill holes shall be wet drilled unless otherwise specified in this Specification in compliance with special ground condition.

7.7.2 Ventilation

The Contractor shall agree ventilation proposals with the Employer's Representative. Agreement shall not relieve the Contractor of his obligations under the Contract.

Proposals shall include but not be limited to the types of fan employed, sitting arrangements where appropriate, the power supply and the fan performance data, together with duct characteristics.

In forcing systems, fans shall normally be placed on the surface. The inlet to any surface forcing fan shall have unobstructed access to fresh air. It shall not be in the vicinity of a storage site for oil, chemical or diesel drums. The fan shall also be sited so that it cannot draw in internal combustion engine fumes or gas from charging batteries.

Blasting fumes shall be discharged from the underground works into a filter system or diverted adequately to ensure that concentrations of noxious or other harmful gases or dust are kept to the minimum limit as stated in the applicable laws/ Standards or the limits specified in the contract of lower.

If booster fans are to be employed by in-line staging, they shall be of an approved flameproof (FLP) construction and a monitoring system shall be installed so that the status and condition of such fans can be monitored at all times.

Provision shall be made for the fan to be run continuously whether persons are within the underground works or not. After tunnel break-through the ventilating system shall be kept in operation in order to maintain the fresh air-volume requirements stated hereinafter.

If a ventilation system ceases to function for any reason and for a period exceeding 30 minutes, all work in areas being ventilated by that ventilation system shall immediately cease and all workers shall immediately leave the areas.

Where a fan has been stopped and restarted, the condition of the air shall be tested before personnel enter the tunnel. If only forcing surface-mounted fans are employed, the ventilation system should be restarted and run continuously ensuring that any plugs of oxygen-deficient, flammable or noxious mixtures of gas are flushed out. Care should be taken that workmen do not encounter any plugs of these gases on re-entry to the tunnel. The Contractor should consider that air residence time in long drivages can be several hours and that layered gases of different densities are difficult to disperse, especially where the gradient of the tunnel changes.

All equipment and ventilation duct shall always be maintained in sound working order. Any damage to ventilation duct shall be repaired within 12 hours of the damage.

The outlet of the duct shall be kept as close to the face as is practicable, designed to avoid turbulence and creation of dust and not more than 10 m away.

Where dust is being produced by the tunnelling system, exhaust ventilation shall be used to extract such dust from the working area.

Tunnelling shall not continue more than 10 m from the shaft or pit unless positive ventilation has been established.

The fresh air supply for underground works shall not be less than two cubic meters per minute at the face for each man underground and four cubic meters per minute per kW power for all diesel units operating underground. These fresh air volumes shall be cumulative, and the Contractor shall allow, in his design calculations, for the maximum number of persons and diesel-powered equipment deployed in the Works at any one time. Any estimated losses, e.g. due to the leaks in the ducts, shall be considered. The fresh air supply shall also be adequate to produce a linear velocity of 0.3 meters per second throughout the underground works.

Testing devices shall be provided for measuring carbon monoxide, methane, oxides of nitrogen and aldehydes in underground works during the operation of internal combustion engines. Readings of carbon monoxide content shall be taken by the Contractor at least once during each shift. Readings of oxides of nitrogen content and of aldehydes content shall be taken frequently to ensure safety of the workers. A record of all taken readings shall be kept by the Contractor and submitted to the Employer's Representative daily.

Ventilation ducts shall be firmly fixed to the vaults in such position that a minimum clearance of 20 cm remains between the duct and the extremities of vehicular traffic employed in the Underground Works.

7.7.3 Monitoring

Atmospheric monitoring equipment shall be positioned at each working face and also within 20 m of the tunnel entrance when the tunnel has advanced 250 m or more. Monitors shall also be provided every 500 m along the

tunnel. Monitoring equipment shall be capable of continuously monitoring the levels of potentially explosive gases, toxic gases and radioactive gases as appropriate and the oxygen content. The equipment shall give both visual and audible warning of the presence of potentially explosive, radioactive or toxic gases and where the oxygen content falls below safe working levels defined in Table 2. An immediate and effective means of communicating warnings to the surface shall be installed. The atmospheric monitoring system shall be a fixed system supplemented by portable monitoring equipment as necessary, except in small tunnels where the use of portable equipment only shall be permitted at the discretion of the Employer's Representative.

Table 6: Admissible maximum concentrations of pollution gasses in underground works

Pollution gas	Max. concentration
H ₂ S	10 ppm
SO ₂	2 ppm
CO	50 ppm
NO ₂	5 ppm
CO ₂	5000 ppm
CH ₄	1000 ppm
Silica dust	8 mg/m ³

Each working shaft and the full length of all tunnels shall be monitored continuously for the presence of explosive or noxious gases or lack of oxygen. Records shall be kept of monitoring results. If concentrations of noxious gases or other inflammable gases exceed the permissible limits stated in Table 2, BS 6164 or HSE guidance document EH40, or oxygen content below the level set out in BS 6164, all operations shall be interrupted immediately and personnel shall be removed to a safe area. All sources of ignition shall be extinguished or removed. All equipment with the exception of ventilation equipment shall be shut down.

When any explosive gas concentration of 1.25% is present, all persons other than those essential for safety shall be withdrawn from all parts of the tunnel. The use of explosives and locomotives shall be prohibited and all electrical equipment not intrinsically safe shall be disconnected. All persons shall be withdrawn when the explosive gas concentration exceeds 2.0%.

The required measures will be mutually determined and agreed to by the Employer's Representative and the Contractor. If required by the Employer's Representative, the Contractor shall consult the services of an independent consultant experienced in gaseous tunnelling. Re-entry and resuming of the Work shall be prohibited until the Employer's Representative has authorised re-entry.

If the ventilation system is for any reason not in operation for a period greater than 2 hours, a start-up procedure shall be invoked. This requires that the shaft and tunnel shall not be re-entered until one complete air change in the tunnel has taken place and the tunnel atmosphere is shown, by monitoring, to be safe.

Persons re-entering after shutdown must carry instruments to detect the presence of dangerous gases and the sufficiency of oxygen, and these must be used continuously during re-entry.

7.7.4 Checking & Inspection

During each shift, the following checks shall be made:

- The fan or fans shall be checked for heat, unusual noise and vibration. The results shall be reported, and remedial action shall be taken if required.
- The ventilation ducting shall be checked for damage and the joints checked for integrity. The results shall be reported, and remedial action shall be taken if required.
- The atmospheric monitoring system shall be checked at both local and remote stations and the results shall be recorded.

The air flow quantities shall be checked at both the face and 20 m from the shaft bottom on a weekly basis. These figures shall be recorded and compared with the calculated flows. Any shortfall shall be made good.

The ventilation records shall be maintained and be made available for inspection by the Employer's Representative.

7.7.5 Control of Dust Silica and Noxious Gases

To reduce the amount of dust, only wet drilling will be allowed and during mucking, muck piles shall be kept constantly damp by sprinkling with water. The use of high-pressure water jets for this purpose is not permitted.

Air Samples for this purpose shall be taken within 10 days of commencing underground excavation, at 30 days

intervals thereafter and within 20 days following major changes in tunnel excavation operation or whenever required by the Employer's Representative. Samples shall be taken from actual working areas. The sampling and testing shall be performed by a qualified person or laboratory to be proposed by the Contractor and approved by the Employer's Representative. A copy of the test results shall be submitted to the Employer's Representative within 2 weeks of the sampling date.

In general, the concentration of fine dust (diameter less than 0.005 mm) may not exceed the value of 8.0 mg/cum of air and in relation to the silicon dioxide SiO₂ content in the rock this value is lowered in compliance with Table.

Table 7: Maximum admissible fine dust concentration with respect of SiO₂ content in the rock

per cent per weight	mg/m³ air
1-15%	8.0
15-20%	6.0
20-30%	4.0
30-60%	2.0
60-80%	1.5
80-100%	1.3

The Contractor shall take necessary measures and install appropriate equipment in agreement with the Employer's Representative if the concentration of fine dust exceeds the limits stated in Table 3.

Use of internal combustion engines, other than approved mobile diesel-powered equipment will not be permitted in underground construction Sites.

7.8 Lighting

Floodlighting on the site surface shall be adequate for the safe operation of the site. It shall be shrouded where necessary to ensure the light is directed to areas within the site, and to avoid nuisance.

Lighting in the tunnel shall extend the full length and not be less than that required for safe working and access. Lamps shall be located with an interval of 25 m.

An alternative source of power and emergency lighting system shall be provided to allow emergency securing operations and evacuation safely in the event of a primary power failure as specified in Clause 3.5.1. An adequate number of hand lamps shall be located at key points underground.

The Contractor shall also provide suitable movable lamps to illuminate any area in Underground Works including areas for instrumentation and where the Engineer may wish to carry out inspection and rock mechanics tests or instrumentation.

Lighting illumination by flame is strictly not permitted in the underground Works.

8 GEOTECHNICAL INSTRUMENTATION MONITORING

8.1 General

The Contractor shall submit to the Employer's Representative for agreement a detailed method statement for instrumentation and monitoring, including instrumentation layout, trigger, design and allowable values and the procedures for evaluating the monitored data.

The Contractor shall appoint within his site team an experienced Monitoring Employer's Representative who shall lead the Contractor's monitoring team. The Monitoring Employer's Representative shall present the results of the previous day's monitoring in the daily monitoring meeting as per 8.4 with the Employer's Representative where they shall be presented to the Employer's Representative by the Monitoring Employer's Representative.

The frequency of such review meeting may be increased if requested by the Employer's Representative. In any case it shall be adapted to the frequency marked by the monitoring program from a holistic point of views, so it may be decreased also under the approval of Employer's Representative.

The Contractor's Site Manager shall attend monitoring review meetings if requested by the Employer's Representative.

The accuracy and precision of the required measurement will depend on the purpose of the monitoring.

Assessments shall be carried out to establish the zone of influence due to tunnelling works, i.e. ground perturbation ring around the cavity, and to determine if there is a likely damage that will occur to existing

above-ground and subsurface infrastructure.

The outcome of the assessments shall determine the type and amount of monitoring that will be required.

Instrumentation and monitoring for the tunnel and appurtenant structures shall be carried out with the following instruments but not limited to:

- theodolites and reflectors/optical targets
- tape extensometer and convergence pins
- borehole extensometers (multiple-point, in rock mass ring periphery)
- strain gauges (in final lining)
- load cells (anchors)
- radial pressure cells (interface ground/primary lining, optional on representativeness)
- sliding micrometre (optional in face extrusion control)

All instrumentation operating on electrical, mechanical or hydraulic systems shall be accompanied by individual test certificates, and shall be tested in the presence of the Employer's Representative prior to installation, unless specifically stated otherwise.

The installation of instruments may interfere with the overall construction progress. The Contractor shall make provision for such interferences in his construction schedule. He will not be entitled to any compensation or extension of the Time for Completion by reason of any such delays, including repair and replacement of damaged instruments if the damage is due to construction procedure of Contractor.

No material shall be installed prior to the Employer's Representative's approval. However, approval by the Employer's Representative of the Contractor's proposals and drawings or data shall not relieve the Contractor from his sole responsibility to meet all the requirements.

8.2 Ground Movement Monitoring

In this particular Project, initially it is not expected an influence from tunnel excavation to the ground surface movements and settlements, even in portal areas, due to presence of competent rock formations in the excavation slopes which will be stabilised, if required. The natural slope gradients are high and tunnels will gain quickly ground rock cover, and values of overburden will be huge.

Consequently, in this Contract it might not be mandatory for the Contractor to monitor the effects of tunnel construction at the surface, including all ground movements and the effects on all structures..

Nevertheless, Employer's Representative may decide the installation of control points to monitor movements in civil constructions, buildings and other structures located in stretches above tunnel alignment near the portals, if there are chances of portal instability or poorer ground conditions than forecasted.

In this case, monitoring shall be referenced to stable survey stations located outside the zone of influence of the Works. Such benchmarks and coordinated stations shall be established and agreed with the Employer's Representative before any ground is excavated and before any ground support or treatment. They shall be checked at intervals during the duration of the Works.

The Contractor shall observe, record and analyse the readings to establish trends in movement and reconcile movements measured with those predicted. He shall provide a copy of all recorded results to the Employer's Representative. He shall make available results to the Employer's Representative in accordance with an agreed programme. However, movements greater than predicted shall be reported to the Employer's Representative immediately.

Prior to construction Works commencing, in case of monitoring requirement, a defect survey shall be carried out of all structures within the zone of influence and a schedule of defects shall be prepared.

This schedule shall be agreed by the Contractor and the owner of the structure, or his representative, prior to the start of construction. Existing pipelines, tunnels and services shall be regarded as structures

During the execution of the Works, defects which have been scheduled shall be inspected and monitored as necessary. Defects which arise during the course of the Works shall be recorded. The Contractor shall keep records of such inspections and a copy shall be available to the Employer's Representative.

Monitoring of settlement, scheduled defects and defects arising during the course of the Works shall continue at agreed intervals for a period of at least 6 months after completion.

8.3 Tunnel Excavation Monitoring

The Contractor shall survey, monitor and record tunnel construction as it proceeds to form a registry of the Work, available to the Employer's Representative at any time. Monitoring shall generally be per unit of advance and include line, level, cross-sectional accuracy, shift advance and total advance. Spatial relationship between excavation volumes/paces and cavity deformation is crucial to understand ground/support behaviour.

Monitoring of construction work's units parameters like lining concrete temperature, pressure & volume of contact/treatment grouting, and all other concerned, as well as environment parameters like water ingress flow quantities, noxious gases concentration, are not included in this kind of monitoring, unless they will interfere in the instrumentation monitoring results. This kind of Works monitoring shall be considered in another separate chapter.

All information recorded by the Contractor shall be provided to the Employer's Representative on a daily basis unless another interval has been agreed.

3D deformations of the tunnel lining shall be monitored by means of optical methods, and complemented by tape extensometer measurements when and where required. The points to be observed are marked by targets or reflectors mounted on standard convergence bolts.

Where the Contractor considers that any corrective action he may take will exceed the tolerances in the Contract, he shall so inform the Employer's Representative and obtains his agreement. Measurements shall be carried out with a free-stationed high precision electronic theodolite as laid down in Clause 8.9.2 with integrated coaxial EDM device. The flow of data shall be fully automatic. The software shall allow determination of displacements in an absolute coordinate system with an accuracy of $\min \pm 1.0$ mm.

The Contractor shall determine the elevation of tunnel crown, and/or invert points as directed by the Employer's Representative, during tunnel excavation to monitor vertical settlements and bottom heaves, being able to interpret and figure the absolute amount of displacements together with convergence readings out. Pins or bolts shall comply with Clause 8.9.1. The method of performing the level measurements shall be such as to ensure an accuracy of ± 1 mm.

Necessary conclusions shall be drawn from the geotechnical measurements, from their magnitude, alterations and tendencies about stability of the primary lining and surrounding rock, performance of the initial support applied and ground response to the supporting elements, either defined by the Project or countermeasures put on ground as adaptation to unpredicted conditions.

The locations and spacing between geotechnical measurement sections depends on geological conditions, frequency of geological alterations, rock mechanical behaviour, tunnels length, primary stress conditions, and size of tunnels. The location and spacing between designed measurement sections shall be modified during tunnelling according to the local geological conditions, and the experience gained during tunnel driving, as required and approved by the Employer's Representative.

In this sense, geological mapping of tunnel face, its record and geotechnical interpretation will be in full swing with the implementation, and modifications if required, of the instrumentation monitoring program at such sections location. The Contractor shall keep copies of all recent face records at the workface for the information of supervisory personnel.

8.4 Daily Review Meeting

The monitoring instrumentation shall be read on a regular basis - as per drawings and monitoring plan - and the results shall be made available for a daily review meeting (DRM) attended by the senior members of the Contractor's and the Employer's Representative's staff. Input into the meeting shall also include current geotechnical investigations, face logs and any recent non-conformance reports relating to the tunnel construction.

This DRM shall be held daily during the excavation of the tunnels at the site unless otherwise agreed by the Contractor and the Employer's Representative. Periodicity of such meeting would be most suitable adapted to the monitoring plan.

The minimum team attending the meeting shall include the following persons:

- Monitoring Contractor's Representative
- Monitoring Employer's Representative
- Contractor's Representative

▪ Employer's Representative

At the meeting the Contractor shall present the current results of all monitoring equipment of the tunnels together with its evolution trend and comparison with the values of variables predicted by the calculations. Additionally, the Contractor shall present the installed support measures and most recent geological mapping records, along with sequential excavation round lengths and cycle time for excavation/support.

The purpose of the daily review meeting is to assess the behaviour of the set primary lining/ground in order to:

- confirm the design input parameters and assumptions
- confirm that the construction methods are appropriate for the ground conditions
- provide early warning of potentially unpredicted behaviour
- determine the likely cause of adverse behaviour
- confirm the safety of the applied construction method

The outcome of the meeting shall be a report, the Required Excavation and Support Sheet (RESS) as per Clause 8.6, agreed by the Contractor and the Employer's Representative, who states that tunnelling may continue as proposed, or gives the requirements for modifications to the tunnelling (e.g. support measures, shorter advances, smaller headings etc.).

The Contractor shall keep minutes records of the geotechnical instrumentation monitoring meetings, which shall be signed by the attendees. Monitoring results shall be attached to the minutes and recorded on site. All records from these meetings including face logging and monitoring results shall be kept and be available for inspection until the termination of the Contract.

8.5 Key Performance Indicators

A key performance indicator (KPI) system shall be developed for monitoring variables so that actions can be taken in a timely manner, thereby ensuring that damage to existing buildings and subsurface infrastructure is within calculated predictions.

The KPIs to be used to guide construction shall relate to specific monitoring activities as follows:

- surface ground and concerned structures displacement monitoring (not required under expected conditions)
- in-tunnel convergence (SCL) and face displacement monitoring
- ground movement monitoring in the tunnel periphery
- deformations/strains observed on the primary lining, (and final lining if required)
- geological mapping

The KPI values specified in the design documentation shall be used to indicate whether there is cause for concern during tunnel construction or no. To ensure that the response is appropriate for any specific concern, certain procedures shall be implemented when a KPI is exceeded. These are summarised below.

- A full review of the lining performance shall be conducted for the relevant tunnel sections and checked against the KPI values. This includes checks on the ground/soil conditions, the quality of construction and the monitoring results provided by the Contractor.
- A comprehensive review of the trends for monitoring data specific to the area of concern shall be carried out by the Contractor and the Employer's Representative, including asymmetrical behaviour.
- The Contractor shall assess the extent to which the deformations comply with the SCL serviceability and extreme limit conditions.
- Together with the Employer's Representative, the Contractor shall decide whether changes in the SCL, other support elements and excavation sequence are required. This is an interactive process that will determine whether it is safe to proceed with construction or if there is reasonable cause for concern, the extent to which it is necessary to implement additional measures or emergency procedures. These measures will be included in a new RESS.
- The Contractor and Employer's Representative shall implement the Action Plan, the emergency response to develop contingency measures. If there is founded cause for concern, it is emphasised that the response must be rapid. Please refer to point 8.7.
- The performance of the tunnel is kept under continuous review until the monitoring data indicate that KPI

trends show a stable condition.

At least three trigger values shall be established: a green, amber and red limit. The green limit marks the boundary of normal behaviour. The amber marks the boundary of serviceability while the red trigger should be set below the ultimate capacity of the lining. The Contractor's Action Plan should include pre-planned contingency measures that can be taken if a trigger value is exceeded.

All monitoring results which indicate that amber and red trigger levels are reached in a specific tunnel section, shall be cross-checked through an on-site inspection to the concerned section/stretch, in order to detect lining structural defects, signs or symptoms which may confirm the instrumentation monitoring interpretation.

If a trigger value is reached, first the site team should check that the reading is correct, reliable and consistent with the readings from other instruments. If the trigger has really been breached, then contingency measures will be instigated, in accordance with a predefined Action Plan and as directed in the DRM. The contingency measures are designed to correct any anomalous behaviour.

8.6 Required Excavation and Support Sheet (RESS)

Based on the design and the evaluation of the results of monitoring, a RESS will be issued as the outcome of the Daily Review Meeting (DRM) as per Clause 8.4. In the absence of any approved changes, the RESS will reflect exactly what is shown on the relevant design drawings.

The RESS shall be prepared and endorsed by the Contractor's Site Manager, who is responsible for the tunnelling works, the Designer and the Employer's Representative on site. Unless all the three signatures are obtained, the proposals indicated on the RESS shall not be implemented. It shall be applied a communication procedure to ensure agility in the decisions and actions derived from.

The RESS shall address, but not necessary be limited to, the following matters:

- the tunnel section (chainage) to which the RESS is applicable
- the support to be installed
- the excavation sequence
- the method of working related to ground support including staging of application of sprayed-concrete layers and lapping of reinforcement
- monitoring to be installed in the tunnel section in question, and spacing between sections
- measures to be taken during stoppage of works
- other instructions relevant to the tunnel section in question
- reference to relevant design drawings
- ground conditioning

A copy of the RESS will be given to the foreman in charge of the work in the tunnel and shall be kept at the working face.

A RESS is required for every advance per round of the tunnel excavation.

If, for any reason, the approved design method of working is changed, then this will be reviewed prior to the DRM and, subject to acceptance by the Employer's Representative, a new RESS will be issued.

8.7 Contingency Measures and Emergency Procedures

The Contractor shall determine contingency measures to deal with potential hazards that may affect the Works. The Contractor shall submit for approval to the Employer's Representative an Action Plan which shall detail the actions, procedures and contingency measures to be followed, in the event that the monitoring system shows unacceptable levels of deformation/displacement, or other variables defined in the warning & alarm criteria, if potential hazards occur.

Hazards to be addressed include:

- changing ground conditions
- excessive strain of the linings
- excessive ground (and surface/structures if it is the case) deformations
- unplanned stoppages
- insufficient labour resources
- failure of services to underground works (air, light, power, etc.)
- incidents within underground works
- delay in supply of sprayed concrete (SCL)

Among the first measures designed in the Action Plan are:

- Verification of the reliability of instrument readings, and level of confidence w.r.t. real ground/lining system behaviour. It must be cross checked with an additional set of measurements.
- Site inspection to evaluate the effects of unacceptable values, or critical trends in variables/parameters controlled, on the tunnel lining or structures concerned. If the visual inspection shows signs of excessive deformation, new structural defects (cracks), or overstress symptoms (bending of steel reinforcement, LSC

limit deformation, etc.), it is required to activate the support countermeasures protocol.

- Increase of density of monitoring sections along the concerned stretch to evaluate the extension of the phenomenon or potential hazard. This shall be executed according to specified subsidiary monitoring sections.
- Increase of frequency in monitoring readings for concerned sections or stretch
- Activation of support countermeasures protocol, with quick action based on coordination of all involved parties. It is important to establish the trigger limits which allow applying on time support countermeasures compatible with the response time available, in order to avoid further lining degradation, and protect the structural integrity of tunnel.

In underground construction works, changes tend to be progressive with evidence of structure or ground behaviour becoming apparent before failure occurs. For this situation a system of hierarchical trigger levels will be appropriate. This allows proportionate response to adverse indications from monitoring.

Trigger levels will be based on the results of assessments of at-risk infrastructure. If the assessment indicates that the at-risk infrastructure is unlikely to be able to tolerate the change due to the Works, then triggers will be set based on the levels of change that will be tolerable.

There may be some situations where change is less progressive and monitoring may simply be required to give a yes/no response. In these cases, reporting is simple and systems of triggers are not appropriate.

8.8 Instrumentation

8.8.1 General

The supply of all labour, supervisors, plant, Contractor's Equipment and materials and the execution of all work necessary to supply, assemble, check, calibrate, drill, install, backfill, embed, test and protect instrumentation in the tunnel and appurtenant structures or elsewhere as specified on the drawings and as specified herein, shall be provided by the Contractor.

During the period of the Contract, the Contractor shall ensure that his construction operations do not interfere with, or damage any of the existing instrumentation, shown on the drawings, or the instrumentation to be installed by the Contractor and by others. The Contractor will be penalized, as specified herein if any of the existing instruments or instruments that have been installed by others or by the Contractor, are damaged by his construction equipment. In addition to the penalty, the Contractor, within the days required by the Employer's Representative, shall supply and install a replacement instrument adjacent to each instrument that was damaged by his construction equipment, at no additional cost to the Employer.

Not less than 120 days prior to the required installation date of each instrument, which is shown on the Contractor's work schedule, the Employer's Representative will either confirm that the instrument to be supplied is to conform to the requirements of the Specifications or he will issue information on the number, type, model number, manufacturer, supplier, location and other details of the instrument or instruments that are to be supplied and installed.

The Contractor's request for approval to supply and install alternative instruments shall provide sufficient information on each alternative instrument for the Employer's Representative to compare it with the specified instrument. The information shall be submitted to the Employer's Representative not less than 90 days prior to the first installation of that instrument.

Not less than 60 days prior to the start of instrument installation, the Contractor shall submit to the Employer's Representative a detailed description of all instrumentation, cabling and accessories including any ancillary measuring equipment, details of his checking, testing, calibrating, installing and monitoring procedures for each of the instruments.

Not less than 30 days prior to installation, each instrument shall be checked, tested and calibrated according to the instrument manufacturer's instructions and as specified herein to ensure that the instruments are in good working order and properly calibrated. A report on each such checking, testing and calibration of each instrument shall be submitted to the Employer's Representative not more than seven days after the checking, testing and calibration of that instrument.

Each instrument shall have a certificate from the manufacturer stating that the instrument was assembled in its factory, inspected before leaving such factory and presenting details of the instrument tests and calibration. A copy of the certificate for each instrument shall be submitted to the Employer's Representative not more than three days after the delivery of the instrument to the site.

A manual shall be provided with each type of instrument.

The Contractor shall supply all components, accessories and electrical leads for the instruments from the sensor to the observation house or station including materials, equipment and tools required to install, calibrate and protect the instruments as specified herein and as shown on the drawings.

All instruments and their accessories shall be new and have been successfully performed in similar projects.

The instruments and accessories shall be stored at the site by the Contractor under the condition conforming to the manufacturer's requirements.

Instruments shall be handled, stored and installed with care so as to avoid damage. If during handling, storing and installation instruments are damaged, the Contractor shall replace and reinstall the instruments within 30 days as specified herein, as shown on the drawings or as required by the Employer's Representative and at no additional cost to the Employer.

All instruments and equipment used and required for the geotechnical measurements shall be made available to the Employer's Representative throughout the construction period.

8.8.2 Installation Comments

Instruments shall be installed as specified herein and in accordance with manufacturer's instructions at the locations and to the lines, slopes, dimensions and elevations shown on the drawings or directed by the Employer's Representative. No instrument shall be installed until the Employer's Representative has approved the testing and calibration. Instruments and instrument leads shall not be backfilled or embedded in concrete until the Employer's Representative has inspected the installation and has given his approval.

All work in connection with the calibration and installation of instrumentation shall only be done in the presence of the Employer's Representative. Calibrating, adjusting, assembling, installing and maintenance work in connection with the installation of instrumentation shall be undertaken by personnel who have been employed full time during the last five years installing geotechnical and other instruments on major civil works projects.

Instrument installation shall be supervised by a graduated geotechnical Employer's Representative who has specialized in the installation and monitoring of instruments in soil, rock, fill, concrete and metals.

The instrumentation supervisor and all other Contractor's personnel working on instrument installation shall be subject to the approval of the Employer's Representative and shall be replaced for cause if required by the Employer's Representative. Unless otherwise required by the Employer's Representative, the calibration of each instrument shall be checked and, if necessary, adjusted at the site and the instrument shall be installed by the Contractor, all in the presence of a representative of the manufacturer.

During construction of the Works, the Employer's Representative will survey the installed locations of instruments. The Employer's Representative will take an initial set of readings of all instruments immediately after the Contractor has completed their installation. The placement of concrete and backfill material over the instruments or instrument leads shall not be started until these readings have been taken.

To ensure that the instruments are being installed as specified and to make a permanent record of the soil and rock properties, the Employer's Representative will take samples of soil and rock from drill holes and will perform in situ tests whenever he considers them necessary. The Contractor shall allow time in his construction schedule to enable such samples to be taken and such tests to be made.

All instruments and connections shall be protected from damage and displacement during the progress of the work.

At all times, the Contractor shall ensure that adequate lighting is available, whether by natural or artificial means, to ensure proper execution of the work.

Instruments embedded in concrete shall be visibly and clearly marked. No traffic or equipment other than placing and compacting equipment, or shotcrete machine required for concrete placement shall be allowed to pass close to any instrument or connection installed in the concrete or rock until they are conveniently embedded. Protection cages, markers and barricades shall be provided by the Contractor where required by the Employer's Representative.

Cables and tubes shall be installed in the maximum lengths practicable. Splicing and coupling shall be performed in accordance with the manufacturer's recommendations. Calibration readings shall be taken prior to and immediately after splicing. Open ends of all incomplete lines of tubing and casing shall be kept plugged or sealed and the Contractor shall at all times during installation keep the insides of casings and tubes free from

foreign matter. Cables and tubes shall be protected from mechanical damage.

The instrumentation shall be put in operation at the earliest practicable period during construction in order to obtain relevant information pertaining to the support design performance of the tunnel.

The Contractor shall protect all instruments and connections from damage and displacement during the progress of the Works. If damage or displacement of the instruments or connections occurs during the progress of the Works, they shall be repaired or replaced immediately by the Contractor and new baseline readings shall be taken before any further construction work proceeds.

The Contractor shall be fully responsible for the maintenance and repair of all instrumentation for the duration of the Contract period.

The geotechnical instrumentation and monitoring program may always be subject to alterations and modifications if required by the actual geological or geotechnical conditions or the Employer's Representative.

8.8.3 Quality Assurance

The Contractor shall prove that the system of monitoring instruments and measurement devices are suited to the particular purpose and fulfil the requirements and specifications. All instruments shall be factory calibrated and shall have multiple zero reading features. The Contractor shall carry out an agreed program of functional tests.

Comments on instrument calibrations and certificates are included in paragraph 8.8.1.

Not more than 15 days after the installation of each instrument, the Contractor shall submit type and model of instrument, location coordinates and elevation, date and time of installation, weather, temperature, rainfall and wind conditions, construction activities in the vicinity during installation, drilling records, core log, groundwater observations, a description of any unusual observations during drilling, installation records, method, materials, any unusual observations during installation, a plan and sections to scale showing the structure in which the instrument has been installed, instrument location, the exact location of the leads, location of all connections in the leads, the materials used in its installation, colour photographs of the installation including close-ups of the instrument before embedment and adjustments made and testing data taken during installation.

The Contractor shall cooperate with the Employer's Representative to permit continuous observations and recording of the data to be obtained by the Employer's

Representative from existing instruments previously installed and those installed by the Contractor and by others.

The Contractor shall allow in his construction planning for the instrument readings to be completed by the Employer's Representative within a reasonable time.

During the time that the instruments are being read no construction equipment shall be operated within 50 meters of the instrument.

The Contractor, after consultation with the Employer's Representative, shall program his work and make all necessary arrangements to allow the reading of instruments as soon as possible after their installation. Such arrangements shall include, where necessary, the provision of temporary read out points.

During construction, the Contractor shall read the instruments according to the data requirement of the ground behaviour as specified in this section or as directed by the Employer's Representative. The data collected from instrumentation should be immediately provided to the Employer's Representative for his use and he should have access to all the data records through the construction period.

During the service life of equipment, calibrations of readout units are required.

Calibrations of any embedded components provided with in-place calibration check features shall also be required. Instrument calibrations shall be performed by qualified personnel responsible for data collection. The intervals for calibration shall follow the manufacturer's recommendations or be carried out as requested by the Employer's Representative.

Parts of the instrumentation which are not embedded in the rock, fill or other protective material, shall be adequately protected against mechanical (e.g. site vehicles) and environmental damage. Protective covers or housings shall be used to prevent damage of the instruments.

The installed measuring instrumentation as well as the required space for measuring must be kept free and accessible for the entire duration of construction works. Defective or damaged measuring devices shall be replaced at the earliest opportunity to enable the continuity in monitoring readings and trend-lines.

The Contractor shall arrange and maintain all the equipment throughout the construction period which is required for the installation and the monitoring of the measuring sections.

8.8.4 Installation and Reading Frequency

In case of absolute 3D displacement monitoring through optical methods, two measuring cross sections, main measuring sections and subsidiary measuring sections, are defined. The distance between measuring sections with respect to the Excavation & Support Class shall be in accordance to following Table:

Table 8: Distance between measuring sections

Support Category (E&S Class)	Main measuring section	Subsidiary measuring section
10	150 m	75 m
11	150 m	50 m
1	100 m	50 m
2	75 m	37.5 m
3a	50 m	25 m
3b	50 m	25 m
4	30 m	15 m
5b-5v	30 m	10 m
5a	20 m	10 m
5w	20 m	6.5 m

The locations of convergence sections with convergence pin installation will be same as above, allowing cross-check measurement verification for both the methods. The number of convergence pins per section will be the same than optical reflectors, and locations as closest as possible.

The purpose of subsidiary measuring section is to be installed and control activated in the stretches where the main measuring sections are showing displacement exceeding the allowable limits or trigger values.

It might be noted as well that the spacing between optical instrument sections are integer divisions of the distance between cross passages (330 m), because in the cross passages intersections it is required minimum a monitoring section, plus two subsidiary sections (at both sides of CP axis, one per side) for the E&S Classes 3 to 5.

The number of instruments as specified in 8.9 installed in each measuring section shall be in compliance with below Table, with respect to the support category existent in the main measuring section. It is reflected also the recommended spacing between sections, quantified as a multiple of spacing of optical/convergence pins sections

It is assumed that in E&S Classes 10, 11, 1 and 2 there is no requirement of instrument installation and monitoring control other than optical reflector or convergence pins sections. In case of unfavourable evolution or trend in displacements, it could be required the installation of instruments in that section, under the consideration and approval of Employer's representative, but the habitual lack of agility in this process may invalidate this contingency measure.

Table 9: Instrumentation per measuring point with respect to the support category

Instrument	No. per Main measuring section			Spacing b/sections w.r.t. optical spacing		
	E&S Class 3	E&S Class 4	E&S Class 5	E&S Class 3	E&S Class 4	E&S Class 5
Reflectors/ targets/pins	5	5 - (+1 invert)	5 section 5 in face (+1 invert)	x 1 - -	x 1 - x 3	x 1 x 3 x 1
MPBE Extensometers	-	3: crown & 2 shoulders Rods: 3, 6, 9 & 12 m long	3: crown & 2 shoulders Rods: 6, 9, 12 & 15 m long	-	-x 10	x 8
Anchor load cell	-	4, 2 per TH sidewall	6, preferably 3 per sidewall	-	x 5	x 3

Instrument	No. per Main measuring section			Spacing b/sections w.r.t. optical spacing		
	E&S Class 3	E&S Class 4	E&S Class 5	E&S Class 3	E&S Class 4	E&S Class 5
Strain gauges	-	4, 2 per side symmetrical.	6, 3 per side symmetrical		x 10	x 8
Radial pressure cells	-	4, 2 per side symmetrical.	6, 3 per side symmetrical		x 15	x 12
Sliding micrometre	-	-	1 at face centre (full section)	-	-	x 3

Note: Values enclosed in parenthesis are optional, depending on monitoring results and interference

The Employer's Representative will take the initial readings on each instrument which will consist of not less than five separate readings at intervals of 15 minutes. The further reading frequency of each instrument shall be in accordance to following Table unless otherwise specified herein or directed by the Employer's Representative.

Table 10: Reading frequencies with respect to distance to face, E&S Class and time after installation or period

Distance to face (TH, BN or IN)	Time period in days (only for relevant E&S Classes) Max. expected velocity of deformation			Reading frequency
	E&S Class 3	E&S Class 4	E&S Class 5	
0 (-30 at BN & IN)-+50 m	(-10 at BN & IN)-20 2.5-1.5 mm/day	(-15 at BN & IN)-30 6.5-8.6 mm/day	(-25 at BN & IN)-50 14.0-17.5 mm/day	every 24 hours
50-120 m	20-50	30-75	50-100	every 48 hours
120-300 m	50-100	75-180	100-240	once per week
More than 300 m	>100	>180	>240	once per month

Note: TH refers to Top heading stage, BN to benching stage, and IN to invert

Reading intervals shall be agreed with the Employer's Representative and shall be dependent on the position of the excavation face, activities in the vicinity and actual deformation behavior. However, the Contractor shall increase the reading frequency whenever directed by the Employer's Representative.

In the event of any change of trend or where other circumstances may be anticipated, for example influence due to the construction of other structures or nearby junctions, openings or intersections, the frequency of readings shall be increased.

Readings shall continue to be taken until the rate of change in the reading has diminished sufficiently to allow a lower frequency to be adopted with the confidence that the safety of the works is not in doubt and such that the amount of data retrieved allows trends with time to be clearly identified and evaluated. Decrease of any reading frequency shall be in agreement with the Employer's Representative. At any time the Employer's Representative may require an increase of reading frequency. The readings of instruments shall not be ended without the approval of the Employer's Representative.

When the bench is approaching the instrumentation section, which was installed during top heading, the reading frequencies shall be increased again. When the parallel tunnel tube approaches the station of an instrumentation section installed in the first tunnel tube, readings shall be activated again and reading frequencies increased respectively.

At sections where increasing rates of deformation occur, readings shall be taken frequently (at least once per day) until the rate of deformation decreases with time.

Readings shall be taken by the same personnel. If the person needs to be replaced, a series of duplicate readings shall be carried out by the out-going person and the replacement.

The Contractor shall ensure that all activities carried out during the execution of the monitoring programme comply with his Health and Safety Management Plan.

8.8.5 Trigger limits for deformations

The trigger limits for tunnel periphery deformations are green zone to amber zone limit, corresponding to 75% of expected deformation by calculation (deformation tolerance) specified in DPR Design Report, and amber zone to red zone limit, corresponding to 125% of deformation tolerance.

The absolute limit before which the contingency measures and support countermeasures must have been executed or put on ground is the Alarm Limit indicated in the DPR Design Report.

Table 11: Trigger deformation limits for E&S Classes

Excavation & Support Class	Trigger deformation limits (mm)		
	Green limits	Amber limits	Red limits
E&S Class 10	12 (UP) 9 (LO)	19 (UP) 12 (LO)	30 (UP) 19 (LO)
E&S Class 11	13 (UP) 8 (LO)	22 (UP) 13 (LO)	35 (UP) 22 (LO)
E&S Class 1	19 (UP) 12 (LO)	32 (UP) 19 (LO)	40 (UP) 32 (LO)
E&S Class 2	15 (UP) 10 (LO)	25 (UP) 15 (LO)	35 (UP) 25 (LO)
E&S Class 3	22 (UP) 15 (LO)	38 (UP) 22 (LO)	60 (UP) 38 (LO)
E&S Class 4	44 (UP) 30 (LO)	76 (UP) 44 (LO)	120 (UP) 76 (LO)
E&S Class 5a (SM)	135 (UP) 90 (LO)	225 (UP) 135 (LO)	360 (UP) 225 (LO)
E&S Class 5v	165 (UP) 110 (LO)	275 (UP) 165 (LO)	440 (UP) 275 (LO)

Note: UP refers to upper limit and LO refers to lower limit

8.8.6 Reading Information and Presentation

Measurement results shall be both tabulated and presented to the Employer's

Representative in graphical form. The graphical data submission shall be presented as follows:

- development of measuring results versus time related to the progress of the excavation headings
- development of measuring results versus distance of the measuring sections from the excavation face

The Contractor shall use a software package to allow a direct data flow from the optical displacement measurements and to be in compliance with the following Specifications:

- free stationing of the theodolite and calculation of standard deviation in all three coordinate directions
- automatic target identification and recognition of new zero readings
- calculation of 3D-coordinates and displacements of any desired point and its radial distance to the theoretical profile
- correction of errors based on physical effects
- transformation of coordinates after control measurements
- measurement results shall be tabulated and presented in graphs

When recording instrumentation readings, all site conditions that may affect the results shall be recorded including but not limited to the following:

- progress of excavation and other works
- time elapsed between particular construction activities
- taking of first readings
- temperature and humidity
- date and time of reading
- measuring instrument and / or read out unit reference

8.9 Requirements of Instruments

8.9.1 Bolts and Pins

Bolts or pins shall consist of ribbed bars protected against corrosion with a minimum length of 250 mm. Prior to

installation of bolts and pins the type shall be approved by the Employer's Representative. The pins shall be securely attached to the exposed rock or shotcrete surface. After installation the convergency pins shall be protected by a protective cap.

In case of opto-electronical measurements the bolts shall be provided with a plastic cap with a predetermined breaking point serving as an adapter for the mounting of a reflector with marked centre point.

8.9.2 Theodolites and Reflectors for Convergence Measurement

Convergence measurement shall be performed in underground excavation works to determine the absolute horizontal and vertical displacements of measuring points placed around the excavation perimeter.

The measuring points shall consist of plastic reflectors of an approved manufacturer by the Employer's Representative and mounted on a treaded bar grouted into predrilled holes.

The absolute position of the reflectors shall be measured in 3-dimensional space by opto-electronical theodolite equipped with coaxial electronic distance measuring facility and data logging. The equipment shall be such as to ensure an accuracy of 3 seconds for directions and an accuracy of ± 0.1 mm for distances.

The reflectors shall be installed directly behind the face within the heading and bench zones, as appropriate, immediately after the installation of supports. Installation frequencies and numbers of reflectors per measuring cross section shall be in compliance with Table 4, Table 5 and Table 6 or as directed by the Employer's Representative.

The reflectors shall be designed for high precision measurements with two axes of rotation and to be observable from both sides.

The reflectors may be replaced by a positive centred prism, if required, with the same standard as the reflector above and in agreement with the Employer's Representative.

The recorded data shall be available and submitted to the Employer's Representative on a daily basis and discussed as per Clause 8.4.

8.9.3 Tape Extensometers

Convergence measurements shall be supplemented by direct measurement of convergence using tape extensometer units. Arrays consisting of three bolts or pins shall be installed at a spacing of 100 m or as directed by the Employer's

Representative. At each cross section a pin or bolt shall be installed in the crown of the tunnel with the two remaining pins or bolts to be installed in the side walls to enable convergence in three directions.

The tape extensometer unit shall comprise of a steel tape, fixed to the reference pins and tensioned with a constant force. An integrated dial gauge shall allow a sufficient accurate measurement.

8.9.4 Borehole Extensometers

Rod extensometers shall be installed in boreholes drilled in tunnel in upward, horizontal and downward directions.

The rods shall consist of fibre glass or stainless steel fitted with groutable anchors with grout tubes, packers, protective tubes and caps and shall be of the multipoint point type with not less than four downhole anchors installed at different elevations in the bore hole, a rod connected to each anchor and a reference head, where measurements are made. The furthest anchor may be 25 m from the excavation perimeter. So the Contractor shall allow and provide drilling equipment for such a length and for the borehole diameter required for four anchors in one hole in compliance with the manufacturer's recommendations and requirements.

Reference heads shall be of the electric version fitted with displacement transducers to allow remote read out or the use of data loggers. Displacement transducers shall be of the vibrating wire or potentiometer type.

Multipoint extensometers may have a cumulated rod length of up to 50 m and shall comply with the following Specifications:

- Measuring range: 150 mm
- Accuracy: ± 0.01 mm
- Resolution: 0.1 %

8.9.5 Strain Gauges

8.9.5.1 General

Strain gauges shall be required to record the tensile and/or compressive strain in concrete and shotcrete linings and in steel ribs and shall be of the vibrating wire type.

Strain gauges shall be used to measure strain in the tunnel lining which will be used to monitor the performance of the lining in the long term.

Strain gauges to measure strain in steel ribs are used to monitor the performance of the steel rib support.

Strain gauges shall be supplied by an approved manufacturer by the Employer's

Representative and shall permit a remote readout and data storage using an appropriate data recorder.

8.9.5.2 Concrete Strain Gauges

Concrete strain gauges shall be of the embedment type and shall be orientated in the tangential and radial direction before the placing of the concrete for the final tunnel lining or the application of sprayed concrete for the primary lining.

Concrete strain gauges shall be installed in the final tunnel lining as directed by the Employer's Representative.

Concrete strain gauges shall comply with the following Specifications:

- Measuring range: 3000 micro strain, set mid-range
- Operating temperature: -50°C to 100°C

8.9.5.3 Steel Rib Strain Gauges

Strain gauges for steel ribs shall be of the surface mount type and shall be installed parallel to the axis of the steel set and located on the centre line of the web of the steel set.

Strain gauges shall be installed on steel ribs as directed by the Employer's Representative.

Steel rib gauges shall comply with the following Specifications:

- Measuring range: 3000 micro strain, set mid-range
- Operating temperature: -50°C to 100°C
- Resolution: 1 micro strain
- Accuracy: ± 0.1 % F S

8.9.5.4 Load Cells for Rock Bolts and Rock Anchors

Load cells are required to measure and monitor loads within rock bolts and rock anchors. The capacities of the load cells shall be 300 and 600 kN and they shall be suitable for the specified rock bolts and rock anchors.

The cells shall be installed as directed by the Employer's Representative.

Load Cells shall comply with the following Specifications:

- ☐ Load capacity: 150% of FS
- ☐ Accuracy: ± 0.5 % FS
- ☐ Resolution: 0.1% of FS

8.9.5.5 Pressure Cells

Hydraulic pressure cells shall be used for measurement of stress distribution in tunnel lining and sprayed concrete. Hydraulic pressure cells shall consist of a flat jack, which is placed at the rock surface or in the sprayed concrete, so that increasing stress can act on the flat jack. The pressure cells shall be installed as directed by the Employer's Representative. The change of pressure shall be measured and the radial and tangential loads determined.

8.9.5.6 Temperature Gauges

Temperature gauges are required to monitor the temperatures in concrete structures as directed by the Employer's Representative. These gauges are in addition to those the Contractor may need to control the placement temperature of the concrete in compliance with Clause 10.1.4.

The temperature gauges shall comply with the following Specifications:

- Minimum range: -10°C to +80°C
- Accuracy: $\pm 0.2^\circ\text{C}$
- Resolution: 0.1 °C

8.9.6 Cables

Special cables suitable for use in concrete shall be used and shall be subject to the approval of the Employer's Representative.

All cabled instruments shall be supplied complete with the required length of cable. Splicing of cables on site shall be avoided wherever possible. No splicing of cables on site may be performed without the approval of the Employer's Representative.

Switchboxes shall be mounted in recesses in concrete structures, in instrument housings or at temporary read out points. Switchboxes shall be weather- and dustproof and all metal parts shall be of stainless material.

8.9.7 Portable Readout Units

The Contractor shall supply sets of portable readout units suitable for readout of all sensors used in the work.

The readout unit shall be capable of storing of up to 2000 readings with sensor identification number, date and time of record.

The portable readout units shall comply with the Specifications defined in Table

Table 12: Requirements on portable readout units

Parameter	Specification
Range	450 - 600 Hz
Resolution	0.01% FS
Accuracy	$\pm 0.02\%$ of Hz reading
Temperature measurement	-20° - 120°C
Temperature accuracy	$\pm 1^\circ\text{C}$
Memory capacity	min 2000 readings

8.9.8 Instrument Housing

The Contractor shall construct instrument housings as required. Instrument housings shall be of steel cabinet construction with a painted mild steel lockable security door.

8.10 Probing Ahead

Where required the Contractor shall be responsible for probing ahead of the tunnel face in order to prove or investigate the ground.

The selection of plant for probing shall be agreed with the Employer's Representative and shall take the probable nature of the ground ahead and its water-bearing capacity into account.

Probing shall be carried out in such way to allow modification of the excavation and support according to the encountered ground conditions. The number of probes, the diameter of drilling, their positions in the face and angles with respect to the tunnel drive shall be governed by the actual ground conditions and the machinery in use. The maximum probed distance ahead of the face shall be governed by the ground conditions and the degree of uncertainty with distance.

The diameter of probe holes shall be not less than 38 mm.

The used flush shall be suitable for the type of ground conditions anticipated and the machinery in use.

An accurate and systematic record of probe hole positions (positions in the face and angles with respect to tunnel drives), drill penetration rate, drill parameters

(percussion, torque, thrust), flush (colour, percentage return), drilling sounds (loud, quiet, intermittent), water strikes and interpretation of the nature of the ground ahead shall be noted at the time the holes are bored and a copy provided to the Employer's Representative. Full facilities shall be provided for the Employer's Representative to inspect probing work in progress.

9 PRIMARY SUPPORT MEASURES

9.1 General

Generally, the primary support measures are installed immediately after the performed blasting round and a break of work prior to support construction is not permitted. The type and amount of tunnel support is directly related to the Rock Classification as established. The initial support associated with the established rock classification system is shown on the Employer's design drawings. The Contractor may design his own tunnel support. However, as a consequence of variations from the anticipated rock conditions the support systems as shown on the Contractor's design drawings for each Excavation Class may require modifications and adjustment during construction as directed by the Employer's Representative.

The Contractor shall ensure that support elements will be installed or applied in such a manner and sequence as to prevent disintegration and loosening of the rock mass surrounding the excavated tunnel.

Comprehensive records, containing all particulars of the tunnel support actually installed and its performance in the course of the works, shall be prepared and maintained by the Contractor and made available to the Employer's Representative on a daily basis. These records shall include type, quantity and location of installed support elements, the clearance profile after installation of support, deviations from the designed support systems, observations of excessive deformations, shotcrete cracking, etc. Observations of excessive deformations, shotcrete cracking, etc. shall be reported immediately to the Employer's Representative.

The Contractor shall keep a record of the chainage of each face position and shall keep this record updated as the face progresses. This record shall be available for consultation at any time at a convenient location close to the relevant face.

The Contractor shall record the results of all tests performed on the rock bolts prior to, during and after their installation, and submit these documents to the Employer's Representative.

The records as defined above in this Technical Specification will be submitted daily to the Employer's Representative for review and approval.

The Contractor has to check the rock mass support measures by on-going visual inspection.

Surfaces of water sensitive rock mass shall be sealed immediately with adequate measures.

The Contractor shall apply shotcrete on rock masses which tend to local overbreak immediately.

Structural support consisting of wood is only permitted temporarily. It is not permitted to leave wooden support in the shotcrete or concrete layer.

Damaged rock mass support system due to re-profiling shall be reconstructed subsequently (see also 9.12).

The Contractor has to provide an adequate amount of rock mass support systems and required equipment on the site; hence no delays of excavation shall occur. Prior to the beginning of excavation, the required rock supports shall be provided by the Contractor on the site.

Blasting round lengths, time schedules, construction sequences, quantity and location of installed support elements shall be constructed as per drawings. Deviations from the designed support systems shall be reported

immediately to the Employer's Representative and shall be approved.

The Contractor shall in case of emergency be obliged to undertake independently such support measures as he deems necessary without the prior consent of the Employer's Representative. In such cases the Contractor shall inform the Employer's Representative immediately.

Rock mass support is defined as follows:

- Primary support: is defined as the support which is installed systematically within the heading, bench and invert zone in order to ensure the short-term integrity of the underground excavation and safety of personnel during excavation. The installation of primary support is an essential element of the excavation cycle.
- Final lining: is defined as support which is installed subsequent to the primary and supplementary support and which does not form part of the normal excavation cycle. It serves as the permanent lining of the tunnel and shall be a cast in situ concrete lining, plain or reinforced according to structural requirements.
- The final lining may be installed in any section of the tunnel, with the Employer's Representative's approval, at any time after convergence measurements show that movement in the rock in the immediate vicinity has stabilised.

9.2 Rock Bolts, Anchors

9.2.1 General

Unless otherwise defined herein, rock bolts shall comply with the following Indian Standards or their equivalent International Standards:

- IS: 1786 Specifications for high strength deformed-steel bars and wires for concrete reinforcement
- IS: 2062 Steel for general structural purposes

Rock bolts are 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. Steel bars shall be grade 500 N/mm², deformed type 2 bars complying with BS 4449. Threaded parts of bars, nuts and seatings shall comply with the requirements of BS 4190. Face plates shall be of a dish shape in steel to the appropriate standard and shall have a hemispherical seating with centralised slot to suit dimensions of the rock dowels.

Where required, the bar and components shall have corrosion protection and the threaded end shall be sealed by an end cap.

Rock bolts shall be installed according to the length, direction, placement and number as per approved design drawings for each relevant Excavation Class unless otherwise determined by the Employer's Representative. Rock bolt length, direction, placement and number shall be adjusted to the Ground Type.

Comprehensive records about details of the installation of rock bolts during driveage, such as reference number, grout consistency, drilling depth, length, inclination and type of rock bolts, deviations from the theoretical position, type and time of grouting, time of tightening, special observations, details of tests carried out, geological ground condition, etc. shall be kept for each rock bolt and round by the Contractor and countersigned by the Employer's supervisory personnel. Copies of these records should be submitted to the Employer's Representative.

The trademark of rock bolts and anchors to be installed shall be approved by the Employer's Representative. A quality assessment is required, unless common anchor steel and anchor plates were used. The Contractor's construction execution shall comply with the manufacturer's specifications and recommendations regarding drilling, installing, testing and maintenance of rock bolts.

The characteristic bearing capacity of the anchor plate and the connection between the anchor and anchor plate shall be equal to the characteristic bearing capacity (P_{tk} according to BS EN 1537) of the anchor steel.

The diameter of the drillings and the drilling technique shall be adjusted to the anchor type and Ground Type. Holes for the installation of bolts shall be drilled straight and with an accuracy of $\pm 10^\circ$.

The drilling hole shall be flushed and cleaned with compressed air or water immediately prior to the installation of the bolt. The used technique shall be adjusted on the Ground Type (e.g. bore holes drilled in swelling ground no water flushing is permitted).

The water pressure during drilling may have an inadequate impact on the surrounding ground (e.g. decrease of mechanical strength properties) due to this the water pressure may be reduced or dry drilling may be conducted as directed by the Employer's Representative.

Unless instructed otherwise, rock bolts shall be installed and tensioned prior to the excavation of the next bench or round excavation. The tension force shall be determined by the Employer's Representative after completion of the initial testing program.

The Contractor shall provide torque wrenches of a type acceptable to Employer's Representative. All impact and torque wrenches shall be calibrated once every month.

The grouted hole shall be completely filled with grout. This shall be done by filling the drilled hole from the bottom of the hole and withdrawing the grout slowly, always maintaining the hose embedded in the grout. A regular surface shall be provided to seat the face plate by trimming rock surfaces or forming pads of quick-setting mortar. Where mortar pads are required, they shall be of adequate thickness and extend beyond the face plate by 25 mm all round at that thickness before being chamfered at 45°. Care shall be taken to ensure that the mortar does not interfere with the installed bolt.

9.2.2 Bearing Plates

Rock bolts shall have face plates which shall be of a dish shape in steel to the appropriate standard and shall have a hemispherical seating with centralised slot to suit the dimensions of the rock bolts.

Bearing plates shall be flat or dished steel plate of minimum dimensions of 150 x 150 x 10 mm conforming to IS: 2062, or as otherwise recommended by the manufacturer and approved by the Employer's Representative. Bevelled or hemispherical washers shall be used and nuts shall be heavy hexagonal type. For rock bolts that are permanently exposed, the bearing plates shall be coated before installation with an anti-corrosion protective coating compound. Any defects in the coating shall be adequately recoated after installation. The outer ends of the rock bolts, nuts and washers shall also be coated with anti-corrosion compound after installation and tensioning. The remaining portions of all rock bolts shall be clean and free of all deleterious materials.

Anchor plates, directed by the Employer's Representative to be checked, shall be held free until the check for the section is completed.

9.2.3 Grouted Bolts

9.2.3.1 Specifications

Grouted rock bolts (SN-bolts) shall consist of deformed reinforcing steel bars with a corrugated surface and one end shall be fitted with a suitable thread which is to receive an anchor plate and a fixing nut.

High quality cement shall be used for the grouting. The anchor shall reach 40 % of the characteristic bearing capacity (P_{tk} according to BS EN 1537) after 6 hours and 100 % of the characteristic bearing capacity after 12 hours.

Bolts shall have a minimum load capacity as defined in the design drawings. The load capacity shall also apply to the thread, nut, anchor plate and coupling, if any.

Washers and nuts shall allow the secure transfer from the anchor force to the anchor plate.

Where required, the bar and components shall have corrosion protection and the threaded end shall be sealed by an end cap.

9.2.3.2 Installation

Boreholes for all rock bolts shall be drilled to the depths as required by the lengths of rock bolts specified for the respective Excavation Class and at diameters which ensure best workability for grouting, coupling and installation. The minimum diameter of the boreholes shall be 10 mm larger than the diameter of the installed rock bolts/couplings. Holes shall be drilled to produce straight holes of the required length and with an accuracy of $\pm 10^\circ$.

The boreholes shall be cleaned out by flushing with compressed air or with clean water to remove all drill cuttings, sludge and debris prior to fixing the rock bolt. The amount of water-flushing shall be kept to an absolute minimum. The installation of rock bolts shall follow the drilling and preparation of the borehole within 3 hours.

Prior to the installation of the rock bolt, the entire borehole shall be filled with cement mortar by inserting the grout hose to the full depth of the hole and withdrawing as the grout is pumped in. The nozzle shall be kept buried in the grout as the pipe is withdrawn so that air is displaced as the hole is filled. The grouting shall start at the bottom of the hole. For grouting of vertical anchors, the consistence of the mortar shall be chosen that no mortar leakage from the hole is appearing.

The bolts are inserted in the drilling hole after filling with cement grout and therefore fully bonded with the

surrounding rock. The outer end shall be fitted with a suitable thread to receive an anchor plate, a washer and a fixing nut to allow the secure transfer of the anchor force to the anchor plate. The anchor plate is fixed on the bearing surface within 2 rounds behind the face or at least 6 hours with the anchor nut to achieve an approximate force of 20 kN. This force shall be applied by a calibrated torque wrench.

In case of confined working space and/or great length of rock bolts, coupling shall be permitted. The number of coupled parts shall be kept to a minimum. However, the load capacity of such coupled rock bolts shall not be less than that of a standard integral rock bolt. Special attention shall be paid to the grouting procedure in order to ensure full embedment of the bolt by grout.

9.2.4 Frictional Bolts

9.2.4.1 Specifications

Frictional bolts (e.g. Swellex or similar) are mechanically folded steel tubes with immediate bearing capacity after installation in the pre-drilled borehole as high water pressure (~300 bar) inflate the tube and adapt its shape to the irregularities of the borehole (split set bolt, expandable bolt or similar).

Steel anchor plates with a minimum size of 150x150 mm (thickness as required) allow the transfer of the anchor force at the anchor head to the shotcrete or rock surface. The frictional bolts shall have a minimum breaking load of 200 kN or higher as defined in the design drawings.

9.2.4.2 Installation

Boreholes for the rock bolts shall be drilled to the depths as required. The boreholes shall be cleaned of all drill cuttings, sludge and debris.

The installation of rock bolts shall be done not later than two hours after drilling of the borehole.

For inflation of bolts, equipment as recommended by the manufacturer of the bolts shall be used. After applying the water pressure, the water shall be drained into the excavation.

9.2.5 Self-Drilling Bolts

Self-drilling bolts are a combined system of a rock bolt with typical diameters larger than 32 mm outer diameter and a drill rod.

The system enables the installation of rock bolts in case of collapsing boreholes. Grouting of the bolt is conducted through the internal grouting canal.

The installation of self-drilling bolts shall be in accordance to the manufacturer's instructions and requirements.

9.2.6 Pre-stressed Anchors

Borehole drilling, grouting, installation, tensioning and testing procedures of pre-stressed ground anchors shall be in accordance with BS EN 1537.

Pre-stressed anchors shall be transported, stored and installed in compliance with the manufacturer's recommendations.

The boreholes shall be drilled in such way that the borehole is in the defined location given in the drawings within a tolerance of 75 mm and the bore hole axis is inclined within a tolerance of 2°. The maximum tolerance of the bore hole is 1/30 of the anchor length unless otherwise accepted by the Employer's Representative.

Aberration from the defined tolerances shall be submitted immediately to the Employer's Representative.

The drilling method shall be in agreement with the Employer's Representative.

The installation of buckled tendons due to transportation, storage etc. is not permitted. Boreholes shall be of sound condition prior to installation of tendons. Borehole drilling, installation of tendon and grouting shall generally be done in one working day.

Grouting pressure and volumes shall be recorded and made available to the Employer's Representative at any time for review.

The tensioning of the tendons shall commence minimal 7 days after grouting of the fixed anchor length unless otherwise specified by the Employer's Representative.

Pre-stressed anchors shall be tensioned to the specified level as per detailed design or as directed by the Employer's Representative. Pre-stressing equipment shall be calibrated not longer than 6 month prior to any pre-stressing of anchors. The protocol of calibration shall be available at the site.

Records of tensioning sequences of each anchor with information of identification of anchor, time, personal, achieved pre-stressing force and distance shall be kept at site and submitted to the Employer's Representative for review.

Testing of pre-stressed anchors shall be in compliance with Clause 9.11.1 and the requirements of the Employer's Representative. Number of anchors to be tested shall be in compliance with BS EN 1537 or as directed by the Employer's Representative.

9.2.7 Grout

Grout constituents shall comply with Clause 9.10.4 and Clause 10.1.3 of this Specification.

Cementitious grouting material shall be injected starting from the furthest point of the drilled hole so that the dowel is completely encased in grout. Grout shall not be used after a period equivalent to its initial setting time. Where cement grout is used, a set of six cubes of cement grout shall be taken when each series of rock dowels is in progress. Sampling, preparation, curing and testing shall be in accordance with BS EN 196. Half the cubes shall be tested at 1 day and the remainder at 28 days. The average compressive strength determined from any group of cubes shall exceed the specified characteristic strength by:

- 1 N/mm² for cement grout tested at 1 day
- 3 N/mm² for cement grout tested at 28 days.

9.3 Shotcrete

Shotcrete shall be mixed, charged, applied, cured and tested according to given Specifications which are based on "Specification for tunnelling" by British Tunnelling Society. Additionally, to these Specifications and where these specifications do not cover any aspect the "Guideline for Sprayed Concrete", Austrian Society for Concrete- and Construction Technology, 2005, Austria (enclosed as Appendix-1) shall be applied.

9.3.1 General

70 days prior to any shotcrete application the Contractor shall submit detailed description of shotcrete to the Employer's Representative for review and approval such as:

- number and type of equipment used for mixing, batching and applying shotcrete
- Manufacturer's certificates detailing any proposed admixture, inter alia, accelerator admixture and the Contractor's proposals for the use of such admixtures
- mix design

The Contractor shall, 42 days prior to commencement of the actual work of spraying concrete or as otherwise approved, submit results of preconstruction tests of sprayed concrete with the actual materials, inclusive of admixtures, mixed in the proportions proposed for the Works for approval.

The Contractor shall make available testing, production and application records daily to the Employer's Representative when concrete is applied. The application records shall contain information on when, where and how much sprayed concrete was applied in each operation.

The sprayed concrete shall comply with the BS EN 14487-1 Sprayed concrete, except as noted otherwise below.

The requirements listed below generally refer to high-quality temporary or permanent sprayed concrete.

This Specification is primarily for the use of wet-mix sprayed concrete but in certain circumstances dry-mix sprayed concrete may be suitable.

Sprayed concrete shall be applied by either the wet or dry process as appropriate to the circumstances. All aspects of the application of sprayed concrete shall be subject to the agreement of the Employer's Representative. Particular emphasis shall be placed on the provision of adequate ventilation.

The compressive strength of shotcrete in-situ (taken from the tunnel lining or from panels sprayed in the tunnel) shall develop progressively to a final strength according to the minimum requirements specified below. Uniaxial compressive strength tests shall be done in accordance with the provisions stipulated in Clause 9.11.3. The strength development due to suitability tests must exceed the specified in-situ strength by a factor of 1/0.85 (=1.18)

The sprayed concrete mix design shall, unless otherwise stated, comply with the characteristic strengths specified by the detailed design for early-age and long-term loading.

The 28-day-strength (cube) of shotcrete shall be minimum 45 N/mm². The strength development of shotcrete shall be such to meet 5 N/mm² after 12 hours, 10 N/mm² after 24 hrs.

9.3.2 Mixing

The Contractor shall develop a sprayed concrete mix and a plan for its production and application. Constituent materials shall comply with those listed within this Section.

The mix for shotcrete shall be designed by laboratory tests and field trials as indicated in Clause 9.11.3 of this Specification to meet the requirements for strength development and final strength.

Batching and mixing shall be carried out by equipment capable of properly mixing materials in sufficient quantity to maintain the continuous application of sprayed concrete and to the accuracy defined in BS EN 14487-2.

All measuring equipment shall be maintained in a clean serviceable condition and shall be zeroed daily and calibrated once in a month.

If required according to the support category, additional fibres shall be at a stage in the mixing suitable for the sprayed concreting equipment. Fibres shall be added and mixed in a manner to avoid clumping and bending of fibres. Any fibre clumps in the mix shall be diverted and removed by means of a screen placed over the sprayed concrete hopper. Fibres shall be uniformly distributed throughout the mortar matrix without isolated concentrations.

9.3.2.1 Aggregates

Aggregates for sprayed concrete shall comply with BS EN 12620 and the Section 10.1.3.1 of this Specification.

The aggregates shall be clean, strong, durable, suitably graded and shall not contain detrimental amounts of dust, mud, clay or organic impurities.

The aggregate shall be checked for chemical reactions, such as alkali-aggregate reaction, with latent hydraulic binders and admixtures, especially accelerators.

The grading and moisture content of the individual fractions of the aggregate shall be checked and recorded daily.

The total chloride content shall not exceed 0.35 %.

The coarse aggregates shall not contain a large quantity of long stone pieces

The maximum size of the aggregates shall not exceed 16 mm for the dry-mix process and 12 mm for the wet-mix process unless otherwise agreed with the Employer's Representative. The grading shall lie within the grading range in compliance with the Austrian Guideline on Sprayed Concrete given in Table below.

Table 13: Range of the grain size distribution for grain sizes 0/8 and 8/11

Maximum grain size [mm]	passing the screen in [m%]
11	95-100
8	85-95
4	65-75
2	45-55
1	30-40
0,5	18-25
0,25	8-12
0,063	2-6

Frozen aggregates shall not be used. Minimum temperature of the aggregates shall be 5° Celsius.

During rainy and cold weather periods the aggregates shall be stored under cover for at least 48 hours before being used, in order to reduce the water content.

9.3.2.2 Admixtures

Admixtures may be used in sprayed concrete. Admixtures shall be compatible with each other and the mix. Details of the mix design and technical data demonstrating compliance with BS EN 206-1 and BS 8500 shall be submitted to the Employer's Representative for approval.

Accelerating admixtures shall be compatible with the cement used. The compatibility shall be tested in the laboratory and in field trials to achieve the required properties for setting and strength development as specified

in Clause 9.11.3 of this Specification.

Admixtures shall be free of chlorides such that the percentage of chlorides shall not exceed 0.1% by weight.

The required characteristic values and consistency of delivery to the site shall be agreed in writing with the manufacturer of each admixture before commencement of concrete spraying. Storage conditions and usage of admixtures shall comply with the manufacturer's recommendations.

Written confirmation of the stability of admixtures with the mix water shall be provided prior to commencement of site trials.

The content of SO₃ shall not exceed 4.8% by weight of total binder content.

Only liquid alkali-free accelerators (pH value between 3.0 and 8.0 and having alkali content less than 1% by weight Na₂O equivalent) shall be used unless pre-bagged dry mix is used where powdered accelerator has already been mixed in. Only the minimum quantity of accelerator necessary shall be permitted in normal concrete spraying operations. At no stage in the strength development should the strength of the accelerated mix drop below 0.7 times the strength of the uncelebrated concrete mix. The dosage rate to be used is evaluated following the suitability tests carried out in compliance with the characteristic compressive strength requirements of Clause 9.11.3 of this Specification. Compliance with this Clause shall be demonstrated by site trials. Any addition to this dosage rate shall not exceed 1% of the cement content of the mix design by weight. The dosage rate may be reduced if required for down hand and vertical spraying positions. Automatically device shall be used to add the accelerating admixture. Actual dosage shall be decided by laboratory tests. At least one set of tests shall be performed each month.

Testing of accelerators and the base mix with respect to acceleration of setting, early strength and decrease of strength at a later age (28 days), shall take place in due time before commencement of concrete spraying.

Setting time of the Portland cement and accelerator shall be determined in accordance with BS EN 196-1 and 196-3. The results should be:

- initial set <3 min
- final set <10 min

Additives for the improvement of performance, workability etc. may be added with the approval of the Employer's Representative.

Additives intended to be used shall be included in the tests as described in Clause 9.11.3 of this Specification.

Accelerating admixtures shall be used to meet the requirements for setting and strength development of shotcrete applied in-situ.

Laboratory testing of the selected type(s) of accelerator shall be carried out at dosages as recommended by the manufacturer, to establish the variability of the above properties with dosage. Accelerators showing excessive variability with dosage will not be permitted.

Accelerators delivered to site shall be tested at least once every two months for their reaction with the Portland cement used, with particular reference to the setting behaviour and strength decrease after 28 days. The stability of accelerators during storage shall be visually inspected at similar intervals. Storage times and working temperature ranges shall be in accordance with the manufacturer's recommendations. The manufacturer's safety instructions shall be observed.

Plasticisers and retarders complying with BS EN 934-2 may be used to reduce the quantity of the mixing water and to improve the pumpability of the concrete. The effects and optimum dosages of plasticisers and retarders shall be determined by site trials.

The influence of the plasticisers and retarders within the concrete mix shall be checked regularly for setting time, water reduction and development of strength. These values shall be compared with the results from the pre-commencement trials.

Compatibility of plasticisers and retarders with Portland cements, latent hydraulic binders and accelerators shall be verified by observation and site trials.

Hydration control admixtures may be used to control the hydration of the mix as appropriate to expedite construction of the Works. The effects and optimum dosages of hydration control admixtures shall be determined by site trials.

Compatibility of hydration control admixtures with Portland cements, latent hydraulic binders and accelerators shall be verified by observation and site trials. Hydration control admixtures shall be used in accordance with the manufacturer's instructions.

Dosing of admixtures by hand shall not be permitted.

9.3.2.3 Cement & Additions

Portland cement shall conform to the requirements of BS EN 197-1 or National Standards and must be suitable for sprayed concrete application.

The cement content shall be designed to meet the strength requirements of shotcrete applied in the field.

As a minimum, Portland cement shall be CEM I, strength class 42.5; class N and R are both appropriate.

The Portland cement fineness shall not be less than 350 m²/kg and C3A content not less than 5%.

The minimum Portland cement content shall be 360 kg/m³.

The minimum total binder content shall be 400 kg/m³.

In order to determine a suitable dosage rate of accelerating admixtures, suitability tests shall be carried out

Table 14: Maximum level of additions (in percentage of binder)

Cementitious Material	Maximum Addition
Silica fume (solids)	15% of Portland cement
Pulverised fuel ash	30% of Portland cement
GGBS	30% of Portland cement

Pulverised fuel ash and ground granulated blast furnace slag shall conform to BS EN 450-1 and BS EN 15167 respectively and may also be included in the mix provided.

Silica fume shall be in the form of water slurry and shall comply with BS EN 13263-1.

Silica fume (microsilica) shall comply with the following requirements:

- The content of SiO₂ by weight of dry mass shall be not less than 85%.
- The silica fume shall not contain more than 0.4% elemental silica (by weight of dry mass) or any deleterious materials such as quartz, rust and/or cellulose fibres.

- The specific surface area shall not be less than 15000 m²/kg.
- The carbon content shall not exceed 2% and the total alkali content as Na₂O equivalent shall not exceed 2%.
- SO₃ content (by weight of dry mass) shall be less than 2%.
- pH value shall be between 5.5 and 1.0.
- The viscosity shall be 20 seconds with a 4 mm viscosity cup in accordance with British Board of Agreement Certificate 85/1568 and the relative density shall be between 1.3 and 1.4.
- The activity index shall be at least 100% after 28 days.

Testing to establish compliance with items above shall be carried out on a monthly basis.

Silica fume shall be regularly agitated by circulation pumps prior to use.

The compatibility of silica fume and liquid admixtures shall be established by carrying out appropriate accelerated testing procedures agreed with the Employer's Representative.

The optimum content of silica fume shall be determined during site trials.

9.3.2.4 Water

Water shall comply with the Clause 10.1.3.5 in this Specification.

For the dry-mix shotcrete, the water content shall be controlled by the nozzle man to suit the conditions of the shotcreting surface and location of application. An indication that the water/cement ratio is in the correct range will be, that the shotcrete will seem to have a slightly shining appearance immediately following application.

For the wet-mix shotcrete, field trials shall be carried out to determine and establish the suitable water/cement ratio.

Due to aggressive mountain water, admixtures shall be defined in agreement with Employer's Representative.

The water/cement ratio range for permanent sprayed concrete shall be not more than 0.50.

9.3.3 Application

9.3.3.1 General

Details of all equipment to be used shall be made available to the Employer's Representative prior to commencement of site trials. The sprayed concrete nozzle and ancillary equipment shall be of an adequate capacity for the volumes to be applied.

The equipment selected and approved by the Employer's Representative will be capable of maintaining the ratio of concrete and accelerator as selected from the trials and approved by the Employer's Representative. The actual ratio of accelerator to selected concrete shall be identified at the nozzle, and take into account the filling efficiency of the equipment and the efficiency of the accelerator dosage equipment to overcome the air and concrete pressure at the nozzle while spraying at typical outputs and air flows.

Equipment shall be thoroughly cleaned at least once per shift. The spray nozzle shall be checked for wear and where necessary replaced. Transport pipes consisting of hoses and pipes shall be designed to convey the concrete efficiently and without leakage or blockage. The transport pipes shall have uniform diameter appropriate to the mix characteristics determined by site trials and be free of any dents or kinks between the sprayed concrete machine and the nozzle.

Working area for sprayed concreting shall be well illuminated and ventilated. Dust pollution shall be minimised by choice of appropriate equipment and by means of additional ventilation, water sprays and by maintaining equipment in good order.

Protective clothing and dust masks shall be provided for and used by all persons present during spraying.

The equipment shall allow for air and water in any combination to be available for preparation of surfaces and/or cleaning of finished work.

The Contractor shall enable the Employer's Representative access to the sprayed concrete Works at all times and shall allow the Employer's Representative access to inspect the excavated ground surface prior to spraying, if requested.

9.3.3.2 Proficiency of Nozzlemen

Nozzlemen shall hold relevant certificates of competence issued by the Contractor or written evidence of previous satisfactory work indicating compliance with EFNARC Nozzleman Certification Scheme, ACI 506R-03 (USA) or similar National Standards to the approval of the Employer's Representative. Each crew shall demonstrate acceptable proficiency in the application of sprayed concrete to trial areas before being employed on the Works to the agreement of the Employer's Representative.

Subject to the Employer's Representative's agreement, tests for proficiency may be combined with trial mix tests.

Tests for proficiency shall use the equipment selected for use in the Works where practicable.

9.3.3.3 Applying

Rock or previously applied shotcrete surfaces to be shotcreted shall be carefully cleaned of all loose material, scale and other contaminations. It may be necessary to use compressed air and a water jet.

Where groundwater flow could interfere with the application of sprayed concrete or cause reduction in the quality of sprayed concrete. The Contractor shall take all action necessary to control groundwater. Such action shall include the channelling of water by means of pipes and chases.

In order to prevent the build-up of water pressure behind fresh sprayed concrete, apparent water shall be drained through the concrete, either with appropriate drainage holes or by other approved methods, e.g. by installing a perforated drainpipe or drainage channel covered with filter fabric and extending as approved from the leakage area to the drainage system. Such drains must be secured to the rock surface.

Drainage holes shall be drilled in the sprayed concrete lining where the build-up of water pressure may occur, and where drainage was not installed prior to the placement of sprayed concrete. The diameter and spacing of such holes shall be as directed by the Employer's Representative.

The optimum distance between nozzle and surface of application is 1.0 to 1.3 meter. The nozzle shall be positioned at right angles to the surface of application. Two nozzles shall be used at least for regular tunnel heading.

The sprayed concrete shall emerge from the nozzle in a steady uninterrupted flow. Should the flow become intermittent for any cause, the nozzleman shall direct it away from the work until it becomes constant again.

For vertical and near-vertical surfaces application shall commence at the bottom and the leading edge of the work shall be maintained at a slope. Downward spraying shall be avoided where possible. The nozzle may be inclined sufficiently to ensure reinforcement is properly embedded.

The projected shotcrete thickness d_s shall be equal to the summation of thicknesses of each shotcrete layer. The Contractor shall determine the thickness of the shotcrete layers. The maximum shotcrete layer thickness is 20 cm, thicker layers shall be constructed with sub-sequences. Subsequent layer(s) must not be applied before the previous layer has developed sufficient strength to support the additional layer(s). These additional layers shall be completed within a period not exceeding three days.

Steel ribs, roof ties, wire mesh and other reinforcement shall be embedded in shotcrete as shown on the tunnel design drawings. The minimum cover of wire mesh and re-bars applied at the inner side of a shotcrete lining shall be 4.0 cm. Voids behind reinforcement and steel ribs must be avoided.

The shotcrete lining shall be constructed in a way that all bolts and anchors are fully covered with shotcrete of the primary lining. The surface of the primary lining must be smooth enough for the application of the water proofing system according to the specification of the water proofing system.

If more than one layer of reinforcement is installed, the second layer shall not be positioned before the first one is embedded and covered completely with shotcrete.

No rebound shall be shotcreted to avoid structural weaknesses in the lining. Rebound shall be removed immediately after finishing of each shotcrete application. The rebound shall be removed, in particular at horizontal shotcrete connections due to separate excavation sequences and at all construction joints, if necessary by pneumatic hammers, prior to further application of shotcrete.

All joints in the sprayed concrete lining shall be as specified in the Design.

The surface to receive sprayed concrete shall be damp but shall not exhibit free water.

The temperature of the mix before placing shall not be below 5°C and shall not exceed 35°C unless special provisions are made. Spraying shall not be undertaken when ambient temperature is below 5°C unless special measures can be taken to provide protection against frost until the sprayed concrete has developed a

compressive strength of at least 5 MPa.

The surface of the shotcrete lining can follow the rounded surface of the rock mass including corners and edges. The minimum thickness of the shotcrete lining as given in the design drawings must be reached in every point of the lining.

Cracks in the shotcrete induced by shear failure shall be removed and a clean connecting face shall be constructed prior to further shotcreting.

The base mix concrete may be used up to 2 hours after the addition of water to the cement provided that the sprayed concrete can be applied satisfactorily. Any unused material after this time shall be discarded. This period may be extended by the use of hydration control admixtures, subject to the approval of the Employer's Representative.

9.4 Reinforcement - Wire Mesh

9.4.1 General

The reinforcement for primary support measures shall be in compliance with Clause 10.4 of this Specification.

Cutting of reinforcement for better placing due to edges is permitted; hence additional reinforcement in these sections is required.

Welded wire mesh fabric shall be installed in surface excavations in conjunction with sprayed concrete, as shown on the drawings, or as directed by the Employer's Representative. Chain link fabric may be used for surface applications if previously approved by the Employer's Representative.

9.4.2 Specification

Welded wire mesh fabric shall conform to the requirements of IS: 4948 and shall have a mesh size of 150 x 150 x 6 mm as shown on the drawings, or as required by the Employer's Representative.

The diameter of additional steel bars shall be limited to 14 mm according to Austrian Guideline "Sprayed Concrete". The characteristic yield strength of the welded wire mesh shall be 500 N/mm².

9.4.3 Installation

Welded wire fabrics shall be installed in such way so that it follows as close as possible the irregularities of the excavation surface or previous layers of shotcrete. It shall be firmly fixed to prevent vibration and change of position during spraying of shotcrete. The use of wooden pegs or pins for attaching the wire mesh to the rock surface shall not be permitted. Welded wire fabrics shall be installed in the longest practical length. The overlap for welded wire fabrics applied in the shotcrete lining shall be at least twice the pitch distance in circumferential direction. In longitudinal direction, the overlap shall be at least one pitch distance for the first layer of fabric and at least twice the pitch distance for the second layer of fabric.

A minimum concrete cover at the tunnel side of 4.0 cm of all wire mesh layers shall be provided.

9.5 Lattice Girder

9.5.1 General

Steel arches or lattice girders shall be installed to maintain the designed shape of the opening and if necessary, provide an immediate support at the working face over the length of the last excavation completed. The lattice girder mainly functions as reinforcement. If necessary, the installation of steel arches or lattice girders shall also prevent ground loss and shall improve load distribution.

For the application of support arches and lattice girders the following shall be taken into account:

- axial stress and bending moment in the steel arch ribs induced by the ground loads
- lateral stability and bracing of steel arches or lattice girders
- method of installing the steel arches or lattice girders
- method of blocking and spacing of blocking points
- bearing capacity of the ground at the toe of the arch ribs
- the stand-up time of the unsupported part of the excavation
- the groundwater regime and permeability of the ground

9.5.2 Specification

Lattice girders shall consist of three primary bars, connected by stiffening elements to the manufacturer's design or as shown on the drawings. They shall be designed so as to:

- facilitate sprayed concrete penetration into and behind the girder, thereby minimising the creation of projection shadows and/or voids
- provide good-quality bonding between the steel and sprayed concrete, to form a composite structure acting as a continuous reinforced concrete lining
- make allowance for the specified tolerances including convergence

Stiffening Elements: A minimum of 5% of the total moment of inertia shall be provided by the stiffening elements. This percentage is calculated as an average along the repeatable lengths of the lattice girder. To ensure stability against buckling, the maximum spacing between the stiffening elements shall be less than three times the cross-sectional height of the girder.

Dimensions and tolerances: The lattice girders shall be fabricated to meet minimum clearances and tolerances shown under consideration of accuracy of placement during construction, manufacturing tolerances and of lining deflection following installation. Prior to installation, each girder shall be inspected as specified below and all measurements taken shall be recorded along with any comments. Any changes in the inspection frequency must be authorised by the Employer's Representative following a review of previous inspection results.

Each girder inspection shall check the following criteria:

- That the girder is fully identified with the girder type and the unique traceability
- That the girder links and sinusoidals are in the correct positions and are adequately welded.
- That the reinforcement and plate types and sizes are as specified on the drawings.

When inspecting weld quality, the following criteria shall be used:

- The reinforcement shall be free from undercut in excess of 1 mm.
- The weld metal deposition shall be even and blend smoothly with the bars.
- The weld metal shall be free from cracks and porosity.

The chord length shall be checked by measuring the distance from the outer edge of the connection plate to the corresponding point on the connection plate at the other end of the girder. The measurement shall be taken to the nearest millimetre.

The chord height shall be checked by placing a tight cord across the centreline of the girder between the outer edges of the end plates then measuring the height from the chord to the inside edge of the lower main bar. The measurement shall be taken to the nearest millimetre. Where the girder consists of a double radius the chord lines shall be taken along the outer edge of the connection plates to the point at which the radius changes.

Lattice girders shall also comply with the following tolerances:

- The erected lattice girders shall not deviate from the design shape and position by more than -0 mm and +50 mm.
- Lattice girders shall be fabricated to include an allowance for 10 mm of convergence.

Fabrication: Each of the primary bars of the lattice girder segment shall be composed of only one piece of high-yield steel (minimum grade 500 N/mm² characteristic yielding strength). Secondary bars are either plain round profile or deformed high yield steel (minimum grade 500 N/mm² characteristic yielding strength).

The connection elements at the end of the girder segments shall be constructed of flat or angle steel to BS EN 10025:2004, grade S275JR. Connections between lattice girder segments shall be bolted as shown on the drawings. Welded connections between segments shall not be permitted. Nuts and bolts supplied are to be grade 8.8 or higher. The connections shall transfer the maximum tension load of the steel bars.

All welding shall be carried out in accordance with BS EN 1011-1:2009.

9.5.3 Installation

The single steel bar is situated at the outer side of the profile. The lattice girder is usually separated in five elements. Three elements form the top heading arch and two elements are placed as bench segments. The arch elements are connected with screwed head plates which are welded onto the main steel bars. The connection has

to transfer the (tension) forces in the steel arch bars. The lattice girders have to be embedded entirely in shotcrete.

A minimum 50 mm thick sprayed concrete layer must be in place before the installation of the lattice girders. Under no circumstance lattice girders shall be installed under unsupported ground.

Lattice girder segments shall be secured by use of steel wedges, concrete spacers, mortar sacks and/or other appropriate means to maintain position during application of sprayed concrete. The means of support shall be subject to the approval of the Employer's Representative. No wood blocking shall be used.

Lattice girders shall be firmly fixed in their final position against the excavation prior to application of sprayed concrete. Lattice girders shall be sufficiently clear of the excavation and final internal profile of the structure to accommodate the required sprayed concrete cover.

Lattice girder segments shall have butt plates and the method of installation shall ensure tight connection of all elements.

Immediately prior to concreting, casting or spraying, the lattice girder shall be rendered clean and free from deleterious matter.

9.6 Steel Ribs

9.6.1 General

Steel ribs provide an immediate support of the excavation after installation and shall subsequently act as reinforcement and load distributing members for the shotcrete lining. Steel ribs are required as support for forepoling elements, which are installed in advance of the excavation. During the entire construction period, they will contribute as load bearing members within the shotcrete lining.

The steel ribs shall be manufactured to meet the geometrical requirements for the excavation geometries for each Excavation Class including the relevant tolerances.

Prior to the beginning of the work the complete fabrication details, installation procedures and layout, details of joints, rib connections, rib spacers, geometry etc. and certificates of compliance of the materials shall be submitted to the Employer's Representative for approval.

9.6.2 Specification

The fabrication and installation of structural steel support shall conform to the latest edition of the following Indian Standards or, where not covered by these Standards, to the equivalent International Standards:

- IS: 800 Code of practice for general construction in steel
- IS: 816 Code of practice for use of metal arc welding for general construction in mild steel
- IS: 2062 Steel for general structural purposes

Rib splices shall be welded or connected with bolted plates. Splices shall not reduce the section moment of resistance. Where possible all connections shall be welded and all field connections shall be bolted.

Arches, base plates, ties and connections shall be formed from steel with the characteristic in accordance to reinforced concrete standards. Arches shall be rolled to suit the dimensional requirements of the Contract. Welding shall conform with BS EN 1011-1. Holes for ties, struts and any bolted connections shall be drilled. No burning will be allowed whether for temporary Works items or permanent elements.

Threaded tie rods and struts shall be of adequate length to suit arch centres and allow 25 mm projection each end beyond the nut.

Where arches are to be provided as part of the Contractor's obligation for support the Contractor shall provide dimensional details of the arches, calculations regarding imposed loads and design and such other information that the Employer's Representative may reasonably request.

Galvanised arches, where required, shall be treated in accordance with BS EN ISO 1461. All components, including the rods, fish plates, nuts and bolts, shall be galvanised.

9.6.3 Installation

The length of the single segments of the arch is defined by the contractor. Prior to installation the arches shall be clean and free from oil or other deleterious material.

The number of joints in the arch shall be varied to suit the Contractor's method of working subject to the

Employer's Representative's agreement. Steel ribs shall be erected to the lines and levels as indicated on the approved detail design drawings. The exact excavation levels may however be determined by the Contractor to match best his equipment and construction method subject to the approval of the Employer's Representative. Hardwood foot blocks and wedges shall be used to bring the steel ribs to the required line and level. Any timber used in the installation and setting of the steel ribs shall not be permanently remaining in sections where shotcrete or concrete is to be applied. Tie bars shall be provided to connect the rib to the adjacent steel rib and fix it securely in place.

Steel arch ribs and full circle ribs shall be firmly fixed in their final positions against the excavation. Arch bases shall be provided with integral base plates of size to suit the bearing capacity of the ground and shall bear on rock or concrete of adequate strength. If required, the base plates of the ribs shall be anchored to the rock by rock bolts. Arches and ribs shall be sufficiently clear of the excavation and the final internal profile of the structure to accommodate any required concrete cover.

Placing of the steel ribs shall be perpendicular to the tunnel axis. The bearing capacity of the steel ribs shall not be endangered by the joints of the steel segments.

Immediately after placing of the steel support, the ribs shall be interconnected and braced by means of steel tie rods in order to prevent any displacement and to maintain spacing. Immediately prior to concreting, casting or spraying, the arches, ties and struts shall be rendered clean and free from deleterious matter.

Steel ribs shall be embedded in shotcrete, in order to get contact between rock and steel rib by a solid shotcrete packing which shall have a minimum cover to steel of 40 mm. In the case of overbreak, the bulk of the void space may be filled with cast in place concrete or sprayed concrete, as approved. In the case of TH - profiles, the trough of the steel profiles shall be oriented towards the tunnel in order to enable load transfer and to avoid cavities behind the steel profile.

In sections with a ductile tunnel lining, the steel arches are cut in the area of the gaps in the shotcrete lining. To allow shortening of the steel ribs, they are connected with U-profiles, which allow lateral sliding. In these sections head plates are only used for the connection of the bench arch segments.

The Contractor shall survey and record the chainage of all steel ribs installed in order to facilitate any subsequent drilling operations.

Structural steel supports shall be maintained in position after installation. Any steel support installed improperly or damaged shall be adjusted, repaired or replaced by the Contractor without delay, as directed by the Employer's Representative.

9.7 Forepoling

9.7.1 General

To support the excavation roof (tunnel crown) forepoling elements are installed if required at the upper part of the tunnel excavation face. Forepoling shall be applied in rock and soil conditions which tend to produce overbreak, collapses or material inflows immediately following excavation. Forepoling shall be applied locally or systematically, as the circumstances require for the safety of the works and for preventing overbreak. The installation of forepoling always requires the erection of steel ribs. They shall be driven from the supporting frame in a slightly upwardly inclined direction at the crown of the heading and should penetrate at least half a set beyond the next excavation cycle.

Forepoling shall be applied as shown on the approved detail design drawings by the Contractor or as instructed by the Tunnel Designer's Representative and/or the Employer's Representative.

Forepoling shall be properly supported by the steel rib and the shotcrete above the steel rib. Therefore, the shotcreting of the gap between steel rib and the shotcreted sealed rock surface along the area of forepoling shall be completed after the installation of forepoling.

Spacing between consecutive forepoling pipes or bars around the crown of the excavation profile shall not exceed the maximum distance specified on the approved design drawings and shall be reduced if the actually prevailing geological conditions at the tunnel face require to do so.

Great care shall be taken to prevent the disturbance of face boards and supports in general during the forepoling cycle.

9.7.2 Spiles

Where spiling is employed to provide support for advancing the excavation, spiles shall be driven into the ground or placed in pre-drilled and grouted holes as specified on the drawings or by the Employer's

Representative.

9.7.2.1 Specifications

Spiling is to be done with deformed reinforcing steel bars with a corrugated surface and a nominal diameter of 32 mm or tubes with similar steel cross section according to the design drawings. Deformed reinforcing steel bars shall be of a characteristic yield strength class of at min 500 N/mm²

The length of the spiles is as given on the drawings based on the support category or directed by the Employer's Representative. The embedded length of the steel pipes shall be minimum 1 m longer than the instructed round length of the subsequently excavation step.

Pre-drilled and self-drilled spiles shall be grouted. If grout is to be used for pile installation, it shall be commensurate with the ground conditions and angle of pile inclination. If grout is used, Specification and methods should comply with those given in Clause 9.10.4 and 10.1.3 respectively.

The accuracy of pile installation shall be better than $\pm 5^\circ$ away from the alignment specified.

The number, location, overlap and angle of spiles shall be commensurate with the ground conditions and methodology specified on the Contract drawings or by the Employer's Representative.

9.7.2.2 Installation

Spiling with deformed reinforcing steel bars: The spiles are inserted in drill holes with a larger diameter which are filled with grout prior to pile installation. The spiles have a distance of approx. 30 cm. They are installed outside (onto) the steel arch and outside the excavation profile as close as possible to the theoretical line of excavation after the installation of the first layer of shotcrete. After their installation the area of the steel arch and the spiles have to be shotcreted before excavating the next round.

Spiling with steel pipes: Based on the weakness of the ground two methods of installation are commonly used. In rock the pipes are grouted in drill holes with a larger diameter. The grout is pumped into the drill hole through the steel pipe until it flows out from the annulus between rock mass and pipe. In weak ground pipes with a welded tip are pushed into a drill hole of a diameter slightly less than the outer diameter of the pipe. This leads to a tight contact and a fast interconnection of the pipes and the surrounding rock mass. The pipes are not grouted. Both types of spiles have a distance of approx. 30 cm. They are installed outside the excavation profile as described before.

Spiles shall be installed in such manner that a tensile bond is formed between the pile, the ground ahead of the proposed excavation and the sprayed concrete lining. Typically, this may involve grouting the pile into the hole for pre-drilled and self-drilling spiles or hammering the pile in.

Care shall be taken during installation of spiles to ensure minimum disturbance of the ground due to the installation process.

Probing shall be carried out in conjunction with spiling in order that fully embedded spiles are installed prior to the required location.

9.7.3 Pipe Umbrella

9.7.3.1 Specifications

Pipe umbrella shall be of steel pipes with a smooth surface and a diameter of 89 mm and a minimum wall thickness of 8 mm. The pipes shall have a length of 6 m with an overlap of minimum 2 m. The steel pipes shall have a solid steel shell (not punched). The characteristic yield strength of the pipes shall be 310MPa.

9.7.3.2 Installation

The pipes are placed outside the excavation profile as close as possible to the theoretical line of excavation. The inclination of the pipes is approx. 5° and their distance is 30-50 cm according to the ground condition. The pipes are inserted in drill holes with a larger diameter and grouted subsequently to be fully bonded with the surrounding ground.

9.8 Driven steel lagging

9.8.1 General

Steel Lagging (sheet piles) shall be employed mainly in weak ground with low cohesion with the purpose of preventing a collapse of material during and immediately after excavation. The use of lagging will always require the erection of steel ribs.

9.8.2 Specifications

Steel lagging sheets with a thickness of 4 to 6 mm shall be used.

Lengths shall be in accordance with the round length of excavation and the support requirements beyond the face as defined by the drawings or directed by the Employer's Representative.

Voids and gaps behind the lagging sheets shall be either filled with shotcrete or by contact grouting with a suitable cement mortar.

9.8.3 Installation

Lagging sheets shall be driven at distances shown on the approved detail design drawings. They shall be driven in advance of excavation of the respective round to a depth extending a minimum length of 0.5 metres beyond the face of the subsequently round length into the ground.

9.9 Yielding Elements

9.9.1 Specification

Large deformations occurring during tunnel excavation in rock with unfavourable characteristics shall be managed with yielding elements.

The primary tunnel lining shall be divided into segments by means of longitudinal gaps. To make better use of the lining capacity, yielding elements (LSC - Lining Stress Controller or equivalent) consisting of multiple steel pipes in a concentric assembly with a total length of app. 510 mm are installed in the deformation gaps in the circumferential direction.

The yielding elements shall be used to achieve controlled ductility of the tunnel lining in order to prevent overstressing. To allow a smooth initial load development, special provisions have to be foreseen (predetermined breaking points at the ends of the load tube). In order to optimize the bearing capacity of the shotcrete lining, a multi-stage system may be used in agreement with the Employer's Representative, where the bearing capacity of the element unit is increased stepwise.

It shall be possible to adjust the bearing load of the yielding elements to the actual ground conditions (e.g. variation of steel cylinders of LSC).

9.9.2 Installation

Installation shall be done prior to any shotcreting. The elements shall be fixed to the wire mesh or to steel ribs. The elements shall be protected to ensure functionality after primary lining installation prior to shotcreting.

The elements shall have proper contact to the shotcrete lining to transfer the lining forces.

9.10 Grouting

Grouting operation is defined as follows:

- contact or cavity grouting, at pressures up to 300 kPa, to fill voids between final concrete lining and primary sprayed concrete lining, or between the primary lining and rock
- consolidation grouting or strata grouting, at pressures up to 6 MPa, of the rock surrounding the excavated space, which shall commence after completion of contact grouting, where applied
- consolidation grouting or strata grouting in the heading zone, at pressures up to 6 MPa, in zones of sheared and disturbed material or of high water inflow
- final grouting of temporary drainage holes

9.10.1 General

The Contractor shall prepare a detailed grouting Specification to suit best the actual conditions encountered. This grouting specification shall be submitted to the Employer's Representative for approval unless otherwise agreed or directed by the Employer's Representative. The Tunnel Designer's Representative shall specify the maximum pressures to be used for grout injection at each location. The pressures specified are subject to approval by the Employer's Representative.

Records of all details of grouting works such as location, inclination, diameter of boreholes, drilling time, equipment used, results of water pressure tests, mix, quantity, pressure of grouting, development and special events during grouting operation etc. shall be kept by the Contractor, countersigned on site by the Employer's supervising personnel and submitted to the Employer's Representative.

Where necessary due to the nature of the ground conditions or where adverse water conditions are anticipated, the requirements for the use of special grouts shall be stated in the Contract.

Special grouts supplied by proprietary manufacturers may be used subject to agreement with the Employer's Representative.

Preconstruction grout trials shall be undertaken to demonstrate that the required setting times and strength gains will be achieved. Details of the trials and results shall be submitted to the Employer's Representative.

Quality control of grout mortar shall be in compliance with Clause 9.11.2 of this Specification.

As directed by the Employer's Representative, water pressure tests shall be carried out.

9.10.2 Drilling

Grout holes shall be drilled either with percussion type or rotary type drilling equipment, depending on Ground Type.

The diameter at the bottom of the grout holes shall not be less than 35 mm. For percussion drill holes the diameter of the drilling bit shall be at least 8 mm larger than the diameter of the couplings used for the drill rods.

Only water shall be used for flushing during drilling unless directed otherwise by the Employer's Representative. All holes shall be thoroughly cleaned immediately after drilling using water and/or air under pressure. After washing, downward holes shall be kept plugged until the commencement of grouting operation.

9.10.3 Mixing

All grout mixes shall be prepared using high speed, high shearing action mixers to produce a grout of uniform consistency.

General-purpose cement grout shall be mixed in accordance with the proportions given in Table 14. The water content shall be kept to the minimum required to ensure a smooth, fluid mix.

Table 15: Mix proportions for cement grout

Class	Proportion by mass		
	Cement	Sand	Pulverised Fuel Ash (PFA)
G1	1	-	-
G2	1	3	-
G3	1	10	-
G4	1	-	10
G5	1	-	4
G6	1	-	0,5

When, prior to pumping, mixed grout is to be stored for short periods, purpose made agitator tanks shall be used. Grout shall be used within 1 hour of mixing.

When clay or bentonite additives are used, separate mixing tanks shall be provided for mixing and agitation.

Grouts containing polymer additives shall only be mixed in a colloidal-type mixer.

Water meters shall be provided for accurate measurement of water used for mixing. Pressure gauges, safety valves, by-pass valves etc. shall be provided where required on mixers, agitators, pumps and injection hoses.

Special grouts from proprietary manufacturers shall be mixed and used in accordance with the manufacturers' instructions.

9.10.4 Materials

The following types of grout mixes may be used:

- neat cement grout, possibly with admixture
- cement-sand grout, possibly with admixture
- cement (with silica fume) grout with or without sand

- micro-cement grout
- chemical grouts (polyurethane or epoxy)

General the constituents of the grout (cement, water, sand and admixtures) shall comply with the requirements given in Clause 10.1.3 unless specified otherwise hereinafter.

9.10.4.1 Cement

Cement for grouting purposes shall in general be rapid Portland type in accordance to ENV 197. Micro-cement for grout shall be milled from pure Portland cement clinker and shall have a minimum blaine specific area of 900 m²/kg with 95% of all particles <10 and with a maximum particle size of 30.

9.10.4.2 Sand

If sand is required in the grout mix design, it shall comply to the following gradation (Table 15).

Table 16: Sand gradation used for grout mix

Sieve size in mm	Percentage passing by weight
2.00	100
1.00	90 - 100
0.50	50 - 80
0.25	18 - 48
0.125	7 - 25
0.063	0 - 3

9.10.4.3 Additives

Silica fume for grout shall be micro fine powder with an average particle size less than 0.5 um.

Pulverised fuel ash (PFA) shall not be used as a constituent of grouts which contain sulphate-resisting cement.

9.10.4.4 Admixtures

Only admixtures tested prior to the start of grouting work and approved by the Employer's Representative may be used. The approval and Manufacturer's certificates or guarantees will not be accepted as relieving the Contractor of his responsibility for the suitability of any admixture.

If admixtures or chemicals are proposed for use in grout, the Contractor shall transmit all relevant manufactures certificates (including toxicity, health, safety and environmental certification) to the Employer's Representative for review prior to any grouting measures.

Details of accelerating and retarding agents for proposed inclusion within the grout mix shall be submitted to the Employer's Representative for agreement. Any such proposal shall be submitted in conjunction with a statement which outlines the Contractor's interpretation of ground behaviour during tunnel construction.

9.10.5 Grouting

All hoses and piping should be of a small diameter to ensure a high velocity flow without segregation.

Grouting operation shall be performed without major interruptions. In case of an interruption before completion of grouting (plant breakdown), the hole shall be washed with clean water.

Grouting in the tunnel shall be performed in a manner that pressures are equally distributed and do not overstress the initial tunnel lining.

In case of any grout communicating between holes, grouting shall be done simultaneously or holes where grout issues shall be plugged.

Grouting is completed, when the required pressure can be kept constant over a period of 10 minutes.

9.10.5.1 Cavity Grouting of In-situ Lining

The Contractor shall grout all cavities, voids and spaces remaining unfilled outside the in-situ concrete lining. Grouting of a section of lining will not be allowed until that section has achieved its design strength.

Procedures for cavity grouting of in-situ lining to tunnels and shafts constructed with a waterproof membrane shall be subject to agreement with the Employer's Representative.

Grout for cavity grouting shall be in compliance with this Specification, except where otherwise agreed by the

Employer's Representative, who may direct that large voids be filled with other materials. The grout consistency shall be sufficiently fluid, but not more so, to ensure that the grout flows freely under low (<100 kN/m²) pressure into all parts of the space to be filled via grout pipes or grout holes provided for the purpose.

The injection points shall be provided and used for cavity grouting at an average of at least one per 2.5 linear metres of tunnel and more frequently in any areas of excessive overbreak. Vent pipes shall be provided extending to the highest points of cavities. The injection points for cavity grouting in arched roofs shall be located within 500 mm of the crown unless otherwise agreed by the Employer's Representative.

The Contractor's proposals for the installation of grout pipes shall be submitted to the Employer's Representative for agreement. Grout pipes and grout holes for cavity grouting shall be at least 40 mm internal diameter.

Grouting shall be carried out by equipment similar to that used for segmental tunnel grouting. Grouting pressures shall be such as not to damage the Works or any other property.

Grout pipes shall not remain within 25 mm of a finished concrete internal surface, and when no longer required all injection holes in concrete linings shall be filled with dry pack mortar to within 25 mm of the finished concrete surface and finally made good.

Control grouting, to verify that voids have been completely filled with grout, shall be carried out where directed by the Employer's Representative.

9.10.5.2 Consolidation or strata grouting

Consolidation grouting of the rock shall be carried out in sections of the Tunnel structures as shown on the drawings or as directed. Additionally, consolidation grouting may be required during the excavation works, in order to consolidate the heading face or seal off inflow of groundwater.

Strata grouting shall start with neat cement grout. Depending on the grout consumption the water/cement ratio may be reduced subsequently. In case of large grout consumption, injections shall be continued with cement mortar grout. Final injections shall be done with neat cement grout again.

Grouting of a hole will be considered as complete when the rate of grout consumption at the maximum grouting pressure is less than an amount set by the Employer's Representative, or otherwise directed.

Upon completion of grouting, the packer shall remain in the hole and the pressure maintained until the grout has attained its initial set.

9.11 Testing

9.11.1 Rock Bolts

The required bearing capacity of rock bolts is to be ensured by pull out test procedures, in agreement with the Employer's Representative. The pull out tests shall be conducted with a hydraulic press, in appearance of the Employer's Representative. The test results shall be recorded and forwarded to the Employer's Representative for review.

The equipment for pull out test procedures shall be provided and maintained by the Contractor during the whole construction phase.

9.11.1.1 Suitability Test

A detailed suitability test program elaborated by the Contractor set up on basis of BS EN 1537 shall be approved by the Employer's Representative prior to all testing work. Deviations from the European Standard shall be approved by the Employer's Representative.

Suitability tests in different ground types and with all types of bolts shall be conducted prior to the commencement of tunnelling. The tests shall be performed in similar geological ground conditions as expected during tunnel excavation. The location of the bolts to be tested shall be selected by the Employer's Representative.

A minimum of five bolts of each type shall be tested. Depending on the testing procedure and the test results the Employer's Representative may require further bolts to be tested.

Adequate testing equipment shall be provided to record bolt elongation, movement of the bolts and tension forces.

The bolts shall be installed in the designed manner and the external anchor resistance (R_a according to BS EN 1537) shall be determined. The anchor shall be stressed to the external anchor resistance R_a or to the proof load

Pp. The proof load Pp is defined to 0,8 Ptk (= characteristic bearing capacity according to BS EN1537).

For each type of rock bolt information of type, testing equipment, location and installation records, applied testing loads and records of deformation shall be forwarded to the Employees Representative. For failed pull-out tests, the evaluation and interpretation of test results as specified in BS EN 1537 and proposed action shall be submitted to the Employees Representative.

Based on the suitability tests and considering the economical respects the Constructor shall define the rock bolt types in agreement with the Employees Representative.

With specific order of the Employer's Representative rock bolts with a smaller proof load Pp (according to BS EN 1537), due to smaller shaft friction may be installed. The characteristic anchor resistance Rak of the rock bolt is therefore determined with the factor Ra (according to BS EN 1537) based on the suitability tests. Further quality testing is based on the characteristic anchor resistance Rak.

9.11.1.2 Quality Tests during Tunnel Excavation

The Employees Representative will select 5 % of all rock bolts, which shall be tested.

The test quantity can be reduced to 3 % of all rock bolts, in case of on-going positive test results and in agreement with the Employees Representative. The Employees Representative may order additional quality tests in case of a high failure rate of the rock bolts with no additional costs for the Employer. The quality tests shall be conducted in attendance of the Employees Representative and only with hydraulic presses. The test results shall be documented and forwarded to the Employees Representative for review.

The pre-stressing of rock bolts, chosen by the Employees Representative, shall be tested with adequate torque wrench.

The bearing capacity of rock bolts shall be ensured by pull out tests. The testing stress is 80 % of the critical strength (= characteristic bearing capacity Ptk according to BS EN 1537) of the bolt system.

Bolts which fail the tests or which are pulled out shall be replaced. For each failure, the Employees Representative shall require further bolts to be tested in the vicinity.

9.11.2 Grout Mortar

Prior to acceptance tests of rock bolts, tests with available cements and sands shall be carried out to determine an appropriate mix design to achieve the specified strength and a proper workability in association with the grouting equipment used.

Additives may be used to improve workability. The influence of the additive on the strength development shall be followed by tests. The grout mortar shall be tested on cubes 5 x 5 x 5 cm. The cubes shall be cured in water. Five numbers of cubes shall be prepared for each compressive strength test. The resultant strength is the average evaluated from the three remaining values after elimination of the highest and the lowest value.

During construction, cube sample shall be taken weekly at each five bolts drivage from the grouting hose at the nozzle. Preparation and evaluation shall follow the procedure as described above.

9.11.3 Shotcrete

The testing procedure and quantity of tests shall be in accordance to "Guideline for Sprayed Concrete", Austrian Society for Concrete- and Construction Technology, 2005, Austria.

An Employer's Representative shall be on site at all times to check the consistency of materials and workmanship with the design intent, and to ensure that ground and groundwater conditions are in accordance with design assumptions. The Contractor shall establish a procedure to respond effectively to changes in ground and groundwater conditions from the design assumptions.

The Contractor shall establish and maintain the instrumentation and monitoring required by the design. The Contractor shall establish a procedure that will enable prompt and regular review and effective response to the results from the instrumentation and monitoring. The shotcrete lining designer shall be included in the monitoring review procedure.

9.11.3.1 Strength

The compressive strength of sprayed concrete after 28 days shall be in accordance with BS EN 206-1, with minimum concrete strength class C35/45. According to BS EN 13791 a reduction factor of 0.85 can be applied for cores from in-situ concrete. The early-strength development shall conform to Table 16, unless otherwise specified in the detailed design.

Table 17: Sprayed concrete early strength development for a C35/45 mix,

Age	Uniaxial compressive strength (cube), MPa
1 h	0,5
3 h	2,0
12 h	5
24 h	10
28 d	45

The concrete shall not show any decrease in strength with time.

9.11.3.2 Field suitability tests - preconstruction tests

Prior to first application of shotcrete mixture in the tunnel the field suitability tests under construction conditions using concrete components intended for executing the construction job shall be performed and approved by the Employer's Representative. Field suitability tests determine the early and final strength of the intended shotcrete mixture. If the conditions or the mixture of the shotcrete vary to the tested ones, the field suitability test has to be repeated.

The equipment proposed for the application of concrete in the Works shall be used for the trial. The trial will establish whether the selected equipment is capable of efficiently mixing concrete, accelerator and air at the nozzle, and is capable of positioning the nozzle at a suitable distance and orientation to the surface geometry of the structure to which the concrete is to be applied.

For each mix design a trial mix shall be sprayed into test panels (3 Nos. per trial mix). Different dosages of the accelerating admixture shall be tested following the recommendation of the accelerator manufacturer.

If a particular quality of finish is required other than as sprayed, the trials will evaluate the methods and tools to be used to achieve the required finish and the Employer's Representative will approve the method and quality of finish achieved.

The compressive strength development up to 1.2 N/mm² shall be determined indirectly by the Penetrometer using a plunger of 3 mm diameter.

The compressive strength development in the range between 2 and 16 N/mm² shall be determined using the bolt-driving method.

The compressive strength above 10 N/mm² shall be determined by crushing of cylindrical shotcrete specimens. After spraying, the test panels shall be covered and not be moved for 18 hours after spraying. Cores for strength testing shall be obtained from the panels between 18 hours and 1 day. The cores for determination of final strength shall be stored in water until 3 days before testing. The specimens shall have a diameter of 100 mm and be cut to a height of 100 mm. The average value of five test results shall exceed the strength specified in Clause 9.3.1 by 5 N/mm².

If required by the Employer's Representative, the trial shall include the construction of the proposed joints including layer joints and advance joints.

Should any mix fail to produce satisfactory sprayed concrete, the Contractor shall repeat the construction of test panels and test the same mix, plant and labour or make such adjustments as he considers as necessary.

9.11.3.3 Quality Control Tests

The performance requirements shall be set by the Designer.

The strength class of the shotcrete shall be ensured by the quality tests. If the strength class of the tested shotcrete is smaller than the required one, adequate measures shall be performed to secure the shotcrete strength. The Employer's Representative shall, in the event of repeated failure in Quality Control, require the Contractor to adjust the mix to achieve the required strength. A new quality test shall be performed if differences in the mixture of the shotcrete will be taken.

In sections where the strength class can't be ensured, the thickness of the shotcrete layer may be increased, by order from the Employer's Representative, based on following equation:

F is the required compression strength in N/mm², M is the measured compression strength in N/mm², d is the required theoretical shotcrete thickness in cm and d1 is the additional required shotcrete thickness in cm.

The Contractor shall keep a record, in a form to be agreed with the Employer's Representative, of all tests on sprayed concrete, which shall be kept on site identifying the tests with the section of work to which they relate.

The testing procedure and quantity of tests is according to the Austrian Guideline “Sprayed Concrete”. A summarize is given by following clauses.

Site-specific calibration is required for the strength tests of young sprayed concrete as per BS EN 14488-2.

Every 500 m³ of shotcrete delivered to the site, the early strength of shotcrete up to 30 minutes and at 1 day shall be tested. The test results shall comply with the requirements for early strength given in Clause 9.3.

Every 500 m³ of shotcrete delivered to the site, the in-situ final strength of shotcrete shall be tested. The specimens shall be prepared by means of core drilling at random places from the tunnel lining after 1 to 3 days but as close as possible to 24 hours after placing. The specimens shall have a diameter of 100 mm and be cut to a height of 100 mm and water stored until 3 days before testing. The average 28 days strength of five cores shall exceed the strength specified in Clause 9.3

Where the nominal required sprayed concrete thickness is less than 100 mm, the cores for the compressive strength testing shall be taken from areas where the actual thickness is greater than 100 mm. Alternatively additional sprayed concrete thicknesses shall be applied in selected areas agreed by the Employer’s Representative for subsequent coring of test specimens.

All required drillings for the testing procedure shall be filled with concrete subsequent.

9.11.3.4 Measures on Strength Failures

Failure of 1-day compressive strength tests:

- 1) Inform the Tunnel Designer’s Representative and the Employer’s Representative,
- 2) Immediate examination of tunnel lining in suspect area,
- 3) Immediate examination of elements concerned in making, transporting and placing of shotcrete,
- 4) Assess the results of the geotechnical monitoring program to determine any correlation between non-conformance and tunnel deformation behaviour,
- 5) Prepare to take further tests at three days, 6) Take further compression tests as soon as possible,
- 7) The Contractor may propose measures for strengthening of the area for approval of the Employer’s Representative

Failure of final strength:

- 1) Inform the Tunnel Designer’s Representative and the Employer’s Representative,
- 2) Further cores shall be taken from the tunnel lining in the vicinity of the failed specimen to establish the area of non-conformance,
- 3) Assess the results of the geotechnical monitoring program to determine any correlation between non-conformance and tunnel deformation behaviour,
- 4) The Contractor shall propose measures - if any - for strengthening of the area for the approval of the Employer’s Representative

9.11.3.5 Thickness of Shotcrete

Measures to establish the total thickness of shotcrete shall be set up by the Contractor and approved by the Employer’s Representative. These may include visual guides installed prior to shotcreting or holes drilled after completion of shotcreting.

All required drillings for the testing procedure shall be filled with concrete subsequently.

The thickness of shotcrete is defined as a minimum thickness, consequently the shotcrete shall not be less than nominal design thickness at any place. 5 independent tests shall be done per every 500 m³ of applied shotcrete per construction element (e.g. tunnel lining, shaft lining, slope support...).

9.12 Cross Section Check of Primary Lining

9.12.1 Tolerances

No reduction of the theoretical thickness of the inner concrete lining is permitted unless it is approved by the Employer’s Representative. To achieve this requirement, no support elements such as shotcrete, anchor heads, steel ribs etc. may protrude into the theoretical inner concrete lining, as shown on the drawings.

The primary lining must be constructed outside the inner lining and inside the overbreak-line at any point.

In the area of the invert and the foundation beams no rock parts or rock peaks may protrude into the theoretical excavation line.

For tunnel sections with no concreted invert arch the Contractor shall excavate the bottom level of the invert with an accuracy of +0 to -100 mm related to the theoretical excavation line of the invert.

If the bottom excavation level, after the clearing of all detritus material, is more than 100 mm below the designed theoretical excavation line, the Contractor shall backfill such areas up to the designed, theoretical level by means of sub-base material or as directed and approved by the Employer's Representative.

For tunnel sections with a concrete invert arch no reduction of the designed, theoretical thickness of the concrete structure is permitted. Over excavation must be compensated with structural concrete for the invert arch as specified or as directed by the Employer's Representative. The inside face of the invert arch may deviate not more than +/- 50 mm in elevation from the theoretical cross section.

9.12.2 Profile Control

The final geometry of the primary lining shall be checked solely and systematically by the Contractor in order to accommodate the designed nominal thickness of the inner concrete lining. After incremental displacements are smaller than the permitted displacement velocity and prior to the water sealing construction, the Contractor shall measure the excavated profile by electronic means, or another method approved by the Employer's Representative.

Provision is made for the final concrete lining to be cast using a rail mounted shutter running on footing beams constructed to the designed longitudinal alignment levels and cross falls at each side of the tunnel.

It is the Contractor's responsibility to ensure that the minimum clearance for the final lining, as shown on the drawings, is provided. In order to establish deviations from the theoretical profile the Contractor shall provide a gantry furnished with a template set to show the minimum profile required to give the nominal thickness of the final concrete lining. The gantry shall be designed to move along the rail tracks to be used for the movement of the tunnel shutter and is to provide access for the marking out of the areas of the initial lining which protrude into the minimum clearance zone.

The Contractor shall submit full details of the design of the gantry with its template for the approval of the Employer's Representative. On approval the Employer's Representative will issue instructions with regard to the systematic checking of the geometry of the template during profiling operations.

The Contractor may prefer to use advance surveying techniques and data processing to establish the final clearance profile. The Contractor shall define a method of marking out areas of deviation from the theoretical profile to be approved by the Employer's Representative.

The clearance checking of the primary lining shall not commence until the rate of convergence at any of the adjacent monitoring stations is more than 2 mm per month.

Any deviations from the theoretical clearance profile shall be made good, either by providing extra shotcrete or inner lining concrete in the case of excess clearance, or by re-profiling any parts of the tunnel support protruding into the clearance profile. Contractor is responsible for these Works without any extra payments. The remedial Works shall be in agreement with the Employer's Representative. No re-profiling shall be carried out without approval by the Employer's Representative. If the thickness of the re-profiling layer is more than 1/3 of the primary lining thickness or if an area is larger than 5 m² detailed procedures including structural stability proof shall be elaborated and shall be reported in a written document to the Employer's Representative prior to commencement for approval. The Structural safety of the tunnel shall not be endangered due to re-profiling and is secured by geotechnical measurements prior, in between and afterwards. Measurement equipment in the re-profiling area shall be replaced in adequate vicinity.

Records shall be kept for each stage the remedial measures executed.

The final clearance profile shall be recorded at intervals in longitudinal direction and points along the periphery of the tunnel as proposed by the Contractor in agreement with the Employer's Representative.

The final checking of the clearance profile after completion of re-profiling and surface shall be done in presence of the Employer's Representative.

10 CONCRETE WORK

10.1 Concrete

Concrete shall be mixed, charged, applied, cured and tested according to given Specifications which are based

on “Specification for tunnelling” by BTS and the Indian Standards. For the tunnel inner lining and where these Specifications do not cover all aspect, “Guideline for Inner Shell Concrete”, Austrian Society for Concrete- and Construction Technology, 2006, Austria (enclosed as Appendix-2) shall be applied.

10.1.1 General

All structural elements must be designed for fire load if required according to the above-mentioned standards and guidelines.

The final lining cross section geometry shall be checked, and the tolerances shall be in accordance with these Specifications.

If squeezing ground conditions are observed during primary lining construction, stress gauges and pressure cells shall be installed in the final lining to monitor the actual stress-strain condition of the final lining. Minimum three stress gauges and pressure cells shall be installed in cross sections where squeezing ground conditions are encountered or as directed by the Employer’s Representative. Records shall be kept available at site and submitted to the Employer’s Representative for review.

Concrete and concrete constituents and all materials and operations relating to concrete shall meet the requirements of the Indian Standards Code of Practice for Plain and Reinforced Concrete IS 456 unless otherwise specified herein and as required by the Employer’s Representative.

Where concrete is to be placed in aggressive ground, appropriate ground investigation shall be undertaken to identify the nature of the chemical composition of groundwater and ground.

The grade and properties of the concrete used in each part of the work shall be as stated on the drawings or in the Specification.

No material shall be added to ready-mixed concrete at the site unless approved by the Employer’s Representative. Full responsibility shall be taken for ensuring that any materials added to ready-mixed concrete on site not causes the concrete to fail the quality control testing requirements of this Specification. Items made from such concrete which fail the quality control testing shall be rectified.

Concrete is not permitted to contact to aluminium during mixing, conveying and placing.

10.1.2 Concrete Requirements

Concrete mixed by the Contractor or any other Sub-Contractor shall comply with the exposition classes and strength classes as defined in the approved detailed design drawings and BS EN 206-1.

The maximum chloride content of concrete shall be in accordance with IS 456.

Chloride content class for concrete containing steel reinforcement shall be Cl 0.20 (maximum Cl content by mass of cement 0.20%) and for concrete containing pre-stressed steel reinforcement Cl 0.10 (maximum Cl content by mass of cement 0.10%), unless otherwise directed by the Employer’s Representative.

Consistence of concrete mix, other than concrete mix used for tunnel lining, shall be in compliance with IS: 456.

10.1.3 Concrete Composition

10.1.3.1 Aggregates

Aggregates shall be supplied only from sources approved by the Employer’s Representative. The Contractor shall demonstrate compliance with laboratory tests that shall be made at regular intervals to confirm the suitability of aggregate.

Approval of a source shall not be constructed as constituting acceptance of all materials from that source.

The quality of all aggregates used in the work, including processing such as washing, classifying, screening, rescreening crushing and blending, necessary to meet the required Specifications, shall all be subjected to acceptance of the Employer’s Representative.

Aggregate shall be free from earth, clay, loam and soft, clayey, shaley or decomposed stone, organic matter and other impurities and shall be hard and dense.

Aggregates shall not contain any other matter likely to affect the long-term durability of the concrete. Reference is to be made to the BRE Digest 330 for guidance in reducing the risk of deleterious alkali-silica reaction to the absolute minimum. Mineral aggregates shall comply with IS: 383 and BS EN 12620 respectively.

Tests shall be carried out in accordance with International Standards, as appropriate, and the results shall

comply with the limits given therein, or as otherwise specified. Testing will be carried out to BS EN 932, BS EN 933, BS EN 1097 and BS EN 1744 as appropriate.

If necessary, fine aggregate shall be washed to remove excess fines.

Coarse aggregate shall be washed at the aggregate source. However, further washing at the batch plant may be required if the aggregate is found to be unacceptable to the Employer's Representative.

Coarse aggregate shall be tested for drying shrinkage characteristics in accordance with BS EN 1367-4. The drying shrinkage shall not exceed 0.075%.

Coarse aggregate delivered to the batching plant shall have a uniform and stable moisture content.

The acid-soluble sulphate (SO₃) level shall not exceed the values specified in BS EN 12620.

The alkali reactivity of aggregates in combination with the proposed cement shall be tested in accordance with IS 383 and IS 2386.

The maximum permitted level of equivalent acid-soluble chloride ions (Cl⁻) for any single constituent or combination of the constituents of the concrete in the hardened mix shall not exceed the limits given in BS EN 206-1.

The total estimated sulphate content (SO₃) shall comply with the limits given in BS EN 206-1.

The water-soluble chloride ion content of the sand and coarse aggregate, combined in the proportions intended for a particular mix, shall not exceed the values given in IS 23 86; Methods of test for aggregates for concrete.

Hardness and abrasion characteristics of the aggregate will comply with BS EN 12620.

Water absorption shall not exceed the permitted value in BS EN 12620.

Where specific thermal characteristics of the mix are required, the aggregate will be appropriately selected and tested in accordance with BS EN 1367.

Each size of aggregate shall be stored separately in drained concrete-based bins or on stages to prevent intermixing and the inclusion of foreign materials

The size of aggregates shall be in accordance with IS 456 such as to establish the required properties of the concrete best. The grading of aggregates shall conform to IS:383.

10.1.3.2Cement

The Contractor shall submit cement and cementitious material manufacturers' certificates in accordance with the relevant Standard. Details of all cements and cementitious materials shall be supplied including any alternative sources that might be used. The Contractor shall show that the quantity and quality required can be attained and maintained throughout the construction period. Any cement type proposed for usage in the Works shall be approved by the Employer's Representative.

Cement shall comply with the requirements as per:

- IS 269 Ordinary Portland Cement, 33 Grade
- IS 8041 Rapid Hardening Portland Cement
- IS 8112 Ordinary Portland Cement, 43 Grade
- IS 12269 Ordinary Portland Cement, 53 Grade
- IS 12330 Ordinary Portland Cement, 33 Grade

Requirements to be met by cement (heat build-up, water segregation, fineness, C3A content, cement temperature) shall comply with BS EN 197.

Where Sulphate resistance is required, the selected cement will be appropriate to the required Design Chemical (DC) class.

Where specified or appropriate to use, blast furnace cements, Portland slag cements and blended ground granulated blast furnace slag (ggbs) cements will comply with the blending proportions specified in BS 8500-2.

Where specified or appropriate to use, Portland limestone cements and blended limestone cements will comply with the blending proportions specified in BS 8500-2.

Cementitious materials shall have a reactive alkali content not exceeding a value of 0.6% by mass and/or the

total mass of reactive alkali in the mix shall be calculated and controlled to satisfy the requirements of BS 8500-2 and the British Research Establishment (BRE) Digest 330. Certification will be supplied by the producer to demonstrate compliance with BRE Digest 330.

Cementitious materials shall be supplied in bulk, unless such cementitious materials are to be used for mortar finishing, patching or grouting. Bulk cementitious materials shall be delivered to the Site in bulk carriers which shall be clean and dry prior to loading. All carriers for bulk or bagged cement shall be equipped with watertight closures for all openings.

Immediately upon delivering to the site, cementitious materials shall be stored in dry, watertight, ventilated structures.

Cements which have exceeded the manufacturer's designated shelf life will not be used and appropriate measures shall be taken for its safe disposal or return to the manufacturer.

10.1.3.3 Admixtures

No admixtures shall be permitted without written acceptance of the Employer's Representative.

All admixtures shall be obtained from the same manufacturer to ensure compatibility between the admixtures. Technical details including data of all admixtures proposed to be used shall be forwarded to the Employer's Representative for review. The Contractor shall carry out tests and trial mixes to determine that the admixtures are compatible with the other mix ingredients.

Unless otherwise specified by the Employer's Representative, all admixtures shall be of a liquid type.

Handling and storing of admixtures shall be in accordance with the manufacturer's recommendations. Admixtures shall be stored in weatherproof buildings at a temperature not higher than 35 degree Celsius. Mechanical agitators shall be used for those admixture solutions required by the admixture manufacturer to be agitated prior to and during use.

Admixtures shall be in compliance with IS: 9103. Water-reducing admixtures in liquid form shall comply with BS EN 206 and BS EN 934.

Admixtures shall not be mixed together prior to introduction to the mix.

The use of set-retarding and water-reducing admixtures shall be in agreement with the Employer's Representative, unless otherwise specified in the Contract. Admixtures not covered by International Standards shall not be used.

Concrete containing fly ash shall not be air entrained, unless the Contractor supplies proof (from tests on trial mixes or previous production) that the amount of air entrained can be controlled within specified limits and that the compressive strength of the concrete will be satisfactory.

10.1.3.4 Additions

General suitability as a Type II addition is established for the following:

- fly ash conforming to BS EN 450-1
- silica fume conforming to BS EN 13263-1
- ggbs conforming to BS EN 15167-1
- metakaolin with an appropriate agreement certificate

General suitability as a Type I addition is established for the following:

- filler aggregate conforming to BS EN 12620 or BS EN 13055-1
- pigments conforming to BS EN 12878

10.1.3.5 Water

Water for concrete mixing and curing shall be clean and free from injurious amounts of oil, silt, salt, organic matter, acid, alkali, sediment or other deleterious substances and shall conform IS 456-1978 and BS EN 206 respectively.

Recycled water may be used provided controls are in place to demonstrate compliance with BS EN 206.

The Contractor shall supply, install, operate and maintain a system for water supply for concrete, mortar, shotcrete and grout manufacture. Not less than 40 days prior to the start of concrete production, shotcrete

placement, or grout injection whichever occurs first, the Contractor shall submit to the Employer's Representative details of the method by which the Contractor proposes to ensure a clean and adequate supply of water.

Alternative water storage facilities shall be provided to ensure that concreting, shotcreting and grouting operations will not be hindered by a temporary breakdown in the main water supply system.

The permissible limits for solids when tested in compliance with IS 3025 shall be as given in Table 17.

Table 18: Limits of deleterious material in water for concrete mixing

deleterious material	max. permissible limit
organic	200 mg/lit
inorganic	3000 mg/l
sulphates (SO ₄)	500 mg/lit
chloride (Cl)	500 mg/lit
suspended matter	2000 mg/lit

The pH value of the water shall not be less than 6.

10.1.3.6Fibres

Fibres are generally accepted for use in concrete conforming to BS EN 206-1 and BS 8500 if the fibre conforms to BS EN 14889, an European Technical Approval.

Fibre-reinforced concrete will be trialled and tested to ensure it meets the designers' requirements before inclusion in the works. Historical data of the same fibre and dosage will be accepted in place of trials provided the data are deemed appropriate.

10.1.4 Temperature

Every effort shall be made to maintain the temperature of concrete during manufacture, placement and curing as per IS 7861 (Part I & II) unless otherwise specified herein.

The concrete temperature at the time of placing shall not exceed 27°C nor be less than 5°C. Fresh concrete temperatures of 13°C to 18°C are most favourable. Concrete and concrete constituents may be heated to reach the preferable concrete temperature. Heating of concrete or concrete constituents shall under no circumstances increase the concrete temperature above 27°C.

Aggregates shall be heated uniformly and carefully; all frozen lumps, ice and snow shall be eliminated before entering the concrete mix; average aggregate temperature shall not exceed 60 °C and maximum spot temperature shall be below 100 °C. Frozen aggregates shall not be used.

Mixing water shall not be heated exceeding 60°C.

To avoid surface cracking caused by heat generated during setting of concrete, the temperature difference between a measuring point at the surface and a measuring point in the centre of a concrete body, or 1000 mm inside the surface if the body is more than 2 m thick, shall be less than 20°C, if not otherwise approved by the Employer's Representative. The location of the measuring point at the surface plane shall be defined as 10 mm inside the surface on a perpendicular projection of the structure member's centre point to the surface plane.

Temperature difference across construction joints shall be less than 15 °C at the time of concrete placement.

The maximum temperature during setting of concrete shall not exceed 40 °C except it is approved by the Employer's Representative.

10.1.5 Mix Design

The selection design and quality control of mixes shall be carried out by the Contractor or on his behalf by the manufacturer.

The Contractor shall design concrete mixes for each class of concrete. The concrete mixes shall be designed to produce a workable plastic mixture with the lowest slump that will suit the specified condition at the time of placement and will produce concrete of uniform consistency that conforms to the requirements specified for the various parts of the works.

In order to minimize thermal cracking, the cement content of all classes of concrete shall be the minimum necessary to produce the specified strength, permeability, freeze-thaw resistance and temperature rise requirements.

10.1.6 Mixing and Batching**10.1.6.1 General**

The Contractor shall provide at the site, modern and dependable, automatically or semi-automatically controlled batching and mixing plant or plants, in an "as new" condition, capable of supplying concrete in accordance with the Specifications and at a continuous rate adequate to meet the requirements of his schedule for concrete placement. Each plant shall have not less than two concrete mixers, each with a separate power and drive system with a standby generator and other equipment to ensure a continuous supply of concrete during concrete placement operations.

10.1.6.2 Batching

The Contractor shall provide, operate and maintain all necessary equipment and plant required to determine accurately and to control the amount of each separate ingredient entering the concrete mix. The actual amount of fine aggregate, each size of coarse aggregate, cement, fly ash, admixtures, ice and water entering each batch of concrete shall be determined by automatic weighing of each ingredient separately and not cumulatively. All constituents shall be weighed or metered in compliance with the limits prescribed in BS EN 206.

Proportioning of concrete mixes shall be in accordance with IS 456-1978 and IS 4925.

Admixtures shall only be introduced using purpose-made equipment accurately calibrated. Where such equipment is unavailable, and where agreed with the

Employer's Representative, alternative dosing methods to the manufacturer's recommendations may be adopted.

Water shall not be added to concrete after it has left the mixer unless controlled, recorded and agreed with the Employer's Representative.

Where fibre reinforcement is added to the concrete mix, this shall only be introduced using purpose-made equipment.

All necessary measures shall be taken to prevent charging the batching plant with frozen aggregates. Aggregates in bins at the batching plant shall be kept above zero degrees Celsius at all times. Heating and cooling equipment shall be provided with sufficient capacity to heat or cool the water and aggregates to a uniform temperature so that the concrete will meet the placement temperature requirements.

Free access for testing and inspection of the cementitious materials shall be provided. The batchers shall be arranged that the loading cycle cannot start again as long as materials remain in the batchers.

A thermometer shall be installed in the cement day bin such that the operator can see readily the temperature of the cement at the time of batching.

The plant shall be equipped with a batching recorder which shall print the mass or volume for each material in each batch, identify the concrete mix being batched, the size of each batch in cubic meters, and the time and date of batching. The records shall be submitted to the Employer's Representative at the end of each shift and shall become the property of the Employer's Representative.

The accuracy of the measuring and weighing equipment shall be maintained so that the indicated mass does not vary by more than 0.6 per cent from the true mass throughout the range of use.

The measuring and weighing equipment shall be capable of being operated to control the delivery of materials so that the combined inaccuracies in feeding and measuring do not exceed the limits in Table 18.

The Contractor shall provide standard certified test weights and any other auxiliary equipment required for checking the operating performance of each measuring and weighing device. Unless otherwise required by the Employer's Representative, check tests of equipment used for measuring water, cement and the admixtures shall be made at intervals not exceeding one month. Check tests of measuring and weighing equipment used for measuring fine and coarse aggregate shall be made at intervals not exceeding two months. The tests shall be made in the presence of the Employer's Representative and the Contractor shall make such adjustments, repairs or replacements as the Employer's Representative may deem necessary to secure satisfactory performance before further use of the measuring or weighing equipment will be allowed.

All aspects of the batching and mixing operation including quantities of aggregates, cement, fly ash, admixtures and water shall be automatically recorded.

Table 19: Batching tolerances

cement	2,0 % per weight
fine aggregates	3,0 % per weight
coarse aggregates	3,0 % per weight
admixtures	2,0 % per weight
water	1,5 % per weight

10.1.6.3 Mixing

The mixing plant shall combine fine aggregates, each size of coarse aggregates, cement, fly ash, admixtures, ice and water into a uniform mass and shall discharge the mixture without segregation.

The batching and mixing plant shall have capacity of batching and mixing concrete at a rate in excess of the Contractor's peak placing requirements. A standby mixer with a capacity of not less than 40% of the peak placing requirements shall be available at all times for use during critical concreting operations.

A mixer timer with an automatic lock which will not release the discharging mechanism until the completion of a pre-set mixing time shall be provided on all mixers.

Separation of coarse aggregate from the mortar shall be avoided by arranging the discharge mechanism so that the concrete will fall vertically into the receiving container or hopper.

Mixers shall be examined by the Contractor at regular intervals to ensure that wear on the blades and liners does not allow dead spots or agglomerations of mortar around the sides of the mixer. Mixers shall be cleaned of any hardened materials which have built up on the insides. Should a mixer at any time produce unsatisfactory results, in the opinion of the Employer's Representative, its use shall be discontinued until it is repaired or replaced.

Mixer performance tests shall be performed on all mixers, as soon as the equipment is in operating condition at the start of the Work, at least once every 30 days during the course of the Work and at any time the Employer's Representative suspects any type of operating difficulties with the machinery. At the end of the mixing period prescribed by the Employer's Representative for the test, two samples of concrete shall be taken.

When necessary mixing times shall be increased until the required uniformity and consistency of the concrete is adequate. Mixers shall not be used if they produce unsatisfactory concrete.

10.1.7 Conveying

Concrete shall be conveyed from the mixer to the place of final deposit without segregation, contamination, loss of ingredients, loss of entrained air, loss of slump or damage from exposure. Trucks, buckets, belt conveyors, pumps, chutes and drop pipes may be used for conveying concrete and shall be of such size, design and condition as to ensure a continuous and even supply of concrete at the point of delivery. Alternative methods will be required to prove their success in conveying concrete rapidly, without segregation and the loss of materials. All conveying equipment shall be supported independently of the forms.

Concrete conveying equipment shall be checked by means of site trials prior to general use for its ability to deliver uniform concrete as per Clause 10.1.11.1. Slump tests shall be made on samples of concrete taken from the first and last one-tenth of a batch of mixed concrete. If these slumps differ by more than 25 mm, the equipment shall not be approved for use until the condition causing the inconsistency is corrected. Concrete conveying equipment used shall be examined daily for accumulations of hardened concrete or mortar, or for wear of the blades. Where necessary, the uniformity test may be repeated.

The time elapsed between completion of the mixing of the concrete at the plant and its discharge at the forms shall not exceed 45 minutes for concrete agitated while in transit and 30 minutes for non-agitated concrete. These basic limits apply in the case of non-set-retarded concrete. For set-retarded concrete the limits may be increased. Open conveyances shall be covered against the weather when required by the Employer's Representative.

Dispatch tickets or a record direct from the batching plant recorder shall be furnished to the Employer's Representative with each batch of concrete recording the serial number of ticket, date, batch number, truck number, amount and class of concrete, location of placement, and time of mixing. At the end of each day or shift, the Contractor shall supply the Employer's Representative with a written report concerning the quantity of each class of concrete and the number of batches produced.

Equipment to be used to convey the concrete shall not contain hardened concrete or foreign materials.

In general, the use of chutes to convey concrete will not be permitted, except that chutes less than 3 m in total length may be used with acceptance of the Employer's

Representative. The delivery end of the chute shall be as close as possible to the point of deposit. The chute shall be thoroughly flushed with fresh clean water before and after each run, the water used for this purpose being discharged outside the form.

Concrete in the walls and arches of tunnel linings shall be placed by a displacement type pump or by other approved methods by the Employer's Representative. The equipment used in placing the concrete, and the method of its operations, shall be in a way to permit introduction of the concrete into its final location without high-velocity discharge and resultant segregation.

Concrete pumps shall have a variable speed control and shall be capable of pumping concrete containing 20 mm aggregate through delivery lines not less than 75 mm diameter and for a distance required for placement within the works to meet requirements of this Specification.

10.1.8 Placing

10.1.8.1 General

The Contractor shall develop a detailed plan of concrete lifts for each structure which shall show the location of all construction joints and all concrete lifts in the structure and shall take reinforcing steel bars, embedded parts and water stops into account. The submission shall include calculations supported by laboratory and full scale test data showing how the temperature control requirements will be achieved. The plan for each structure, which shall include detailed drawings, shall be submitted to the Employer's Representative not less than 80 days prior to the start of concrete placement in that structure and not less than 20 days prior to the submission of reinforcing steel bar placement drawings, bar bending schedules and bar lists for that structure. The Employer's Representative shall have the right to require the Contractor to move the location of any construction joint if the location proposed by the Contractor will have an adverse effect on the design and performance of the structure.

The construction joints shown on the drawings shall not be moved unless the Contractor can satisfy the Employer's Representative that there is justification for the relocation and that there will be no adverse effect on the performance of the structure.

After the Contractor's plan for construction joints and concrete lifts has been approved by the Employer's Representative no additional joints shall be incorporated into the Works unless approved by the Employer's Representative.

Details of proposed additional joints shall be submitted to the Employer's Representative not less than 60 days prior to concrete placement at the location of the proposed additional joints.

Concrete shall not be placed in any part of the Works until the foundations, previously placed concrete, formwork, reinforcing steel bars, embedded parts and water stops in that area have been inspected by the Employer's Representative and permission has been given by the Employer's Representative for concrete placing to proceed. Concrete shall be placed only in the presence of the Employer's Representative.

All surfaces to be in contact with the in-situ concrete lining shall be thoroughly cleaned and scaled of all loose or defective material.

The surfaces of waterproofing membranes shall be thoroughly cleaned to remove any loose and foreign materials. They shall be cleaned by washing with a stream of air and water, but care shall be taken not to displace the membrane or its fixing and seals.

Concrete shall not be placed in still or running water and shall not be subjected to the action of running water until the concrete has set.

All formwork shall be true to form, securely made and supported, and joints shall be sealed to prevent the loss of cement from the mix. Where required, grout pipes shall be incorporated for pressure relief and subsequent grouting.

Concreting shall not commence until the formwork has been inspected and agreed with the Employer's Representative.

The build-up of water pressure behind uncured linings shall be prevented. Concrete shall be placed continuously in each length of formwork. Concrete shall be protected from rain during placement.

The time between batching and complete discharge shall be less than 90 minutes and shall be such that the concrete can be placed and consolidated without the addition of extra water. The time between batching and complete discharge shall be reduced to a maximum of 60 minutes when the air temperature exceeds 25 degrees Celsius.

In order to reduce bleeding, slump shall not be higher than necessary to achieve proper placement and consolidation.

The depth of concrete placed in each lift shall be as shown on the Contractor's drawings. All concrete shall be deposited in approximately horizontal layers 50 centimetres in thickness at such a rate that the formation of cold joints will be prevented. Each new lift of concrete shall be placed on the oldest exposed lift.

Hardened or stiff concrete shall not accumulate on reinforcing steel or formwork.

Partially hardened concrete shall not be re-tempered with or without additional aggregate, cement or water.

Once concrete placing has started it shall be carried on as a continuous operation until the placing of the lift is completed. The rate of placing shall be such that each successive layer can be vibrated and bonded into the previous layer.

When concrete is placed on an inclined surface, the placing operation shall begin at the lower end of the slope and shall progress upward.

The sequence of work within the tunnels or shafts shall be arranged as that no damage occurs to permanent linings. The proposed sequences and methods of operations shall be agreed with the Employer's Representative.

Before any concrete is placed for tunnel linings the Contractor shall demonstrate to the Employer's Representative that his concrete mix, equipment and working methods are capable of producing fully compacted concrete to the required surface finish. If required by the Employer's Representative, this shall take the form of a trial length.

10.1.8.2Preparation

Immediately after the removal of blasted rock, excavated rock surfaces against which concrete will be placed shall be scaled and cleaned to remove unclassified material, loose, broken and detached rock fragments and unsound, slaked, deteriorated and closely fractured rock which remain in the excavated surface of the rock. Where required by the Employer's Representative, scaling and cleaning shall be followed by dental excavation to remove the unclassified material remaining in open and debris filled joints, cracks, fissures, seams, crevices, faults, shear zones and other relatively narrow openings. The purpose of scaling, cleaning and dental excavation is to produce a sound, intact, tightly anchored rock surface.

Scaling, cleaning and dental excavation will require the use of manual labour, with hand held pneumatic tools, shovels, bars, trowels, compressed air jets, high pressure water jets, brooms, brushes and other hand held tools. High pressure water jets shall not be used.

Foundation surface of the rock, concrete and shotcrete shall be protected against weathering and the deleterious effects of frost action, rain, groundwater seepage and construction equipment until concrete placement commences.

Shotcrete in underground works shall be cut back so that no shotcrete protrudes inside the concrete pay line (see 7.6 and 9.12).

Rock, shotcrete and concrete surfaces against which concrete is to be placed shall be kept continuously damp for a period of not less than 24 hours immediately prior to concrete placement.

Surfaces of reinforcing bars, forms and embedded parts shall be cleaned of all dried mortar, grout, oil and all other coatings except epoxy coating and galvanizing.

Immediately before concrete is placed, forms shall be inspected to ensure that the forms are accurately placed to the specified tolerances and are sufficiently rigid and braced to prevent movement during concrete placement and that all reinforcing bars are in the correct position and secured against movement during the placing operation. Chemicals shall not be used to remove ice or hardened concrete from the forms.

In hot weather or concreting on surfaces which are highly water absorbent, the surfaces against which concrete is to be placed, including reinforcement and formwork, shall be lightly sprayed with water to prevent excessive absorption of water from the fresh concrete. Pre-wetted surfaces shall be free from excessive water before concreting.

10.1.8.3Placing

The concrete shall not be placed until the rate of convergence at any of the adjacent monitoring stations is less than 4 mm per month, unless otherwise approved by the Employer's Representative.

Concrete shall be placed while still sufficiently plastic for adequate compaction and shall be carefully worked

around all reinforcement and embedded fixture and corners of the formwork.

Concrete shall be inspected at the point of placing.

There shall be no vertical drop greater than 1.5 m except where equipment such as tremie pipes and chutes satisfactory to the Employer's Representative to use to confine and control the falling concrete. Horizontally movement of concrete exceeding 1.0 m by the use of vibrators is not permitted.

Concrete shall be placed as close as possible to its final position, in continuous near level layers not exceeding 500 mm. Each layer shall be compacted before succeeding layers are placed. The depositing of large quantities of concrete at any one point and running or working it along the forms will not be allowed.

Placing equipment shall be operated by experienced operators only. In general, the concrete placing shall continue uninterrupted until the structure is filled over the entire length of the formwork. In the event of equipment breakdown or if for any other unavoidable reason placing is interrupted, the Contractor shall thoroughly compact the concrete to a reasonable level or flat slope while the concrete is plastic. The concrete at the surface of such cold joints shall be cleaned with a high-pressure air water jet before the concrete achieves a primary set, to provide an irregular clean surface free from laitance. Prior to restarting concreting, the surface shall be wetted. The work shall be carried out in a way that a sound dense homogeneous structural element is produced.

The concrete which forms the openings to caverns and niches or other recesses shall be placed concurrently with the concrete in the parent tunnel at the same cross section.

Concrete shall not be subjected to disturbance between 4 hours and 24 hours after placing.

10.1.8.4 Consolidation

As concrete is being placed, it shall be compacted thoroughly and uniformly by means of vibrators, supplemented by hand spading, ramming, and tamping to produce dense, homogeneous concrete, that is at its maximum density, that is in complete contact with forms, that is effectively bonded to the reinforcing steel bars and the embedded parts and that has smooth formed surfaces, free of air pockets and blemishes.

Concrete shall be consolidated with the aid of approved immersion type mechanical vibrators complying with IS 2505. Immersion vibrators shall be a minimum of 40 mm in diameter and shall be capable of transmitting vibration to the concrete at frequencies in excess of 150Hz or 4000 rpm and shall visibly affect the concrete at a radius of 300 mm.

At least one vibrator in working order shall be held in reserve for emergency use.

Concrete vibrators shall not be used for moving concrete. Vibrators shall be operated as nearly as practicable in a vertical position. The vibrating head shall be allowed to penetrate under its own weight until it can re-vibrate the top 5 centimetres of the underlying concrete layer. The vibrator shall be withdrawn slowly to avoid the formation of voids and shall be carefully positioned to avoid contact of the vibrating head with the formwork. Vibrators shall be inserted at uniform spacing over the entire area of placement. The distance between insertions shall be approximately 1.5 times the radius of action of the vibrator. Vibrators shall be held stationary until the concrete is consolidated and then withdrawn slowly. The concrete ingredients shall not be allowed to segregate and no laitance shall be allowed to appear on the surface.

Vibrators shall not come in contact with nor disturb embedded parts, waterstops, reinforcing steel bars and formwork.

Particular care shall be taken with the compaction of concrete surrounding water bars to avoid honeycombing and to prevent the displacement of the water bar. Care shall also be taken to avoid displacement of pre-fixed pipes, block-outs, thermocouples and the like.

Where placing concrete for tunnel linings, formwork vibrators shall be used for compacting concrete in the tunnel arch above the highest openings in the formwork. They shall be operated at intervals of not more than 1.2 m behind the advancing slope of the concrete in the shoulders and crown of the arch. The location and operation of the vibrators shall be carefully coordinated with the withdrawal of the discharge line so as to avoid settlement and flow of the concrete from the filled crown.

10.1.8.5 Finishing

The surface of formed and unformed concrete shall be within the specified allowable deviations from the lines, slopes, elevations and dimensions shown on the drawings and shall be smooth and uniform in texture and free from streaks, discoloration and surface irregularities to the extent specified herein.

Any damage to finished concrete resulting from the action of removing from work or any other cause shall be repaired to the satisfaction of the Employer's Representative.

Formed Surfaces:

Table 20: Formed concrete finishes

F1	No specific requirement
F2	The irregularities in the finish shall be no greater than those obtained from the use of wrought thickness square-edged boards arranged in a uniform pattern. Fins shall be removed and imperfections shall be made good.
F3	The resulting finish shall be smooth and of uniform texture and appearance. The formwork lining shall leave no stain on the concrete and shall be so joined and fixed to its backing that it imparts no blemishes. It shall be of the same type and obtained from only one source throughout any one structure. The Contractor shall make good any imperfections in the finish. Internal ties and embedded metal parts shall not be used

All formwork joints for F2 and F3 finish shall form a regular pattern.

Unformed Surfaces:

Table 21: Unformed concrete finishes

U1: Screened finish	The concrete shall be levelled and screeded. No further work shall be applied to the surface unless it is a first stage for a wood float or steel trowel finish.
U2: Wood float	A pre-screeded finish shall be floated with light finish pressure using a wooden float to eliminate surface irregularities.
U3: Steel trowel finish	A steel trowelled finish shall be first wood-floated and then trowelled under firm pressure with a steel float to produce a dense, smooth, uniform surface. The final surface shall be free from trowel marks.

When required by the Employer's Representative and before commencing concreting the Contractor shall prepare a trial panel to demonstrate that the required surface finish can be achieved by the equipment and methods proposed. The panel shall be filled with the proposed concrete compacted by the method to be used in the work. When agreed with the Employer's Representative the trial panel shall be retained and will form the benchmark against which all Works concrete shall be prepared.

Where the concrete surface is to receive waterproofing, it shall be in accordance with the waterproofing system manufacturer's recommendations.

Permanently exposed concrete surfaces shall be protected from rust marks and all kinds of stains.

After removal of the formwork no treatment, other than that approved for curing, shall be applied to the concrete until its surfaces have been inspected by the Employer's Representative.

Where any surface fails to comply with the Specification in respect of finish, dimensional tolerance, or in any other way, the Contractor shall rectify the work as agreed with the Employer's Representative.

The Contractor shall be responsible for preventing any damage to the finished concrete surfaces and shall adopt any necessary protective measures to prevent subsequent staining from any cause.

10.1.8.6Curing

The concrete shall be protected from damage due to load overstress, heavy shocks, excessive vibrations and the effects of rain and running water particularly during the curing period.

Curing and protection of concrete in cold weather shall be carried out in compliance with IS 7861 Part.

All concrete should be allowed to cure by methods which will ensure the production of concrete of the specified quality.

Curing materials and methods shall be compatible with any subsequent waterproofing.

In general, concrete shall not be placed when the temperature at the location of the Work is below, or likely to fall below, 5°C before the section of work can be completed except in emergencies.

Concrete shall be continuously moist cured from the time that the concrete has hardened sufficiently to prevent damage to the surface finish and shall be continued for not less than 14 days for concrete not containing fly ash

and 21 days for concrete containing fly ash or until fresh concrete has been placed on or against the concrete surface or until a membrane curing compound has been applied. All material and equipment required for adequate curing and protection shall be on hand before concrete placement begins.

Concrete shall be protected from exposure to rain for 12 hours, from exposure to the sun for 72 hours and from exposure to flowing water for 14 days. For concrete surface temperature below 5°C, the duration of curing shall be extended for the number of days the temperature has been below 5°C.

Concrete shall be moist cured by maintaining the surfaces continuously wet for the duration of the specified curing period.

During the curing period concrete shall not be intermittently wetted and allowed to dry.

Curing water temperature shall not exceed 25 grade Celsius or above the expected minimum ambient temperature of the curing period.

At least 14 days prior to the use of curing compound, full details of the proposed compound shall be submitted to the Employer's Representative for review. Such details shall be accompanied by test certificates to show that the compound will give satisfactory results for the proposed application.

Curing compound shall be wax-based compounds and shall be approved by the Employer's Representative. The compound shall be applied in strict accordance with the manufacturer's Specification and shall be applied as soon as the surface water has disappeared.

Curing compounds shall be delivered to the Site in suitably labelled containers to enable identification of the batch number and date of manufacture.

Curing compounds shall comply with the requirements of ASTM C309.

For each curing compound proposed for use in the Works, the Contractor shall obtain a Certificate of Compliance from the supplier, supported by test certificates from a laboratory with appropriate registration, certifying that the curing compound complies with this Specification.

The curing compound shall be applied by a pressurised sprayer to give a uniform cover. The sprayer shall incorporate a device for continuous agitation and mixing of the compound in its container during spraying.

The curing compound shall be applied using a fine spray at a rate of 0.2 litres/m² and per coat or otherwise directed by the Employer's Representative. The application rate shall be checked by calculating the amount of curing compound falling on felt mats, each approximately 0.25 m² in area, placed on the concrete surface.

Two coats shall be applied at the full rate. The curing compound shall be applied to unformed surfaces immediately after completion of all finishing operations, and to formed surfaces within half an hour of the removal of formwork from the section.

10.1.9 Joints

Joints in concrete are either movement (deflection, expansion or contraction) joints or construction joints. All construction joints shall comply with IS 11817.

Joints shall be formed on horizontal or vertical planes except for joints in tunnel linings which shall be formed on radial planes.

Joints in horizontal planes, which intersect with exposed surfaces making an angle of 45° or more with the horizontal, shall be truly horizontal. Joints in horizontal planes, which intersect with exposed surfaces making an angle of less than 45° with the horizontal, shall be formed to provide at least 75 mm of surface normal to the slope of the surface.

Construction joints shall be positioned only where agreed with the Employer's

Representative. The Contractor's proposal on constructions joints shall be given on lift drawings submitted to the Employer's Representative for review.

Formed construction joints shall be formed using purpose-made stop ends. Expanded metal stop ends shall not be used.

Unformed construction joints shall be formed using a grout check or similar so that the exposed edge is a crisp true line.

The joint surface shall be either: brushed using water to remove laitance and expose the aggregate without disturbing it, treated with retarder and then water-jetted to remove laitance and expose the aggregate to a depth

of not less than 3 mm without disturbing it, or lightly roughened by light chipping or needle-gunning of set concrete. Hacking of set concrete shall not be permitted.

Construction joints shall be clean and damp, with no standing water, immediately before wet concrete is placed against them.

At horizontal construction joints on exposed surfaces forms shall be constructed with strips to produce a straight joint at the exposed surface, unless otherwise directed.

Movement joints shall be constructed as shown on the drawings. The Contractor shall provide the various joint components and install these in accordance with the drawings and the manufacturer's recommendations, or as directed or approved by the Employer's Representative.

Any material used for expansion joint filler shall be approved by the Employer's Representative.

Sealing compound is applied as surface sealant for movement joints or other boundaries of construction elements. The compound shall be polyurethane-rubber type or other type approved by the Employer's Representative. 56 days prior of any sealing compound is applied, the Contractor shall submit a sample of the proposed sealing compound together with the manufacturer's technical data and the details of the recommended method of application for approval.

10.1.10 Water Stops

Water stops shall be installed as shown on the drawings or as directed by the Employer's Representative.

Detailed information on all water stops, their properties, installation and standard support, shall be submitted to the Employer's Representative for approval. Only approved water stops shall be used in the Works and the manufacturer's regulations and instructions shall be followed.

All joints of sealing strips shall be welded by the appropriate device to the tensile strength at least 80% of the initial material.

Prior to any concrete work the water stops shall be placed as given in the drawings and adequate measures shall be made to prevent a dislocation of water stop due to concreting works.

Thermoplastic sunken sealing strips for construction joints shall be in compliance with DIN 18541.

10.1.11 Quality Check & Tolerances

The Contractor shall keep logs on all his concrete activities, i.e. production, placing, supervision and production control, inspection and testing. These logs shall be available to the Employer's Representative for examination at any time.

The Contractor shall supervise and inspect the concrete works to fulfil the provisions of this Specification. This applies to the inspection of materials and products, of concreting execution, of false work and formwork, of reinforcement, of concreting operations and of pre-cast concrete elements.

The Employer's Representative may at any time, unless critical concrete work is done, inspect and test any Contractor's equipment intended for batching, mixing, transporting, placing and testing concrete.

10.1.11.1 Trial Mix Testing

In conjunction with the design of concrete mixes, the Contractor shall complete a laboratory trial mix program for each class of concrete. The trial mix program will be used to confirm to the satisfaction of the Employer's Representative, that the proposed concrete mix designs will produce concrete having the properties required by the Specification with minimum cement content.

Unless otherwise agreed with the Employer's Representative, field trial mixes shall be prepared under full-scale site conditions at least 35 days before the commencement of concreting and tested in accordance with IS 10262, BS EN 12350 and BS EN 12390.

For each concrete plant proposed by the Contractor the field trial mixes shall be tested separately.

The field trial mixes shall be tested to determine compliance under statistical evaluation where required by BS EN 206. An acceptable value for the limits of the required properties shall be established during the trials which shall thereafter be used to monitor the Quality Control of the mixes and set the standard of compliance.

In the event quality control tests indicate that concrete below the specified standards is being produced, the Employer's Representative may order such adjustment of mix design, additional quality control, or other measures as it may deem necessary to raise quality to specified standards.

If, at any time during the Work, the Contractor proposes to change or modify the source, type or quality of any concrete material or materials for the selected concrete mix designs, the laboratory testing program shall be repeated for each class of concrete affected by the proposed change.

Detailed test results on the concrete mix designs with changed or modified materials shall be submitted to the Employer's Representative not more than three days after the completion of each test.

The 28 day compressive strength test results and details of the changes or modifications to the concrete mix designs proposed by the Contractor shall be provided to the Employer's Representative before the changed or modified concrete mix designs are used to produce concrete for the works.

The following minimum values of samples shall be taken for trial mix testing:

- nine compression test cylinders (3 for each of 3, 7 and 28 days)
- six shrinkage test prisms
- three test cubes (200 mm) or slabs (200 mm x 200 mm x 120 mm) for water permeability testing according to DIN 1048 Part 5
- one specimen for sulphate and chloride testing

10.1.11.2 Conformity Control of Concrete

In the event the specified strength criteria are not met, the Employer's Representative may, if he deems it necessary, require that the unacceptable concrete be cut out and replaced.

The conformity control of strength parameters required shall be demonstrated in accordance with BS EN 206-1. Specimens tested to demonstrate compliance will be cubes, cylinders or prisms appropriate to the testing standards and BS EN 206-1.

Test samples shall be made, cured, stored, transported and tested according to BS EN 12350 and BS EN 12390. Spot samples will not be used to evaluate strength parameters.

Concrete cube test results will be acceptable if statistical analysis of the results meets the requirements of BS EN 206-1.

Concrete shall be tested for durability properties by means of absorption and capillary suction (sorptivity) tests where appropriate. An appropriate test method will be agreed by all parties before testing is undertaken.

Compaction factor, slump, Vebe, flow table or other workability tests shall be carried out as required during concreting of permanent works to control workability at the batching plant and at the site of the pour. The degree of workability shall be as specified or as determined during the trial mixes. Permitted tolerances shall be in accordance with BS EN 206. Samples tested will be either spot samples or composite samples taken in accordance with BS EN 12350-1 and the appropriate tolerances for compliance will be applied in each case.

Where inspection reveals non-conformity, appropriate measures shall be taken in accordance to EN206-1 and in agreement with the Employer's Representative.

10.1.11.3 Production Control of Concrete

All concrete shall be subject to production control by the Contractor in accordance to EN 206. All data of production control shall be recorded by the Contractor and made available to the Employer's Representative at any time.

10.1.11.4 Tolerances

Surface finishes shall generally conform to the types and tolerances indicated in Table 21 unless otherwise specified herein, as shown on the drawings or as required by the Employer's Representative.

The Contractor shall carry out a cover meter survey over all reinforced concrete surfaces within 24 hours of removal of formwork. The cover survey shall be undertaken on a 500 mm grid over the whole structure. Access for the Employer's Representative to verify cover meter surveys shall be provided.

The deviation of the inner face of the concrete lining according to the theoretical cross section may in general not exceed 50 mm to the inner side. At the lower side wall (walkway level/cable duct) the deviation of the inner face is limited to the inner side in order to maintain minimum dimensions of the cable ducts. Pre-cast concrete cover plates for the cable ducts shall be fabricated based on the as-built survey results. No tolerance will be permitted inside of the specified clearance profile for vehicles or pedestrians.

In any case and for all specified deviations permitted, the specified theoretical thickness for the inner concrete lining as well as the specified clearance profile for the roadway and the walkways shall be maintained.

Niches, recesses and similar structures are to be constructed with a tolerance of +/-50 mm related to the designed stationing.

Pre-cast elements and other structural elements are to be constructed and placed with a tolerance of +/-15 mm, related to the theoretical tunnel cross section.

Table 22: Types and tolerances for finishing of concrete surfaces

Type of finishing	General areas of application and method of forming	Tolerances in mm
F1	Formed surfaces of construction joints and other surfaces which will not be permanently exposed, including surface upon or against which backfill or concrete is to be placed. Minor blemishes caused by entrapped air or water will be accepted. In general the surface will require no treatment after form removal, other than repair of defective concrete and specified curing, or treatment as specified for construction joints.	+10
F2	All permanently exposed formed surfaces for which type F3 finish is not specified. For which sheathing or lining shall be placed so that joint marks on the concrete surface will be in general alignment, both horizontally and vertically, and conform to a standard pattern. Immediately on the removal of forms, all unsightly ridges or fins shall be removed, all holes left by removal of ends of form rods shall be neatly filled with mortar and surfaces treated to meet the required tolerances by tooling and rubbing. In general, not more than 50 air voids of 5-15 mm diameter per m ² will be accepted. Air voids exceeding 15 mm in diameter shall be repaired. When filling holes and repairing defective areas of permanently exposed surfaces, effort shall be made to match the colour of the concrete. The use of release agents which may permanently stain or discolour the finished surface will not be permitted.	+5 -5
F3	Formed surfaces which will be exposed to flowing water. These surfaces shall be hard, smooth and dense, free from offsets, pits, voids, air holes and irregularities and shall be chipped, ground and thoroughly cleaned as necessary to conform to the required tolerances.	+3 -3
U1	Unformed, screeded surface which will be covered by fill materials, static water or concrete. Type U1 finish shall be used as the first stage. Types U2 and U3 as finishes. Finishing shall consist sufficient levelling and screeding to produce an even, uniform surface meeting the required tolerance.	+10 -10
U2	Unformed surfaces not permanently concealed by fill or concrete or not required to receive Type U3 finish. Floating by means of hand or power driven equipment shall be started as soon as the screeded surfaces has stiffened sufficiently, and shall be the minimum necessary to produce a surface that is free from screed marks and that is uniform in texture. If type U3 finish is to be applied floating shall be continued until a small amount of mortar without excess water is brought to the surfaces so as to permit effective trowelling.	+5 -5
U3	Unformed, screeded surfaces which will be exposed to flowing water. This finish shall be applied by steel trowelling after the concrete has hardened enough to prevent excess of fine materials and water from blemishes, ripples and trowel marks. After the surface has nearly hardened, it shall be trowelled once more until the surface is hard and glossy in appearance.	+3 -3

10.1.12 Repair of Damage

All irregularities on concrete surfaces shall be repaired to produce smooth, uniform surfaces that conform to the tolerances specified herein for the finishes shown on the drawings.

The Contractor shall notify the Employer's Representative not less than 24 hours prior to the start of any concrete repairs.

Surface irregularities shall not be repaired until they have been inspected by the Employer's Representative. The Employer's Representative will inspect the surface irregularities and determine whether the surface irregularities shall be repaired by cutting out the concrete to a depth of 75 millimetres beyond the reinforcing

bars and filling the cavity with cement mortar or concrete, or whether the concrete shall be cut out to a shallower depth and the cavity filled or patched with cement mortar or saran latex dry pack mortar or epoxy sand mortar, or an alternative mortar approved by the Employer's Representative. The Employer's Representative will also determine the extent to which concrete shall be cut out, the shape of the resulting cavity, the material that is to be used for the repairs and whether the filling shall be secured with keys, dovetails or anchors. Reinforcing steel bars shall not be cut.

Should the concrete exhibit any form of cracking at 28 days, in excess of 0.15mm width, it shall be brought to the attention of the Employer's Representative. The Employer's Representative may, at his discretion and based on the particular crack location, require that the crack be repaired. Where so instructed, the concrete shall be repaired using an epoxy injection system or other approved method of permanent crack repair. Repairs using an epoxy injection system shall not be performed for at least 56 days from the original date of concrete placement.

Repairs shall be performed only in the presence or on direction of the Employer's Representative.

The Contractor shall repair all leakage spots in concrete joints or elsewhere in agreement with the Employer's Representative.

10.2 Lean Concrete

The strength class C12/15 shall be applied for wet lean concrete. With the following constituents:

- Cement shall be in accordance with Clause 11.4.2.1
- Water/cement ratio shall be in accordance with Clause 11.4.2.2
- Aggregates shall be in accordance with Clause

Consistence shall comply with Clause 11.4.3.1.

Wet lean concrete shall be spread uniformly, without segregation and without varying degrees of pre-compaction. The concrete shall be struck off to a level so that the surcharge is sufficient to ensure that after compaction the surface is at the required level.

The spread wet lean concrete shall be compacted using internal or external vibration, or a combination of both to meet the required density.

At transverse and longitudinal construction joints between two separately constructed slabs, the previously laid slab end or edge shall present a vertical face before construction of subsequent slabs.

Longitudinal joints in wet lean concrete shall be staggered by at least 300 mm from the position of longitudinal joints in any superimposed concrete slab, and by 1m for transverse joints.

Curing of wet lean concrete shall comply BS EN 12390-2 as appropriate.

The density shall be determined as in Clause 11.4.3.3 and sampling shall be as specified therein.

The surface of the wet lean concrete after compaction and finishing and before overlaying shall be free from ridges, loose material, pot holes, ruts or other defects. The surface of wet-laid concrete bases shall be roughened before the application of any curing compound by brushing with a wire brush or stiff broom.

Trial concrete mixes shall conform with BS 8500-2 for designed concretes for strength class C12/15 and above, unless recent data relating entirely to the proposed concrete, satisfies the requirements of the Specification.

At least 10 days before the start of the main wet lean concrete works a trial length of at least 400 m² for mechanised construction and 30 m² for hand-guided methods shall be constructed. The trial length shall be laid to assess the suitability of the proposed material, plant, equipment and construction methods to meet the requirements of the Specification. The main construction in the Permanent Works shall not start unless the trial length complies with the Specification. If any trial length does not conform to the Specification another trial length shall be constructed. Trial lengths not complying shall be removed unless they can be rectified to comply with the Specification.

After satisfactory completion of the trial, the material, plant, equipment and construction methods shall not be changed unless the Contractor lays a further trial length to assess the suitability of the proposed changes or agrees the changes with the Employer's Representatives.

10.3 No-Fines Concrete

No-fines porous concrete shall be used for the surround of ground water drainage pipes in tunnels at locations indicated on the drawings.

No-fines porous concrete shall be composed of ordinary Portland Cement and 37.5 mm single size aggregate complying with Clause 10.1.3.1.

The ratio of aggregate to cement shall be 8:1 by volume or 10:1 by mass.

The concrete shall be mixed by machine or by hand to a uniform colour and consistency before placing. The quantity of water used shall not exceed that required to coat all of the aggregate particles without forming excess grout.

No-fines concrete shall be compacted by hand.

10.4 Reinforcement

10.4.1 General

The items of work falling within the scope of work under this section shall be in accordance with the Indian and European Standards Specification (Latest edition) given under:

- IS:280-1978: Specifications for mild steel wire for General Engineering purposes
- IS:432-1966/82: Specifications for mild steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement
- IS:432 (Part I): Mild steel and medium tensile bars
- IS:432 (Part II): Hard drawn steel wire
- IS:456-1978: Code of practice for plain and reinforced concrete
- IS:814-1974: Specifications for covered electrodes for metal arc welding of structural steel
- IS:814 (Part I): For welding products other than sheets
- IS:814 (Part II): For welding sheets
- IS: 1139-1966: Hot rolled mild steel medium tensile steel and high yield strength deformed bar for concrete reinforcement
- IS: 1786-1979: Specifications for cold worked steel high yield strength deformed bars for concrete reinforcement
- IS:2502-1963: Code for practice for bending and fixing of bar for concrete reinforcement
- IS:5525-1979: Recommendations for detailing of reinforcement in reinforced concrete constructions
- IS:9417-1979: Recommendations for welding cold-worked bars for reinforcement concrete constructions
- BS EN 10080: Steel for the reinforcement of concrete. Weldable reinforcing steel. General
- BS 4449: Steel for the reinforcement of concrete - Weldable reinforcing steel - Bar, coil and decoiled product
- BS 4482: Steel wire for the reinforcement of concrete products. Specification
- BS 4483: Steel fabric for the reinforcement of concrete

The Contractor may adjust the position of lap joints to fit in with available stock lengths, or construction joints, subject to the Employer's Representative's agreement to the altered positions. The Contractor shall amend the bending schedules, as necessary, to allow for such alterations.

Reinforcement shall be obtained from a Certificated Authority for Reinforcing Steels Quality Assurance approved supplier and the Contractor shall provide copies of the manufacturer's certificates of test results relating to the steel reinforcement to be supplied.

Reinforcing steel bars and welded steel wire fabric may be stored outside in an approved manner provided that they do not rust and are placed on sleepers which will prevent the steel from coming into contact with the ground and a protection against contact with aggressive elements is provided.

Reinforcing steel bars shall be free from dirt, oil, flaky rust, loose mill scale and any other coating that would destroy or reduce the bond with the concrete.

Tying wire shall be 1.6 mm diameter soft annealed mild steel, and when fixed shall not project into the concrete cover.

Where the Contract so requires, the Contractor shall produce bending schedules.

10.4.2 Placing and fastening

Placing and fastening of reinforcement shall comply with IS 456 unless specified otherwise herein.

All reinforcement shall be accurately placed, securely fixed and adequately maintained in the positions shown on the drawings. The reinforcement shall be fixed so that the cover specified on the drawings is achieved, subject to the tolerances specified therein.

Reinforcing steel bars shall be installed as shown on the drawings and shall be solidly attached to the formwork. Reinforcing steel bars shall be tied together with wire ties to form a rigid grid which shall be supported in its required position, on chairs and with spacers and hangers. The wire ties shall be used in a staggered pattern at a spacing not exceeding 60 centimetres. Reinforcing steel bars shall be accurately placed within the specified tolerances and shall be secure against displacement during concrete placement.

Reinforcement shall not be re-bent on site unless agreed with the Employer's Representative.

The minimum clear distance between parallel reinforcing steel bars shall be the nominal diameter of the reinforcing steel bars or 1.25 times the maximum size of the coarse aggregate, whichever is the greater, provided that the minimum clear distance between parallel reinforcing steel bars in beams shall not be less than 30 millimetres and in columns shall not be less than 50 millimetres.

Spacer blocks shall be of comparable strength, durability and appearance to the surrounding concrete and shall be factory produced. Site-produced concrete or mortar cover blocks shall not be used.

Spacers and chairs shall ensure that the reinforcement is correctly positioned, be as small as possible consistent with their purpose, and designed so that they will not overturn or be displaced when the concrete is placed. Wire cast in the block for the purpose of tying it to the reinforcement shall be as specified below.

Prior to placing reinforcement on rock or gravel foundation, the foundation shall be covered with at least 50 mm thick layer of concrete or other approved cover.

Tying wires shall be 1.6 mm soft annealed iron wire unless drawings require the use of stainless steel tying wire. Where stainless steel tying wire is required it shall be 1.2 mm diameter stainless steel wire throughout the structure.

Projecting ends of ties or clips shall not encroach into the concrete cover.

Overlap between adjacent sheets of welded wire fabric shall be a minimum of 2 squares.

Concreting shall not commence until the reinforcement has been inspected in accordance with the Inspection and Test Plan.

10.4.3 Splicing

Joints or splices in reinforcing bars shall generally be made at the positions shown on the drawings, but the contractor would be permitted to make joints or splices at positions other than those shown on the drawings, providing that such positions are approved by the Employer's Representative-in-Charge and that joints and splices in adjacent bars are staggered if directed by the Employer's Representative-in-Charge.

Approval of such additional splices will generally be restricted to splices not closer than 8 m in horizontal bars or 4 m in vertical bars measured between mid-points of laps. The number of splices shall be kept to a minimum.

If the Contractor proposes to use mechanical couplings for reinforcing bars, he shall submit samples of the proposed coupling to the Employer's Representative for approval not less than 60 days prior to their proposed use.

10.5 Formwork

10.5.1 General

Material and workmanship shall comply with IS 456 and IS 14687.

The supply of all labour, supervisors, Contractor's equipment and materials and the execution of all work necessary to design, supply, fabricate, erect, treat, support, brace, use, remove and dispose of formwork for retaining and forming concrete structures as specified herein and as shown on the drawings shall be provided by the Contractor.

Not less than 60 days prior to the start of fabrication of formwork and falsework for each structure or part of a structure, the Contractor shall submit to the Employer's Representative design calculations and erection

drawings showing the formwork and falsework for that structure or part of the structure. The general method and system proposed shall be submitted in detailed drawings of the formwork to the Employer's Representative for agreement.

The erection drawings shall indicate the method and schedule of construction, member sizes and type, grade and quality of materials, the arrangement of joints, splices, liners and locations of temporary openings and embedded parts. Details of mechanical equipment that will operate or be supported on the falsework, shall be submitted with the erection drawings. Design assumptions, loads and allowable stresses shall be indicated on the erection drawings.

All formwork shall be dimensioned, constructed and securely braced as to prevent displacement.

All joints in the formwork and between the formwork and previous work shall be sufficiently tight to prevent loss of liquid from the concrete.

Formers for all chases, grooves, recesses, etc. shall be securely fixed as part of the formwork. No part of the concrete shall be cut away for any such item, or for any other reason, without the Employer's Representative's agreement.

The face of the formwork shall be clean and applied with non-staining release agent. The agent shall not touch reinforcement, or items to be embedded, and shall not be allowed to collect in the bottom of the formwork, or flow onto previously placed concrete.

Before any concrete is placed, the Contractor shall examine and clean out the formwork and ensure that the specified reinforcement cover is attained.

Where cyclical casting, e.g. in-situ concrete tunnel lining, striking times may be agreed with the Employer's Representative following criteria determined from trial lengths.

10.5.2 Material Requirements

The surface of steel plate formwork and steel faced lumber formwork shall be smooth and free from dents, buckles and other surface irregularities. The sheathing for steel formwork shall be steel plate not less than three millimetres thick. All bolts and rivet heads shall be countersunk. Means shall be provided to ensure a snug fit of steel plate sheathing and steel faced sheathing against previously hardened concrete so as to provide smooth joints.

Lumber used for formwork shall be free from warp, loose knots and decay and shall be sawn straight and dressed smooth.

Plywood shall be non-warping and non-wrinkling and shall be manufactured with waterproof glue. Only plywood sheets with identical length and width shall be used.

Fillers for repairing and reconditioning formwork shall be subject to approval by the Employer's Representative. All filler material shall be sanded flush and sealed with an approved sealer to prevent adhesion to the concrete.

10.5.3 Tunnel Formwork

Formwork for tunnel lining shall be constructed in such lengths that each concrete placement can be completed without cold joints.

Concrete pads, pedestals and other means to support tunnel formwork shall be subject to approval by the Employer's Representative on the basis of the effects of such supports on the structural properties of the tunnel section and on the finish of the lining.

Formwork for tunnel lining above the invert shall be provided with rows of openings along each side. The bottom row shall be located with the centreline of the openings above the longitudinal construction joint at the invert. Successive rows shall be located on two meters centres above the next lower row. The rows of openings shall be staggered. Openings shall permit access for inspection and vibration of concrete being placed behind the formwork. Each row of openings shall be provided with a platform for access to the openings. Openings shall be located at a minimum spacing of 2.5 meters along the tunnel centreline and up the tunnel walls. Openings shall be not smaller than 45 by 60 centimetres, with the long dimension parallel to the centreline of the tunnel.

10.5.4 Execution

10.5.4.1 Preparation

Formwork shall be constructed in strict accordance with the erection drawings after they have been reviewed by the Employer's Representative and shall produce concrete conforming to the lines, slopes, elevations and dimensions and with the surface finishes shown on the drawings. Joints between formwork sections shall be sufficiently tight to prevent loss of mortar from concrete. Formwork shall be securely tied and anchored to maintain shape and position and to avoid warping and bulging.

Formwork for curved surfaces shall be constructed to conform accurately to the required curvatures of the surfaces within the allowable tolerances specified.

Formwork joints shall fit together without gaps greater than two millimetres at any point. The joint marks on the concrete surface in the water passages shall follow in general the line of water flow. Forms shall be placed so that the joint marks on concrete surfaces will be in alignment both horizontally and vertically and the joint marks between surfaces shall be smooth.

10.5.4.2 Installation

Formwork shall be braced to maintain its position and shape. Formwork and falsework shall be arranged for ease of dismantling and stripping to ensure that its removal will not damage the concrete. Formwork blocking and supports to be left permanently in the concrete shall be fabricated of steel.

The interior surfaces of formwork shall be covered with colourless mineral form oil or other bond breaking compound approved by the Employer's Representative. The bond breaking compound shall be applied before reinforcing steel bars are placed. Form oil or bond breaking compounds shall not come in contact with reinforcing steel bars or with concrete surfaces on which additional concrete, epoxy mortar or any bonded coating is to be placed.

10.5.4.3 Tolerances

Formwork and falsework shall be constructed, located, supported and braced in such a manner that the finished surfaces of concrete structures are within the allowable construction tolerances as defined in Clause 10.1.11.4 of this Specification.

10.5.4.4 Concrete Placement

Temporary openings shall be provided in the formwork at any place where necessary to facilitate concrete placement, insertion of vibrators, cleaning and inspection. The temporary openings shall be closed with removable panels that are flush with the formwork surface on the inside. Immediately before concrete is placed, formwork shall be inspected to ensure that it is accurately placed, rigid, tight, clean and free from foreign matter.

Inspection of formwork by the Employer's Representative and approval to proceed with concrete placement shall not relieve the Contractor of his responsibility for safety and accuracy of the Work. Any repairs of concrete due to faulty or inaccurate formwork shall be done by the Contractor at no additional cost to the Employer.

10.5.4.5 Quality Control

The alignment and position of formwork shall be checked frequently during concrete placement. Any misalignment shall be corrected by wedging and shoring.

Formwork and falsework may be reused, provided that the material is undamaged and the surface in contact with concrete is cleaned and is capable of producing the required surface finish. Timber and plywood formwork shall not be repaired with metal patches.

10.5.4.6 Removal

Formwork shall be removed in such a manner as to prevent concrete spalling and to produce sharp and clean joints.

Formwork shall be eased, struck or removed in such a manner that the structure is not distorted, damaged or overloaded.

Except where otherwise agreed with the Employer's Representative, formwork shall not be eased or struck until:

- the concrete has attained sufficient strength to support itself in the position cast without deformation or
- a minimum period in line with Section 6 of ENV 13670-1
- vertical forms and formwork for tunnel crown lining may be removed when the concrete has attained a

compressive strength of min 6 MPa, deduced from the strength development of comparable test specimens cured under similar conditions

- 10 hours after concrete placing unless measures are taken to prevent excessive cooling and drying. These measures shall be agreed with the Employer's Representative

10.5.5 Design and Installation Criteria

Formwork and falsework shall be designed to withstand, safely and without distortion, all loads that will be applied before, during and after concrete placement. The design loads shall include wind, concrete, equipment and personnel. Formwork shall be designed to permit the concrete to be deposited as nearly as practicable directly in its final position and shall have access facilities that will allow inspection, checking and clean-up of the surface of the preceding concrete placement and inspection and vibration of the concrete.

10.6 Design Life and Grade of Concrete Lining in Tunnel

- Minimum Grade of concrete lining M35 conforming to IS 456
- Design life of tunnel lining 100 years

11 PAVEMENT

11.1 General

The Contractor shall furnish all materials, equipment and labour necessary for permanent roadwork as shown on the drawings or as directed. The design for the permanent roadwork will be provided by the Employer.

The Contractor shall design and furnish all materials, equipment and labour necessary for construction roads or tracks to other work sites, to spoil areas, to installation areas and to camps to the extent that he considers necessary for his activities. These roads shall be constructed at the minimum standard necessary for the Contractor to safely execute the Works. The layout and design for all temporary roadwork shall be provided by the Contractor and approved by the Employer before the work commences.

The Contractor shall place compacted and treated, if necessary, selected backfill, either from required excavations or approved borrow areas, to completed structures as shown on the drawings or as directed. The Clause 6.7 for backfill material shall be applied accordingly.

All permanent road work, materials, workmanship, quality, construction tolerances, testing and etc. shall be carried out in accordance with the "Specifications for Road and Bridge Works" by Ministry of Road Transport and Highways (MoRTH 2000), unless otherwise specified in the drawings or as directed by the Employer's Representative. This requirement applies to both the road outside the tunnel or portal buildings/structures as well as that inside these. The main Clauses of the "Specifications for Road and Bridge Works" (MoRTH 2000) which shall be applied are summarized in this Specification.

11.1.1 Tolerances

The design levels of pavement courses shall be calculated from the vertical profile, crossfalls and the pavement course thicknesses as described in relevant drawings. The level of any point on the constructed surface of the pavement courses shall be the design level subject to the appropriate tolerances stated in Table.

Table 23: Tolerances in surface levels of pavement courses

Pavement course	Tolerances
General Adjacent to a surface water channel ¹	± 6 mm + 0-10 mm
Base under concrete pavement surface slabs laid full thickness in one operation by machines with surface compaction	± 10 mm
Unbound sub-base layer	+ 10-30 mm

Notwithstanding the tolerances permitted in surface levels of pavement courses, the cumulative tolerance shall not result in a reduction in thickness of the pavement, excluding the sub-base and filter layer, by more than 15 mm neither from the specified thickness nor a reduction in the thickness of the bituminous surface course by more than 5 mm from that specified.

For checking compliance with this Clause, measurements of the surface levels of all courses shall be taken on a

¹Where a surface water channel is laid before the adjacent road pavement layer the top of that layer, measured from the top of the adjacent edge of the surface water channel, shall be to the given tolerances.

grid pattern in agreement with the Employer's Representative.

The longitudinal regularity of the surfaces of surface courses, binder courses and concrete slabs shall be such that the number of surface irregularities is within the relevant limits stated in Table 19.

An irregularity is a variation of not less than 4 mm or not less 7 mm of the profile of the road surface as measured by the rolling straight-edge set at 4 mm or 7 mm as appropriate or equivalent apparatus capable of measuring irregularities within the same magnitudes over a 3 m length. No irregularity exceeding 10 mm shall be permitted.

Prior to checking any final road surface, it shall be cleaned of loose or extraneous materials. These operations shall be carried out without damaging the surface of the pavement as soon as possible and within 3 days of construction of the pavement.

Compliance with Table 23 shall be checked by the rolling straight-edge along any line or lines parallel to the edge of pavement on sections of 300 m at regular intervals in agreement with the Employer's Representative, whether or not it is constructed in shorter lengths. Sections shorter than 300 m forming part of a longer pavement shall be assessed using the number of irregularities for a 300 m length pro - rata to the nearest whole number.

Pavements shall be measured transversely for irregularities at regular intervals in agreement with the Employer's Representative, by a 3 m long straight-edge placed at right angles to the centre line of the road. The maximum allowable difference between the pavement surface and the straight-edge shall be 3 mm.

A 3 metres long straight-edge shall be used to check longitudinal surface regularity for all lengths of base layers under concrete pavement slabs laid full thickness in one operation by machine with surface compaction.

The maximum allowable difference between the surface and the underside of the straight-edge, when placed parallel with or at right angles to the centre line of the road, shall be:

- 3 mm for pavement surfaces
- 10 mm for bases under concrete pavements

Table 24: Maximum permitted number of surface irregularities

Irregularity limits	Surfaces of each lane of carriageway, each hard strip and each hard shoulder for each irregularity limit				Surfaces of lay-bys, service areas for each irregularity limit			
	4 mm		7 mm		4 mm		7 mm	
Length [m]	300	75	300	75	300	75	300	75
Number of irregularities	40	18	4	2	60	27	6	3

11.1.2 Rectification

Where any pavement area does not comply with the Specification for regularity, surface tolerance, thickness, macrotexture depth, material properties or compaction, the full extent of the area which does not comply with the Specification shall be made good and the surface of the pavement course shall be rectified in the manner described below:

- Unbound base layer: The top 75 mm shall be scarified, reshaped with material added or removed as necessary, and re-compacted. The area treated shall be not less than 30 m long and 2 m wide or such area as necessary to obtain compliance with the Specification.
- Bituminous bases: With coated macadam or asphalt bases, the full depth of the top layer as laid shall be removed and replaced with fresh material laid and compacted in accordance with the Specification. Any area so treated shall be at least 5 m long and the full width of the paving laid in one operation. Alternatively, for low areas in bituminous bases, the Contractor may make up the level with additional binder course material.
- Concrete slabs: Concrete slabs shall be rectified by planning, grinding or bump cutting. Large depressions, which cannot be dealt in this way, shall be rectified by cutting out the surface and replacing by a thin bonded surface repair. Where the slab cannot be rectified as above, the full depth of slab shall be removed and replaced with a slab constructed in compliance with these

Specifications. Remedial works involving the placing of fresh concrete shall be completed in sufficient time for the concrete strength which have to be developed as specified before that section of pavement is opened to

traffic.

11.2 Unbound Sub-Base Layer

11.2.1 General

This work shall consist of laying and compacting well-graded material on prepared sub-grade in accordance with the requirements of these Specifications. The material shall be laid in one or more layers as sub-base as necessary according to lines, grades and cross sections shown on the drawings or as directed by the Employer's Representative.

The sieve size distribution shall be in compliance with Table 24 as per MoRTH (2000).

Table 25: Grading for unbound sub-base layer

Designation	Per cent per weight passing
75.0 mm	-
53.0 mm	100
26.5 mm	70-100
9.5 mm	50-80
4.75 mm	40-65
2.36 mm	30-50
0.425 mm	15-25
0.075 mm	3-10

The unbound mixture shall satisfy the minimum CBR value of 25 when it is compacted and finished.

When directed by the Employer's Representative, this shall be verified by performing CBR tests in the laboratory as required on specimens remoulded at field dry density and moisture content and any other tests for the "quality" of materials, as may be necessary and required by the Employer's Representative.

11.2.2 Laying

Unbound mixtures in a frozen condition shall not be incorporated in the Works but may be used, if acceptable, when thawed. Unbound mixtures shall not be laid on any surface which is frozen or covered with ice.

The unbound mixtures of grading specified herein (Table 24) shall be placed and spread on the prepared surface evenly. Unbound mixtures shall be spread using a paving machine or a suitable spreader box and operated with a mechanism which levels off the material to an even depth.

Material up to 225 mm compacted thickness shall be spread in one layer so that after compaction the total thickness is as specified. Material of compacted thickness greater than 225 mm shall be laid in two or more layers and the minimum compacted thickness of any such layer shall be 110 mm. Where the layers of unbound mixtures are of unequal thickness, the lowest layer shall be the thickest layer.

Moisture content of the loose material shall be checked in accordance with IS:2720 (Part 2) and suitably adjusted by sprinkling water uniformly and at controlled quantities to variable widths of surface or other means approved by the Employer's Representative so that, at the time of compaction, it is from 1 per cent above to 2 per cent below the optimum moisture content corresponding to IS:2720 (Part 8). While adding water, due allowance shall be made for evaporation losses.

11.2.3 Compaction

Compaction shall be completed as soon as possible after the mixture has been spread and in accordance with the requirements for the individual mixtures.

Compaction of unbound mixtures shall be carried out by a method the Contractor demonstrates at site trials that compacted density achieved is at least 98 % of the maximum dry density for the material determined as per IS:2720 (Part 8).

The surface of any layer of material shall on completion of compaction and immediately before overlaying, be well closed, free from movement under construction plant and from ridges, cracks, loose material, pot holes, ruts or other defects. All loose, segregated or otherwise defective areas shall be removed to the full thickness of the layer, and new material shall be laid and compacted.

11.2.4 Site Traffic

Construction plant and other traffic used on pavements under construction shall be suitable in relation to the material, condition and thickness of the courses it traverses so that damage is not caused to the subgrade or the

pavement courses which are already constructed. The wheels or tracks of plant moving over the various pavement courses shall be kept free from deleterious materials.

Final excavation levels (formation level) for pavement construction shall be protected against any wear or deterioration of rock properties following site traffic by backfilling with rock material excavated in the tunnel or similar to a minimum thickness of 0.5 metres.

Ponding water and traffic through ponding water shall not be allowed.

Any deteriorated material shall be removed and replaced prior to pavement works as directed by the Employer's Representative.

The backfill material used for protection purposes shall not be removed until immediately prior to pavement construction works.

No site traffic shall be allowed to run on unprotected invert structures, temporary or final, concrete or shotcrete. Structures as such shall be protected against destruction by backfilling with suitable excavation material from the tunnel or similar with a minimum thickness of 0.5 metres. Backfilling material shall not contain boulders larger than 150 mm diameter.

11.3 Bituminous Base Layer

11.3.1 General

Natural, recycled unbound and manufactured (artificial) aggregates shall be clean, hard and durable and shall comply with BS EN 13043.

Irrespective of source, coarse aggregates for bituminous mixtures shall be considered suitable if:

- the resistance to fragmentation category of the coarse aggregate as defined in clause 4.2.2 of BS EN 13043 shall be LA30 or better for natural aggregates and LA50 or better for blast furnace slag or
- crushed rock aggregate has a Los Angeles Value greater than 30 but less than 35, where evidence can be presented to the Employer's Representative of previous satisfactory use of the source in asphalt.

Natural and manufactured (artificial) aggregates recovered from a previous use in an unbound form shall comply with the requirements of this Clause.

The freezing and thawing (soundness) category, as defined in BS EN 13043, clause 4.2.9.2, shall be MS25 unless otherwise specified herein. The water absorption value of the coarse aggregate shall be determined in accordance with BS EN 13043, clause 4.2.9.1. If the water absorption value of the coarse aggregate is greater than WA242, the soundness test shall be carried out on the material delivered to site. The requirements for water absorption do not apply to blast furnace slag aggregate.

Before work commences, the Contractor shall submit a method statement to the Employer's Representative that includes:

- Laying and compaction procedures for each layer - including paving speed and paved width; size, type and number of rollers; and number of roller passes.
- The joint formation procedures for each layer - including the location of longitudinal and transverse joints; and the method(s) of treating upstanding edges.

11.3.2 Placing

In order to exclude moisture from interfaces and ensure full interlayer bonding, the surface of all bituminous material shall be kept clean and uncontaminated. If any surface becomes contaminated, it shall be made good by cleaning and if this proves impracticable, by rectification.

Prior to placing bituminous material on any new or existing bound substrate, a bond coat or tack coat shall be applied in accordance with Clauses 920 or 942, as appropriate.

Hot bituminous mixtures shall be transported in accordance with the requirements of BS 594987 and shall remain covered whilst awaiting tipping.

Wherever practicable, hot bituminous mixtures shall be spread, levelled and tamped by a self-propelled paving machine. The rate of delivery of material to the paver shall be regulated to enable the paver to operate continuously.

Hand placing of hot bituminous mixtures shall be restricted to the following circumstances:

- For laying regulating courses of irregular shape and varying thickness.
- In confined spaces where it is impracticable for a paver to operate.
- For footways.
- At the approaches to expansion joints at bridges, viaducts or other structures.
- For laying mastic asphalt.

The method of laying shall be such that the finished mat is free from dragging, tearing and segregation of the material.

Dense base course asphalt concrete (formerly macadam) recipe mixtures shall be asphalt concrete conforming to BS EN 13108-1.

Bituminous mixtures shall not be laid on layers with a surface temperature beneath 5°C.

The surface tolerances shall be in compliance with Clause 11.1.1.

11.4 Concrete Pavement

11.4.1 General

The work shall consist of construction of unreinforced, dowel jointed, plain cement concrete pavement in accordance with the requirements of these Specifications and in conformity with the lines, grades and cross sections shown on the drawings. The work shall include furnishing of all plant and equipment, materials and labour and performing all operations in connection with the Work, as approved by the Employer's Representative.

Concrete in rigid or rigid composite pavements shall be of the class C32/40 XF4 and shall confirm to the Clauses of Chapter 10 unless given otherwise below.

Prior to commencement of any concrete works the base layer shall be checked of adequate bearing capacity and elevation the tolerances are given in Clause 11.1.1. The check has to be in appropriate time prior to commencement hence measures shall be taken contemporary and no time delay may occur.

If the thickness of the base layer is not in the range of the tolerances the base layer shall be corrected. If this is not possible, the base layer shall be fully replaced.

The base layer shall be clean and free of deleterious material.

The concrete slab shall be laid in two layers. The surface layer shall be laid monolithically with the lower layer. The surface layer shall be not less than 50 mm thick.

11.4.2 Concrete Composition

The concrete composition shall comply with Clause 10.1.3 unless given otherwise below.

11.4.2.1 Cement

The cement content shall be in accordance to Table 21 and means any of the following materials or combinations below:

- Portland cement CEM I, BS EN 197-1
- Portland slag cement CEM II/A-S and CEM II/B-S, BS EN 197-1
- Blastfurnace cement CEM III/A, CEM III/B BS EN 197-1
- Portland-fly ash cement CEM II/A-V, CEM II/B-V BS EN 197-1
- Pozzolanic cement CEM IV/A BS EN 197-1
- Portland cement CEM I BS EN 197-1 with ground granulated blastfurnace slag (ggbs) for use with Portland cement CEM I
- Portland cement BS EN 197-1
- CEM I with pulverised-fuel ash (pfa) for use as a cementitious component in structural concrete BS EN 197-1

Table 26: Minimum cement or combination contents with 40 mm maximum aggregates

Min. Portland cement CEM I, BS EN 197-1 in [kg/m ³]	320
Min. other cements or combinations permitted	340
Maximum proportion of ggbs in [%]	25
Max./min. proportion of pfa in [%]	25/15
Min. CEM I content in [kg/m ²] for combinations with pfa and ggbs	255

For 20 mm maximum size aggregate 20 kg/m³ cement content per cubic meter fully compacted concrete shall be added, and for < 20mm maximum size 40 kg/m³ cement content shall be added

If the concrete layer shall be laid in two layers, the cement of the surface layer shall be limited to Class 42.5N/42.5R Portland cement CEM I in accordance to BS EN 197-1. The minimum cement content of the concrete shall be 375 kg/m³.

The cement content shall not exceed 425 kg/m³.

11.4.2.2 Water

Water from a water company supply may be used without testing. Water from other sources may be used if it conforms to BS EN 1008. The water content shall be the minimum required to provide the specified consistence for full compaction of the concrete to the required density, as determined by trial concrete mixes or other means. The maximum free water/cement ratio shall be 0.45 for strength classes C32/40 and C25/30 and 0.60 for strength classes C16/20 and C12/15.

If the concrete layer shall be laid in two layers, the free water/cement ratio of the surface layer shall be max. 0.40 for strength classes C32/40 and C25/30.

11.4.2.3 Admixtures

Concrete for pavement slab shall incorporate an air-entraining admixture complying with BS EN 934-2 in at least the top 50 mm of surface slabs.

Plasticisers or water reducing admixtures shall comply with BS EN 934-2. Admixtures containing calcium chloride shall not be used.

11.4.2.4 Aggregates

Aggregates for all pavement concrete, including wet lean, shall comply with IS:383 and BS EN 12620 respectively.

The aggregates shall be free from chert, flint, chalcedony or other silica in a form that can react with the alkalis in the cement. In addition, the total chlorides content expressed as chloride ion content shall not exceed 0.06 per cent by weight and the total sulphate content expressed as sulphuric anhydride (SO₃) shall not exceed 0.25 per cent by weight.

No aggregate which has water absorption more than 2 per cent shall be used in the concrete mix.

If the concrete layer shall be laid in two layers, the surface layer shall comply with following requirements:

- For 6.3/10 mm coarse aggregate or 4/8 mm coarse aggregate the amount of aggregate retained on the 10 mm sieve and 8 mm sieve respectively shall not exceed 3% by mass. The aggregate passing the 6.3 mm sieve and 4 mm sieve respectively shall not exceed 10% by mass.
- The fine aggregate grading shall comply with the 0/2 (FP) or 0/1 (FP) grading in BS EN 12620 except that not less than 99% of the mass of the material shall pass the 2 mm sieve.
- The coarse aggregate shall comprise at least 60% by mass of the oven dry constituents of the concrete.
- The polished stone value (PSV) and the aggregate abrasion value (AAV) of the coarse aggregate determined in accordance with BS EN 1097-8 shall be PSV50 and AAV15. The Category of flakiness index of the aggregate is FI15.

The resistance to fragmentation of the coarse aggregate shall be of class LA20. The resistance to freezing and thawing shall be of class F1 for the coarse and fine aggregates.

11.4.3 Concrete Requirements

11.4.3.1 Consistence (Workability)

The consistence shall be determined by the Degree of Compactibility (Compaction Index) test in accordance

with BS EN 12350-4, or the Vebe test in accordance with BS EN 12350-3. Alternatively, for concrete class C16/20 or below, consistence may be determined by the slump test in accordance with BS EN 12350-2. The sampling for all concrete classes shall be undertaken in accordance with BS EN 12350-1 and the rate of testing in accordance with Table 12 of BS EN 206-1. Consistence shall be carried out at the point of placing, in conjunction with tests for strength and any tests for air content. The consistence shall be maintained at the optimum within the limits specified in BS EN 206-1.

If any determination of consistence gives a result outside the tolerance, a further test shall be made immediately on the next available load of concrete. The average of the two consecutive results and the difference between them shall be calculated. If the average is not within the tolerance or the difference is greater than 0.1 for CI or 20 mm for slump or 6 seconds for Vebe, subsequent samples shall be taken from the delivery vehicles, which shall not be allowed to discharge into the Works until compliance with the Specification has been established.

11.4.3.2 Air content

The concrete shall meet the requirement for exposure class XF4 in BS EN 206-1. This shall be achieved by the use of an air-entraining agent. The minimum quantity of air in air-entrained concrete as a percentage of the volume of the concrete shall be as in Table 26.

Table 27: Minimum air content with respect to max. aggregate size

Max. aggregate size in [mm]	Min. air content in [%]
20	3.5
40	3

The air content shall be determined at the point of delivery to the paving plant by the pressure gauge method in accordance with BS EN 12350-7, at the rate of one determination per 300 m² of slab or at least 6 times per day, whichever is the greater, in conjunction with tests for consistence and strength. For areas less than 300 m² the rate shall be at least one determination to each 20 m length of slab or less constructed at any one time or at least 3 times per day. If the air content is outside the specified limits in BS EN 206-1, the Contractor shall remove the concrete from the Works.

The air-entraining agent shall be added at the mixer by an apparatus capable of dispensing the correct dose within the tolerance for admixtures given in Table 18, to ensure uniform distribution of the agent throughout the batch during mixing.

11.4.3.3 Density (Manual of Contract Documents for Highway Works)

The density of a saturated core cut from the full depth of the concrete pavement shall not be less than 95% of the average density of at least six fully compacted saturated moulded specimens made from the same concrete and tested at the same age.

The density of the concrete pavement shall be determined in accordance with BS EN 13877-2. The density of a saturated core cut from the full depth of the concrete pavement shall be determined in accordance with BS EN 12390-7. The determination of the saturated density of the fully compacted moulded specimens shall be in accordance with BS-EN 12350-1, BS-EN 12390-1 and BS-EN 12390-2.

The core shall have an average diameter of at least four times the nominal maximum aggregate size, and in any case at least 100 mm diameter. Where different concrete mixes are used in separate layers, the density of each layer shall be separately determined by splitting or cutting the cores between the layers.

If the density of any core is below the minimum required, the concrete across the whole width of the slab constructed at the time relating to that core shall be removed. In unreinforced concrete the whole slab length between joints shall be removed. For reinforced slabs, in order to determine the limit of the defective area of concrete which shall be removed, additional cores shall be taken at 5 m intervals on each side of any defective core until concrete of satisfactory density is found. Defective areas shall be made good with new material in accordance with the Specification.

In calculating the density, allowance shall be made for any steel in the cores.

Core holes shall be reinstated with compacted concrete with mix proportions of 1 part of Portland cement CEM I: 2 parts of sand: 2 parts of 10 mm single sized coarse aggregate by mass.

11.4.3.4 Pavement concrete strength

Sampling and testing for and compliance with the specified characteristic core strength of designed concretes

shall be undertaken by compressive strength testing in accordance with BS EN 13877-2 on cores cut from the full depth of the slab. No correction for maturity shall be applied to the 7 day or 28 day strength.

Concrete cores of the appropriate size shall be taken, cured and tested in accordance with BS EN 12504-1 with the exception that the core shall be cured under water at 20°C ±2°C as soon as practically possible. The sampling rate shall be as designated in BS EN 13877-2 for Category 2, three cores shall be taken from areas of concrete of up to 3000 m² and one additional core for every further 1000 m² of concrete laid.

An exception to the above sampling rate is that in the trial slab at least six cores shall be taken, three to be tested at 7 days and three at 28 days.

The end preparation of the core shall be by grinding and the height/diameter (h/d) ratio of the tested specimen shall be between 1 and 2.

If during the construction of the trial length the average corrected core compressive strength, from the three cores, falls below the 7 day corrected core compressive strength given in Table 23, then either the cement content of the concrete shall be increased by 5% by mass, or a further trial slab shall be constructed using an improved compaction technique and/or an increased cement content. The increased cement content shall be maintained at least until the three corresponding 28-day core strength tests have been assessed. If the cement content is increased, the concrete shall be adjusted to maintain the required consistence.

Table 28: 7 day corrected core compressive strength

Concrete Class	7 day corrected compressive strength for CEM I concrete in [N/mm²]	7 day corrected compressive strength for CEM I with pfa or ggbs concrete in [N/mm²]
C32/40	32	26.8
C25/30	25	20
C16/20	16.5	13
C12/15	12	10
C8/10	7.5	6.5
C6/8	5	4

Overlapping groups of four consecutive 28 day corrected core strengths shall be used for assessing the pavement for compliance with the criteria in Table A.1 of BS EN 13877-2. The pavement shall be accepted if the criteria in Table A.1 are satisfied for four results derived from strength tests on cores taken from the constructed pavement. Conformity control of the concrete will be the responsibility of Contractor.

11.4.3.5 Finished Surface Requirements

The finished surface of the pavement shall comply with the requirements of Clause 11.1.1. Where a pavement area does not comply with the Specification in any respect, the full extent of the surface which does not comply shall be rectified in accordance with Clause 11.1.2.

After the final regulation of the surface of the slab and before the application of the curing membrane, the surface of concrete slabs to be used as running surfaces shall be brush-macrotextured in a direction at right angles to the longitudinal axis of the carriageway. The macrotexture shall be applied evenly across the slab in one direction by a brush not less than 450 mm wide. The macrotexture shall be uniform both along and across the slab.

The macrotexture depth shall be determined by the volumetric patch technique as described in BS EN 13036-1. Tests shall be taken within 100 m of commencement of paving and thereafter at least once for each day's paving at the times after construction as given below and in the following manner: 10 individual measurements of the macrotexture depth shall be taken at least 2 m apart anywhere along a diagonal line across a lane width between points 50 m apart along the pavement. No measurement shall be taken within 300 mm of the longitudinal edges of a concrete slab constructed in one pass.

Macrotexture depths shall be as required in Table 28.

Where the required macrotexture depth is found to be deficient the Contractor shall make good the texture across the full lane width over lengths necessary to comply with the requirements of Table 28, by retexturing the hardened concrete surface as described in Clause 11.4.14.

Table 29: Required macrotexture depth and tolerances

Time of test	Required macrotexture depth in [mm]	
	Specified value	Tolerance

between 24 hours and 7 days after the construction of the slab or until the slab is first used by vehicle	an average of 10 measurements	1.0	±0.25
not later than 6 weeks before road is opened to public traffic	an average of 10 measurements	1.0	+0.25 -0.35

11.4.4 Transverse Joints**11.4.4.1 General**

Transverse joints shall be provided in unreinforced and jointed reinforced concrete slabs and shall be contraction, expansion or warping joints at spacing of 25 times the plate thickness and with a maximum of 5.0 m, such that for unreinforced concrete slabs the length/width ratio shall be not greater than 1.5.

Joints in the surface slab and sub-base shall be staggered so that they are not coincident vertically and are at least 1 m apart.

Transverse joints shall be straight within the following tolerances along the intended line of the joint, which is the straight line transverse to the longitudinal axis of the carriageway.

- deviations of the filler board or bottom crack inducer from the intended line of the joint shall be not greater than ± 10 mm;
- the best fit straight line through the joint groove as constructed shall be not more than 25 mm from the intended line of the joint;
- deviations of the joint groove from the best fit straight line of the joint shall be not greater than 10 mm.

Transverse joints on each side of a longitudinal joint shall be in line with each other and of the same type and width.

Concrete pavement layers shall be isolated from fixed structures by expansion joints, or earthworks or a granular layer over the structure, or by bridge-type expansion joints, or by lengths of fully flexible pavement construction. End of pavement surface slabs shall have a transition bay leading into the fully flexible construction.

Transverse joints shall have a sealing groove which shall be sealed in compliance with Clause 11.4.10.

11.4.4.2 Contraction Joints

Contraction joints shall consist of:

- a sawn joint groove complying with Clause 11.4.8
- dowel bars complying with Clause 11.4.6,
- a sealing groove complying with Clause 11.4.10.

11.4.4.3 Expansion Joints

Expansion joints shall consist of:

- a joint filler board complying with Clause 11.4.9,
- dowel bars complying with Clause 11.4.6,
- a sealing groove complying with Clause 11.4.10.

The filler board shall be positioned vertically within the prefabricated joint assemblies along the line of the joint within the tolerances of Clause 11.4.4.1, and at such depth below the surface as will not impede the passage of the finishing beams on the paving machines. The joint filler board together with the sealing groove shall provide a complete separation of adjacent slabs and any spaces around dowel bars and between the sub-base and the filler board shall be packed with a suitable compressible material after fixing the joint assembly.

11.4.4.4 Warping Joints

Warping joints shall consist of:

- a sawn joint groove complying with Clause 11.4.8,
- tie bars complying with Clause 11.4.7, a sealing groove complying with Clause 11.4.10.

11.4.4.5 Construction Joints

Construction joints made at the end of a working day in unreinforced concrete slabs and jointed reinforced concrete slabs shall be contraction joints. In the event of mechanical breakdown of the concreting machinery, or at the onset of adverse weather, emergency joints may be formed.

Emergency joints in unreinforced concrete slabs shall be contraction joints not less than 2.5 m from the preceding or succeeding joint position. The stop end formwork shall be sufficiently rigid to ensure that dowel bars and tie bars will be held in position in compliance with these Specifications.

11.4.5 Longitudinal Joints

11.4.5.1 General

Sawn or wet-formed longitudinal joints shall be provided in surface slabs between or at the centre of traffic lanes within the allowable positions as shown on the drawings, so that bay widths are not greater than 4.2 m. Joints in the surface slab, base or sub-base shall be staggered so that they are not coincident vertically and are at least 300 mm apart.

Wet-formed longitudinal joints shall consist of:

- wet-formed joint grooves complying with Clause 11.4.8,
- a bottom crack inducer,
- tie bars complying with Clause 11.4.7.

Longitudinal joints shall be constructed within the following tolerances:

- deviations of the bottom crack inducer from the intended line of the joint, parallel to the axis of the road shall be not greater than ± 13 mm;
- the joint groove shall be located vertically above the bottom crack inducers within a horizontal tolerance of ± 25 mm;
- the best fit line along the constructed joint groove shall be not more than 25 mm from the intended line of the joint;
- deviations of the joint groove from the best fit line of the joint shall be not greater than 10 mm.
- Sawn longitudinal joints shall consist of joint grooves complying with Clause 11.4.8

11.4.5.2 Longitudinal Construction Joints

Longitudinal construction joints between separate slabs shall have tie bars as in Clause 11.4.7 with a joint groove as in Clause 11.4.8.

11.4.6 Dowel Bars

Dowel bars shall be Grade B500 steel conforming to BS EN 13877-3 and shall be free from oil, dirt, loose rust and scale. They shall be straight, free of burrs and other irregularities and the sliding ends sawn or cropped cleanly with no protrusions outside the normal diameter of the bar. For expansion joints, dowel bars shall be 25 mm diameter at 300 mm spacing and 600 mm long for slabs up to 239 mm thick and 32 mm diameter for thicker slabs. For contraction joints, dowels shall be 20 mm diameter at 300 mm spacing and 400 mm long for slabs up to 239 mm thick, and 25 mm diameter at 300 mm spacing and 600 mm long for thicker slabs.

Dowel bars shall be supported on cradles in prefabricated joint assemblies positioned prior to construction of the slab. For contraction joints, as an alternative to prefabricated assemblies, dowel bars may be mechanically inserted with vibration into the concrete by a method which ensures full recompaction of the concrete around the dowel bars and the surface finished by a diagonal finishing beam, or a longitudinal oscillating float travelling across the slab.

Dowel bars shall be positioned at mid-depth from the surface level of the slab ± 20 mm and centred equally about intended lines of the joint within a tolerance of ± 25 mm. They shall be aligned parallel to the finished surface of the slab to the centre line of the carriageway and to each other within the following tolerances:

- for bars supported on cradles prior to construction of the slab and for inserted bars in two layer construction prior to placing the top layer:
 - all bars in a joint shall be within ± 3 mm per 300 mm length of bar;

- two thirds of the bars shall be within ± 2 mm per 300 mm length of bar;
- no bar shall differ in alignment from an adjoining bar by more than 3 mm per 300 mm length of bar in either the horizontal or vertical plane;
- for all bars, after construction of the slab:
 - twice the tolerances for alignment as above
 - equally positioned about the intended line of the joint within a tolerance of 25 mm.

Dowel bars shall be covered by a flexible polymeric corrosion resistant coating. The coating shall be smooth and free of indentations. During coating, the bar shall be supported at each end. Minimum thickness shall be 0.3 mm. The coating shall also be able to withstand 250 hours immersion in a salt fog cabinet complying with BS EN ISO 7253, without showing any visible crazing or corrosion of the protected bar. The coated bar shall comply with the following pull out test:

Four bars shall be taken at random from stock and shall be coated as required in this Clause without any special preparation. The dowel bars which have been coated shall be cast centrally into concrete specimens 150 x 150 x 450 mm, made of the same concrete mix proportions to be used in the pavement, but with a maximum aggregate size of 20 mm and cured in accordance with BS EN 12390-2. At 7 days a tensile load shall be applied to achieve a movement of the bar of at least 0.25 mm. The average bond stress to achieve this movement shall be not greater than 0.14 N/mm².

For expansion joints, a 100 mm long closely fitting cap consisting of waterproofed cardboard or an approved synthetic material like PVC or GI pipe shall be placed over the sheathed end of each dowel bar. An expansion space at least equal in length to the thickness of the joint filler board shall be formed between the end of the cap and the end of the dowel bar by using compressible sponge. To block the entry of cement slurry between dowel and cap it may be taped.

11.4.7 Tie Bars

Tie bars in longitudinal joints shall be deformed steel bars of strength 415 N/m².

Tie bars for use across joints shall have corrosion protection in the form of a flexible polymeric corrosion resistant coating, bonded centrally onto 150 mm of the previously cleaned centre section of the bars. Where tie bars are to be cranked for construction joints and later straightened, the coating shall be shown to be capable of being straightened through 90 degrees without cracking.

Tie bars in warping joints and wet-formed longitudinal joints shall be made up into rigid assemblies with adequate supports and fixings to remain firmly in position during the construction of the slab. Alternatively, tie bars at longitudinal joints may be mechanically inserted by vibration from above using a method which ensures recompaction of the concrete around the tie bars.

Tie bars in warping joints shall be positioned from the top surface of the slab within +20, -10 mm of the mid depth of the slab. Tie bars shall be positioned and remain within the middle third of the slab depth, approximately parallel to the surface and approximately perpendicular to the line of the joint, with the centre of each bar on the intended line of the joints within a tolerance of ± 50 mm, and with a minimum cover of 30 mm below any top crack inducer of joint groove for slabs 200 mm thick or more, or 20 mm for slabs up to 200 mm thick.

11.4.8 Joint Grooves

Transverse contraction or warping joint grooves shall be sawn in the hardened concrete.

Transverse joint grooves which are initially constructed less than the full width of the slab shall be completed by sawing through to the edge of the slab and across longitudinal joints as soon as any forms have been removed and before an induced crack develops at the joint.

Sawn transverse and longitudinal joint grooves: Sawing shall be undertaken as soon as possible after the concrete has hardened sufficiently to enable a sharp-edged groove to be produced without disrupting the concrete and before random cracks develop in the slab. The grooves shall be between 1/4 and 1/3 of the specified depth of the slab and of any convenient width not less than 3 mm. The sealing groove may be sawn to the required width later. Expansion joint sealing grooves shall be sealed as soon as practical after sawing.

Wet formed longitudinal joint grooves: When slabs are constructed in more than one lane width in one operation, a joint groove shall be formed by inserting a groove former ahead of the finishing beams from dispenser. The concrete so displaced shall be recompacted by a vibrating compactor or similar device, at least

300 mm wide operating symmetrically along the line of the joint. After finishing the concrete, the groove forming strip shall be in the correct position and alignment, within 10° of the vertical, and to sufficient depth below the surface to allow for the passage of the finishing beam within the range 0-3 mm below the finished level of the slab. Groove forming strips in wet-formed longitudinal joint grooves shall be left in place.

Construction joint grooves in surface slabs: The grooves shall be formed by fixing a groove-former or strip or cork seal along the top edge of the slab already constructed, before concreting the adjacent slab. Where the edge of the concrete is damaged, it shall be ground or made good before fixing the groove forming strip. Alternatively the subsequent slab may be placed adjacent to the first and a sealing groove sawn later in the hardened concrete to the minimum of 1/4 to 1/3 of the specified slab depth or to the manufacturer's instructions if greater, and to sufficient width to eliminate minor spalling of the joint arris, up to a maximum of 25 mm for longitudinal joints and 40 mm for transverse joints. The joint shall be sealed in compliance with Clause 11.4.10.

11.4.9 Joint Filler Board

Joint filler board for expansion joints and manhole and gully slab joints shall be 25 mm thick unless otherwise shown in the drawings, within a tolerance of ± 1.5 mm. It shall be a self-expanding cork seal or a firm compressible material or a bonded combination of compressible and rigid materials of sufficient rigidity to resist deformation during the passage of the concrete paving plant.

11.4.10 Sealing of Joint Groover

Sealing shall be carried out continuously along the full length of joint in any one rip, except for remedial areas. When hot or cold applied sealants are used the sealant shall be applied within the minimum and maximum drying times of the primer recommended by the manufacturer. Priming and sealing with applied sealants shall not be carried out when the naturally occurring temperature in the joint groove to be sealed is below 10°C except between 8°C and 10°C it may be carried out when the temperature is rising.

11.4.11 Inspection of Dowel Bars

Compliance with tolerances for the position and alignment of dowel bars as per Clause 11.4.6 at contraction and expansion joints shall be checked

When the slab has been constructed, the position and alignment of dowel bars and any filler board shall be measured after exposing them carefully across the whole width of the slab. When the joint is an expansion joint, the top of the filler board shall first be exposed sufficiently in the plastic concrete to permit measurement of any lateral or vertical displacement of the board. During the course of normal working, these measurements shall be carried out at a rate of one joint per 1500 m length of slab or one per 5 days whichever occurs the sooner. For small areas the rate shall be one joint for up to each 100 joints.

If the position or alignment of the bars in a single joint in the slab is unsatisfactory, then the next two joints shall be inspected. If only the one joint of the three is defective, the rate of checking shall be increased to one joint per day until compliance is being achieved. In the event of non-compliance in two or more successive joints, the Contractor shall revert to the construction of trial lengths and make any necessary alterations to the concrete mix, paving plant or methods until the dowel bar position and alignment is satisfactory.

After the dowel bars have been examined, the remainder of the concrete shall be removed 500 mm on each side of the line of the joint and reinstated to the requirements of the Specification. Alternatively, if the dowels are examined in the penultimate joint of a day's work, that joint shall be made a construction joint for the next day's work and the remainder of the concrete in the last slab may be discarded.

11.4.12 Curing

Immediately after the surface treatment described in Clause 1026, the surface and exposed edges of surface slabs shall be cured for a minimum period of 7 days, by the application of an approved resin based aluminised curing compound, or polythene sheeting or an approved sprayed plastic film which hardens into a peelable plastic sheet and which shall be removed before road marking and opening to traffic.

Resin based aluminised curing compound shall contain sufficient flake aluminium in finely divided dispersion to produce a complete coverage of the sprayed surface with a metallic finish. The compound shall become stable and impervious to evaporation of water from the concrete surface within 60 minutes

The curing compound shall not react chemically with the concrete to be cured and shall not crack, peel or disintegrate within three weeks after application.

Prior to application, the contents of any containers shall be thoroughly agitated. The curing compound shall be mechanically applied using a fine spray on to the surface at a rate of at least 0.22 l/m² For the sides of slip-

formed slabs or when the side forms are removed within 24 hours and for small areas where mechanical application cannot be used, the compound shall be sprayed by hand lance at a rate of at least 0.27 l/m². The rate of spread shall be checked during construction of each trial length and for each 1000 m² of treated slab.

11.4.12.1 Exposed Aggregate Concrete Surface

In order to obtain a suitable exposed aggregate surface, the main requirement shall be the removal of the surface mortar from the top of the slab to produce an exposed aggregate finish. This objective may be achieved by the application of suitable cement set retarder which is sprayed on the surface of the fresh concrete immediately after it has been levelled and finished. Retarded mortar shall be removed by wet or dry brushing generally not sooner than when the surface concrete has reached a maturity of 16 hours at 20°C or after a suitable interval determined by trial.

The finished surface of the pavement concrete after application of retarder shall be protected against precipitation, moisture loss, contamination and dispersal of the retarder by air movements. This protection shall be applied immediately after the application of the retarder.

Where waterproof sheeting is used, it shall be laid onto the surface of the concrete immediately after the retarder has been sprayed. It shall be retained in position until immediately prior to exposing of the aggregate.

The protection system shall not adversely affect either the finish, the line or the level of the concrete surface or the even distribution of the retarder in any way. Where sheeting is used, any air bubbling or blistering shall be prevented.

Brushing equipment shall be used to expose the concrete surface aggregate. Where the brushing equipment runs on the slab, the concrete shall have gained sufficient strength to avoid any damage to the concrete.

Removal of the protection system shall take place as brushing proceeds. If waterproof sheeting is used as protection system, it shall be maintained in position until immediately in advance of the brushing operation.

The Contractor shall complete the process of exposing the aggregate before the retarder becomes ineffective. Failure to do so shall entail the remedial measures.

Sufficient brushing capability shall always be maintained on site to complete the exposure of the aggregate before the retarder becomes ineffective. An adequate back-up brushing facility shall be available on the site at all times for use in case of a breakdown of the brushing equipment.

Brushing shall be used to produce an even macrotexture on the surface of the slab and shall be carried out in the longitudinal direction of the concrete slab.

The wheels of any brushing equipment which may run on the slab shall be fitted with tyres with a shallow tread pattern and a low inflation pressure and be sufficiently wide to avoid damage to the concrete.

Within one hour of completing exposure of the aggregate the surface shall be dampened with water. A curing compound shall be applied to the entire exposed aggregate surface of the slab. In wet weather the curing compound shall be applied as soon as practicable after the rain stops. The surface may, alternatively, be covered by hessian provided it is maintained in a wet condition at all times during the curing period of the concrete.

During brushing, initial interim spot check measurements of the surface macrotexture depth shall be made as soon as it is considered that the required texture depth has been reached. This shall continue until the specified macrotexture depth has been achieved.

In the event that it is not possible to achieve the specified minimum macrotexture depth by further exposure, the Contractor shall treat the surface in accordance with Clause 11.4.14 to achieve the specified macrotexture depth. This treatment shall not be applied until the concrete has reached an age of 28 days.

Failure to achieve a satisfactory minimum macrotexture depth by mechanical means shall result in removal of the full thickness of the slab to the extent required to permit reconstruction of the slab in accordance with the Specification. Where the maximum macrotexture depth is exceeded suitable remedial measures shall be employed.

11.4.13 Trial Tests

The Contractor shall demonstrate the constituent materials, concrete proportions, plant, equipment and methods of construction that are proposed for concrete paving, by first constructing a trial length of slab, at least 150 m but not more than 300 m long for mechanised construction, and at least 30 m long for hand guided methods. The concrete proportions decided by trial concrete mixes may be adjusted during the trial but shall not be

changed once the trial length has been satisfactorily completed unless the Contractor lays a further trial area to assess the suitability of the proposed changes.

The trial length shall be constructed in two parts over a period comprising at least part of two separate working days, with a minimum of 75 m constructed each day when mechanised paving plant is used and a minimum of 15 m on each day for hand guided methods. The trial length shall be constructed at a similar rate to that which is proposed for the main construction in the Permanent Works.

Preliminary trial panels shall be constructed off-line incorporating a top surface of exposed aggregate concrete similar to that specified for the permanent Works. These panels shall be 20 m long and not less than 100 mm deep and the maximum intended paving width. They shall be used to enable the Contractor to determine the required application rate of the retarder and the amount of brushing required to achieve the specified macrotexture depth.

The trial panels may alternatively be constructed on-site, but in this case, they may only form part of the permanent Works if they meet all the requirements of the Specification, otherwise they shall be removed after they have served their purpose.

The surface macrotexture depth shall be determined by volumetric patch technique at approximately 2 m spacings along a diagonal line across each trial panel and shall follow the procedure described in BS EN 13036-1.

The average value of each set of 10 individual measurements shall be taken as the resulting macrotexture depth which shall be assessed against the Specification.

At least two transverse joints and one longitudinal joint of each type that are proposed for unreinforced concrete slabs and jointed reinforced concrete slabs in the main construction in the Permanent Works shall be constructed and assessed in the trial length. If in the trial length expansion joints are not demonstrated, the first 2 expansion joints and at least the first 150 m of longitudinal construction joint for mechanised paving, or 30 m for hand guided method of construction laid in the main construction in the Permanent Works, shall be considered the trial length for these joints.

The trial length shall comply for strength and density with the Specification in all respects, with the following additions and exceptions:

- In checking for compliance with Table 22, the levels shall be taken at intervals of not more than 2.5 m along any line or lines parallel to the longitudinal centre line of the trial length.
- The maximum number of permitted irregularities of pavement surfaces shall comply with the requirements of Table 22 for 300 m lengths. Shorter trial lengths shall be assessed pro-rata based on values for a 300 m length.
- At least 3 cores of minimum diameter 100 mm shall be taken from the slab at joints to check the lateral and vertical location of joint grooves and bottom crack inducers.
- Alignment of dowel bars shall be inspected as described in Clause 11.4.11 in any two consecutive transverse joints. If the position or alignment of the dowel bars at one of these joints does not comply with Clause 11.4.6, but if that joint remains the only one that does not comply after the next 3 consecutive joints of the same type have been inspected, then the method of placing dowels shall be deemed to be satisfactory. In order to check sufficient joints for dowel bar alignment without extending the trial length unduly, the Contractor may construct joints at more frequent joint intervals than the normal spacing required.
- If there are deficiencies in the first expansion joint that is constructed as a trial, the next expansion joint shall be a trial joint. Should this also be deficient, further trial expansion joints shall be made as part of a trial length. Deficient expansion joints shall not form part of the Permanent Works.
- Compliance with Clause 11.4.7 for the position and alignment of tie bars shall be checked by drilling additional cores from the slab unless they can be determined from cores taken for density assessment.

The Contractor shall not proceed with normal working unless the trial length complies with the Specification and any earlier defective trial lengths have been removed, unless they can be remedied to comply with the Specification.

After satisfactory completion of the trial length, the constituent materials, concrete proportions, plant, equipment and construction methods shall not thereafter be changed, except for normal adjustments and maintenance of plant, unless the Contractor lays a further trial length as described in this Clause to demonstrate that the changes will not adversely affect the Permanent Works or in agreement of the changes with the

Employer's Representative.

11.4.14 Texturing of Hardened Concrete

Worn, rain damaged or inadequately textured surface slabs shall be macrotextured by sawing grooves in the hardened concrete surface at right angles to the longitudinal axis of the pavement with machines using diamond or other abrasive cutting discs.

Grooves shall be irregularly spaced and shall be not less than 2 mm and not more than 5 mm wide. The sequence of distances between groove centres in mm shall be 55, 30, 40, 55, 35, 55. A tolerance of ± 3 mm shall be allowed on each of the spacings. The minimum width of grooving head shall be 500 mm and a head not providing a complete sequence of spacings shall use the number of spacings appropriate to its width commencing at the start of the sequence.

Groove depths shall be measured using a tyre tread depth gauge and measurements shall be taken as follows:

- At 10 locations at least 2 m apart along a diagonal line across a lane width between points 50 m apart longitudinally. No measurement shall be taken within 300 mm of the longitudinal edge of a slab. Where a grooved area is less than 50 m in length the locations where measurements are taken shall be as proportional to the requirements for 50 m.
- At each of the 10 locations the depth of 10 adjacent grooves shall be measured.
- The average of each set of 10 measurements shall be not less than 3 mm nor greater than 7 mm.

Slurry from the sawing process shall be prevented from flowing into joints, drains or into lanes being used by traffic, and all resultant debris from the grooving shall be removed.

11.4.15 Weather Conditions

Road pavement materials in a frozen condition shall not be incorporated in the Works but may be used, if acceptable, when thawed.

Road pavement materials shall not be laid on any surface which is frozen or covered with ice.

The temperature of concrete in any pavement layer shall not be less than 5°C at the point of delivery. These materials shall not be laid when the air temperature falls below 3°C and laying shall not be resumed until the rising air temperature reach 3°C unless all surfaces of the concrete slabs are protected by thermal insulation blankets laid immediately after placing and finishing the concrete. The insulation shall be placed before the temperature of the concrete surface has dropped below 2°C and shall be retained for a minimum of 3 days or until the concrete is assessed to have reached 50% of the specified characteristic compressive strength provided the air temperature is above 0°C and rising at that time. Thermal insulation blankets shall be closed cell polyethylene foam sheets, minimum 10 mm thick with a 'U' value of 4 watts/mC (or K value of 0.04 watts/m Kelvin) or suitable material with an equivalent or lower thermal conductivity. They shall be sufficiently robust and capable of being held in place against variations in wind and weather conditions for the necessary curing time.

11.4.16 Construction Traffic

Construction plant and traffic used on pavements under construction shall be suitable in relation to the material, condition and thickness of the courses it traverses so that damage is not caused to the subgrade or the pavement courses already constructed. The wheels or tracks of plant moving over the various pavement courses shall be kept free from deleterious materials.

Concrete slabs may be used by traffic when the cube compressive strength is assessed to have reached 25 N/mm². In the absence of test data establishing compliance, no vehicle with an axle loading greater than 2 tonnes shall run on concrete slabs within a period of 14 days after placing the concrete. Vehicles with rubber tyres with an axle loading less than 2 tonnes, or wheels or tracks of concreting plant, shall not use any part of a newly constructed pavement within 7 days. The above periods before traffic may run on the pavement shall be increased if the 7 days cube strength is below that what is required in the Specification. These periods shall be extended by one day for each night on which the temperature of the layer falls to 0°C or below.

12 WATER PROOFING SYSTEM

12.1 General

Sheet waterproofing membrane systems for the tunnel shall comprise of a geotextile fleece fixed to the primary lining substrate in combination with a sheet waterproofing membrane fastened to this; see Section 12.6 for

details of installation.

Waterproofing shall be applied to crown and sidewalls above footing or invert arch level. The waterproofing membrane shall always be located between shotcrete support and final concrete lining. As the underground structures referred to be not immersed below a distinct groundwater table no membrane waterproofing will be provided for tunnel inverts.

The design life of the water proofing membrane shall be minimum 100 years.

Where the waterproofing system is to be divided into sectors, the water stops should be formed of material that can be welded to the sheet waterproofing membrane.

Additional drainage capacity shall be provided in case of water inflows in agreement with the Employer's Representative by studded drainage membrane made from thermoplastic material (dimpled sheet) attached prior to installation of the geotextile fleece or equivalent drainage layer approved by the Employer's Representative.

Waterproof membranes shall not be stored in direct sunlight prior to use. Waterproof membranes shall be protected from damage at all times especially during installation of reinforcement. The water proofing membrane shall have a signal layer to indicate damages due to handling and installation of reinforcement. The integrity of the signal layer shall be checked prior to concreting of final lining.

Fire protection measures during construction of water proofing system are required as but not limited to the following.

- The amount of membrane stored in the tunnel shall not exceed two working day's production to minimise the fire load stored underground.
- The installation length of the water proofing system in advance of the final lining shall not exceed 300 m, unless special measures are considered in agreement with the Employer's Representative.

12.2 Geotextile Fleece

The purpose of the geotextile fleece is to protect the sheet membrane against mechanical puncture and to provide a drainage path for any ground water along the rock side of water proofing system around the tunnel structure.

The geotextile fleece and the membrane shall be combined in accordance to the hydraulic requirements to drain the encountered water inflows. The geotextile fleece only provides low long term drainage capacity. If the hydraulic capacity of the geotextile fleece is not sufficient an additional drainage layer shall be installed.

The geotextile used in combination with dimpled sheet as strip drain is to protect the dimpled sheet and allows the inflow of ground water into the dimpled sheet drainage area.

The geotextile fleece shall be a non-woven fleece and shall provide a minimum weight of 500 g/m² in tunnel vault and 900 g/m² in tunnel invert if required and in c&c tunnels, in accordance to the Specification set forth in Fehler! Verweisquelle konnte nicht gefunden werden.

Table 30: Requirements of geotextile fleece

Description	Standard	Requirement	
		500 g/m ²	900 g/m ²
Mass per unit area	BS EN ISO 9864	≥ 500 g/m ²	≥ 900 g/m ²
Nominal weight	BS EN ISO 9864	≥ 556 g/m ²	≥ 1000 g/m ²
DSC analysis	BS EN ISO 11357-1 & -3	Tolerance of melting temperature <±10%	
Thickness under normal pressure	BS EN ISO 9863-1	Within the tolerances of the manufacturer	
2 kPa			
200 kPa		M.7 mm	≥3.4 mm
Tensile strength in longitudinal and transversal direction to the direction of production	BS EN ISO 10319	≥30 kN/m	≥50 kN/m
Elongation at break in longitudinal and transversal direction to the direction of production	BS EN ISO 10319	Within the tolerances of the manufacture r	
Elongation at maximum tensile force	BS EN ISO 10319	≥50%	
Static puncture	BS EN ISO 12236	≥3kN	≥7kN
Cone drop test	BS EN ISO 13433	<13mm	<7mm
Behaviour during oxidation	BS EN ISO 13438	design life of minimum 25 years in	

Description	Standard	Requirement	
		500 g/m ²	900 g/m ²
		compliance with EN 13256	
Behaviour in basic environment (p ⁹)	BS EN 14030 and BS EN ISO 10319	Decrease of tensile strength and elongation at break during design life of 25 years: ≤20%	
	BS EN ISO 11925-2 and BS		
Behaviour during fire	EN 13501-1	Class E	
Permeability in flow direction with 200 kPa	BS EN ISO 12958	≥ ^{^^^}	
Protection	BS EN 14574	≥1 mm	

The geotextile is to provide adequate protection from chemical aggression caused in the curing processes of concrete.

Water transmissivity of the geotextile fleece should be designed to suit expected volume of water ingress.

12.3 Fixing Element

The geotextile is fixed onto the substrate with non-projecting disks. The disks are secured through the geotextile and into the substrate with shot-fired nails.

The disks should be made of a compound that allows the sheet waterproofing membrane to be fully welded to the surface.

In order to prevent stresses being transferred from the secondary lining to the sheet waterproofing membrane, the resistance to failure in shear of the nails and disks must be less than the shear resistance of the sheet membrane itself.

All accessories and compounds of fixing elements, flashing, reinforcement for expansion joints, sealing flanges etc. shall be in accordance to the recommendations of the membrane's manufacturer and compatible with the waterproofing system.

12.4 Layer with higher drainage capacity

If the hydraulic capacity of the geotextile fleece for water drainage is not sufficient due to significant water inflows an additional drainage layer shall be installed.

The layer shall have minimum drainage capacity of 360 l/(m²h) with applied pressure of 200 kPa and hydraulic gradient of 1.

Drainage elements with higher drainage capacity shall be in compliance with requirements laid down in Table 30.

Table 31: Requirements of drainage elements

Description	Standard	Requirement
Mass per unit area	BS EN ISO 9864	within the tolerances of the manufacturer
Tensile strength	BS EN ISO 10319	≥ 10 kN/m
Thickness under normal pressure:	BS EN ISO 963-1 (Method A)	2 kPa: within the tolerances of the manufacturer 200 kPa > 4 mm and ≤ [^] mm
Drainage capacity, hydraulic gradient 1, with thickness under normal pressure of 200 kPa (see above)	BS EN ISO 12958	≥ 360 l/(m ² h) and 10-4 m ² /s respectively
Behaviour during fire	BS EN ISO 11925-2 and BS EN 13501-1	Class E

12.5 Waterproof Membrane

The waterproof membrane shall consist of a continuous impermeable heat-welded sheet of one of the following materials:

- soft polyvinyl chloride (PVC) unreinforced
- flexible polyolefin (FPO/TPO) unreinforced

The membrane as supplied shall be of such dimensions and shape as will result in the minimum of on-site seam welds.

The installation of recycled membranes and/or membranes including DEHP (DOP) plasticizer is not permitted.

Unless otherwise stated in the Contract, the membrane shall conform to performance requirements and have properties shown in Table 31.

Table 32: Performance requirements of sheet waterproof membranes

Description	Standard	PVC-P	TPO
Identification	BS EN 13491	manufacturer, type, material, thickness, date of manufacture, CE marking including CE document	
Thickness including signal layer	BS EN 1849-2	min 2.0 mm for seepage water and min 3.0 mm for pressurized water	
Thickness of signal layer	BS EN 1849-2	≤ 0.2 mm	
Density	BS EN ISO 1183-1	tolerance <±0.005 g/cm ³	tolerance <±0.02 g/cm ³
Appearance	BS EN 1850-2	free from blisters, crack, external capsule and voids	
Straightness	BS EN 1848-2	≤ 50 mm	
Flatness	BS EN 1848-2	≤ 10 mm	
DSC analysis	BS EN ISO 113571 & -3	individual evaluation from diagram	
MFR Index (Melt Flow Index)	BS EN ISO 1133 Method A	tolerance <±15 % of nominal value	-
Tensile strength in longitudinal and transversal direction	BS EN ISO 527-1 & -3	M5 MPa	M2 MPa
Elongation at break	BS EN ISO 527-1 & -3	≥ 500 %	≥ 250 %
Youngs Modulus between 1 % and 2 % elongation in longitudinal and transversal direction	BS EN ISO 527-1 & -3	≤ 65 MPa	≤ 20 MPa
Static puncture	BS EN ISO 12236	≥2.8 kN	≥2.5 kN
Burst strength elongation multi-axial elongation test	BS EN 14151	≥50 % with 0 1.0 m ≥80 % with 0 0.4 m	≥50 % with 0 1.0 m ≥80 % with 0 0.4 m
Impact resistance (500 g), method A	BS EN 12691	nominal thickness 2.1 mm: fall height 750 mm nominal thickness 3.15 mm: fall height 1250 mm	
Long term compression strength	SIA-V 280 Test No. 14	impermeable during test duration of 48 h and 7 MPa	
Folding in cold environment	BS EN 495-5	no requirements	no cracks at -20°C
Behaviour during warming: Dimensional change Appearance	BS EN 1107-2 BS EN 1850-2	<2% (1h/100°C) no blistering	<2% (6h/80°C) no blistering
Resistance under water pressure	BS EN 1928 method B	5 bars at 1 hour	
Thermal ageing (70 d with 80°C)	BS EN 1296 (BS EN 1850-2, BS EN 1849-2, BS EN ISO 527-1 & -3)	no requirements	decrease of tensile strength <20% decrease of tensile elongation at break ≤20%
Resistance to oxidation after 90 d with 85°C	BS EN 14575	decrease of tensile strength and elongation ≤20%	values shall be determined in agreement with Employer's Representative
Behaviour after storage in water with 50°C and 8 month	SIA-V 280 Test no 13	no requirements	Change of elongation at break ≤20%, change of mass ≤4%
Behaviour after storage in aqueous solutions (no 2), days with 23°C Ca(OH) ₂ (sat.); NaCl(10%)	BS EN 14415 (BS EN 1847, BS EN ISO 527-1 & -3)	decrease of tensile strength and elongation at break ≤25%	
Behaviour after storage in aqueous solutions (no 3) 90 days with 23°C, H ₂ SO ₃ (5-6%)	BS EN 1847 (BS EN ISO 527-1 & -3)	decrease of tensile strength and elongation at break ≤20% no cracks at folding at -20°C	
Root resistance	DD CEN/TS 14416	No penetration	

Description	Standard	PVC-P	TPO
Tear resistance	BS EN 12310-2	80 N/mm	
Water absorption	BS EN ISO 62	<4,0%	
Fire rating	BS EN ISO 119252 BS EN 13501-1	Class E	Class E
Smoke class	BS EN ISO 11925	E	
Welding	DVS 2225-5	accurate	
Peeling strength of welded seam	BS EN 12317-2	≥6 MPa	
Shear strength of welded seam	BS EN 12316-2	Failure shall appear outside welding seam	

Further guidance on test methods and requirements for mechanical properties and durability can be found in BS EN 13492:2004 (E): “Geosynthetic barriers - Characteristics required for use as a fluid barrier in the construction of tunnels and underground structures”.

Where reinforced concrete is to be placed against the sheet waterproofing membrane, a signalling layer, to give a visual indication of any mechanical damage, shall be provided on the exposed surface of the waterproofing membrane. The signalling layer shall be such that it does not adversely affect the seam welds. The signalling layer shall be of the same material as the waterproofing membrane.

An additional waterproofing strip with a width of 50 cm shall be placed around the vault in the area of construction joints between two final lining blocks.

12.6 Installation

The manufacturer's instructions for installation of felt backing and waterproofing membrane, including procedures for preparation, fixing, welding and splicing, flashing shall be followed solely by the Contractor.

Prior to application of the geotextile fleece layer the primary lining shall be surveyed to confirm that it does not encroach into the designed extrados of the secondary lining. Any proposals to rectify areas of the primary lining shall be agreed with the Employer's Representative.

The shotcrete lining shall be constructed in a way that all bolts and anchors are fully covered with shotcrete of the primary lining. The surface shall be prepared in accordance with the manufacturer's instructions. The surface shall be clean, smooth and free from any deleterious material. Except where indicated on the drawings, all fixtures shall be removed from the primary lining prior to application of the geotextile fleece layer. All core holes shall be backfilled with mortar to be flush with the surface of the primary lining.

Shotcrete cover of minimum 50 mm to rock is required.

For sheet waterproof membranes, the profile of the substrate (tunnel surface) shall not have any irregularities that exceed a ratio of length to depth of 5:1 for PVC-P waterproofing membranes and 10:1 for flexible TPO waterproofing membranes. The minimum radius shall be 200 mm. Transitions and intersections of tunnel profiles such as niches and cross passages shall be rounded off with a minimum radius of 500 mm. The substrate surface shall be free from protrusions or sharp edges which may lead to membrane puncture. Crushed aggregates of a grain size greater than 8 mm shall not be used.

Groundwater penetrating through the primary tunnel lining shall be collected and drained by appropriate measures. This drainage shall be maintained throughout the membrane placing process and shall be so arranged that excess water pressure behind the membrane cannot develop.

All shotcrete surface shall finally be smoothened with fine-graded shotcrete (rounded aggregates, grain size 0 - 8 mm), applied in a layer of 30 mm minimum thickness.

A layer of protective geotextile shall be attached to the substrate by suitable non-projecting fastenings installed directly through the geotextile fleece. When fixing the geotextile fleece overhead, sufficient fixings (minimum 2 to 4 elements per sqm) shall be installed to ensure the fleece is in close contact with the substrate and is self-supporting. The sheets shall overlap by at least 200 mm and jointed by point weld or equivalent method as approved by the Employer's Representative.

When placing the sheet waterproof membrane, no other Works shall be carried out in the vicinity which may cause personnel or equipment to come into contact with the sheet waterproof membrane before it has been protected. If it is likely that excessive dust may be generated in the vicinity of the Works (vehicle movements etc.), then dust suppression measures shall be put in place.

The sheet waterproof membrane shall be fixed to the tunnel structure by means of fastening devices which

preserve the integrity of the sheet waterproof membrane. Sufficient fixings shall be installed to ensure the fleece is in close contact with the substrate and is self-supporting. No perforation of the membrane shall be allowed for installation purposes. The waterproofing membrane shall be laid with the signal layer towards the inside and with sufficient slack to prevent overstressing during concreting. All sheet waterproof membrane overlaps shall be welded in accordance with the membrane manufacturer's instructions.

Where waterproof membrane has been installed in the tunnel invert, it shall be protected from any damage as soon as possible after testing.

Radial joints between sheets of sheet waterproof membrane shall be welded using flat-faced fillet welds. Two lines of weld shall be used on each joint forming a double seam of at least 15 mm wide, with the minimum sheet waterproof membrane overlap 80 mm for manual welding and 100 mm for automatic welding.

All welding personnel shall have certificate in compliance with the qualification testing of welders as per BS EN 13067.

If protrusions through the membrane are required, they shall be fitted with collars to maintain the water tightness of the system.

Star or cross joints shall be avoided.

The length of material roll shall be procured to enable a complete extrados to be installed as a continuous length. Longitudinal joints shall be avoided.

The placing of inner lining concrete sequence and processes shall be such that they do not displace or damage the geotextile fleece or sheet waterproofing membrane.

12.7 Checking

12.7.1 Field Trials

Field trials shall be made to demonstrate the capability of the equipment, workmanship, materials and application methods under field conditions.

The testing programme shall be started sufficiently early prior to installing the membrane to ensure that the required water-tightness can be achieved and allow repetition of the trials should the initial results prove unsatisfactory. All trials and acceptance tests shall be completed satisfactorily by the time installation commences.

Prior to construction, trials shall be carried out in order to establish the speed and temperature of joint welding required to achieve welds which are acceptable to the Employer's Representative. If hand-welded joints are proposed at junctions, then this type of weld shall be pre-tested and agreed with the Employer's Representative.

12.7.2 Construction Testing

On-going inspection of the waterproofing system shall be carried out and documented by the Contractor. The inspection documents shall be made forwarded to the Employer's Representative for review and approval.

A visual inspection of the sheet waterproof membrane shall be carried out as specified in Table 32. Areas where the sheet waterproof membrane is damaged shall be marked up, repairs carried out and tested in accordance with the manufacturer's instructions.

All welded joints shall be tested in accordance with Table 32. Any joints that fail the test and require repair shall be marked with a permanent marker, at the time of the test.

Repairs and hand-welded joints shall be tested by hand-held vacuum chamber in accordance with Table.

Table 33: Construction testing for sheet waterproof membrane

Parameter	Test Method	Frequency	Pass Criteria
Coverage	Visual	A visual inspection to be carried out continuously while the membrane is applied	100% coverage
Double welded seam joints	DIN 16726	Every joint	Pressure drop not to be greater than 10% when a 2 bar (PVC-P) and 3 bar (TPE-O/TPO) pressure is applied for 10 minutes
Hand welding and repairs	ASTM D5641-94	Every hand-weld and repair	Pressure drop not to be greater than 20% when a 0.3 bar pressure is applied for 10

Parameter	Test Method	Frequency	Pass Criteria
	(2006)		minutes

A visual inspection of the fleece shall be carried out. Areas in which the substrate is still visible, or where the fleece is damaged, shall be marked up and an additional layer of fleece applied with a minimum lap of 200 mm around the area.

12.7.3 Failure Measures

Where tears, rips or defective joints in the geotextile fleece are noted, these shall be repaired with a minimum overlap of 200 mm.

Where tears, rips or defective joints in the sheet waterproof membrane are noted, these shall be repaired in accordance with manufacturer's recommendations. These shall be tested by hand-held vacuum chamber in accordance with Table 32.

Any sheet waterproof membrane not meeting specified requirements shall be removed and replaced including any associated water management measures or smoothing layer. The cause of the problem shall be rectified before placing any further sheet waterproof membrane.

MEP SYSTEM

DRY TYPE TRANSFORMER

Illustration



Basic Information

50 Hz three-phase dry type transformer cast under vacuum in filled epoxy resin. Indoor type
Includes active filler, essentially composed of trihydrated alumina, a fire suppressant.

Technological Description

thermal class F;
ambient < 40°C, altitude <1000m;
natural air cooling type AN;
It complies with standards: IEC 76-1 to 76-5; IEC 726 (1982);

Technical Data

insulation level: 17.5 kV and 24 kV

rated power (kVA) ⁽¹⁾ (*)	160 ⁽²⁾	250	315 ⁽²⁾	400	500 ⁽²⁾	630	800	1000	1250	1600	2000	2500	3150
rated primary voltage ⁽¹⁾	20 kV												
rated insulation level ⁽³⁾	24 kV												
frequency ⁽¹⁾	50 Hz												
maximum ambient temperature	40°C												
secondary voltage at no load ⁽¹⁾	400 V												
HV tapping range (off-circuit) ⁽¹⁾	± 2.5 %												
vector group	Dyn 11 (delta, star neutral brought out)												
losses													
no load losses	650	880	1030	1200	1400	1650	2000	2300	2800	3100	4000	5000	6300
(W) at 75°C	2300	3300	4000	4800	5700	6800	8200	9600	11500	14000	17500	20000	23000
load losses at 120°C	2700	3800	4600	5500	6500	7800	9400	11000	13100	16000	20000	23000	26000
rated impedance voltage (%)	6	6	6	6	6	6	6	6	6	6	6	6	7
no-load current (%)	2.3	2	1.8	1.5	1.5	1.3	1.3	1.2	1.2	1.2	1.1	1	1
switching current													
le/ln (peak value)	10.5	10.5	10	10	10	10	10	10	10	10	9.5	9.5	9.5
time constant	0.13	0.18	0.20	0.25	0.25	0.26	0.30	0.30	0.35	0.4	0.4	0.5	0.6
noise level ⁽⁴⁾													
acoustic power LWA	62	65	67	68	69	70	72	73	75	76	78	81	81
dB(A) acoustic pressure LPA at 1 metre	50	53	55	56	56	57	59	59	61	62	63	66	65

(*) the rated power is defined by natural air cooling (AN).
Should there be particular constraints, it may be increased by 40% by forced cooling addition (AF). Please consult us.

(1) other possibilities upon request, consult us.

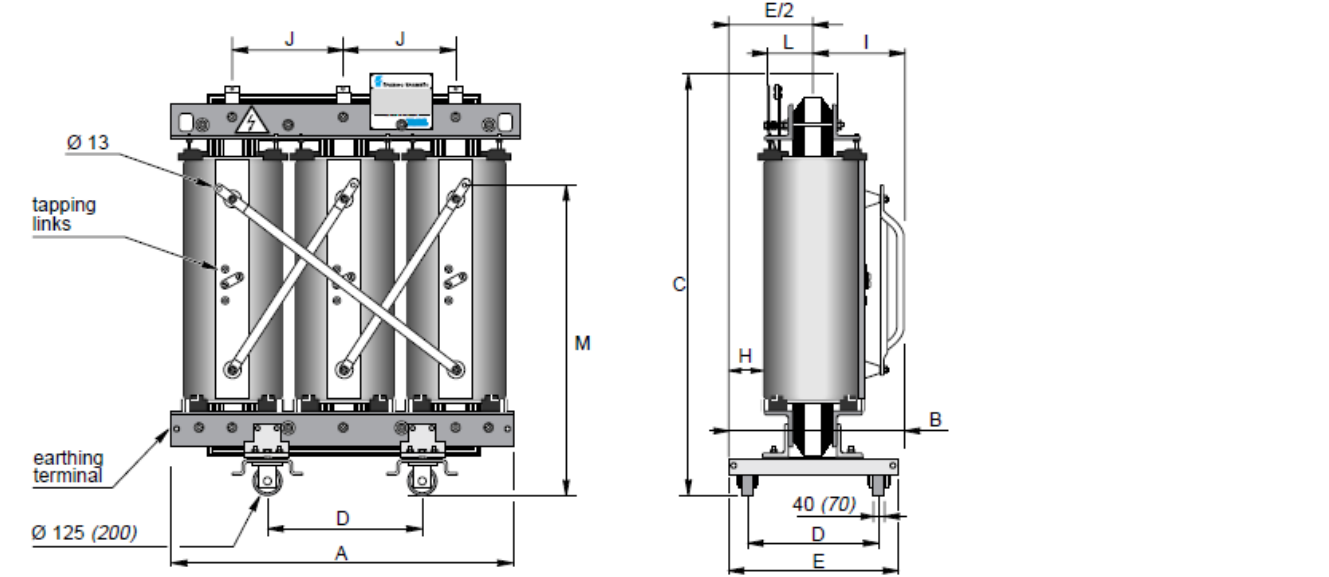
(2) non standard ratings available on request.

(3) reminder of insulation levels:

rated insulation level (kV)	7.2	12	17.5	24
kV r.m.s. 50 Hz - 1 mn	20	28	38	50
kV B.I.L. 1.2/50 µs	60	75	95	125

(4) according to CEI 551

Basic Dimensional Sketch



insulation level: 17.5 kV and 24 kV - low voltage 400 V

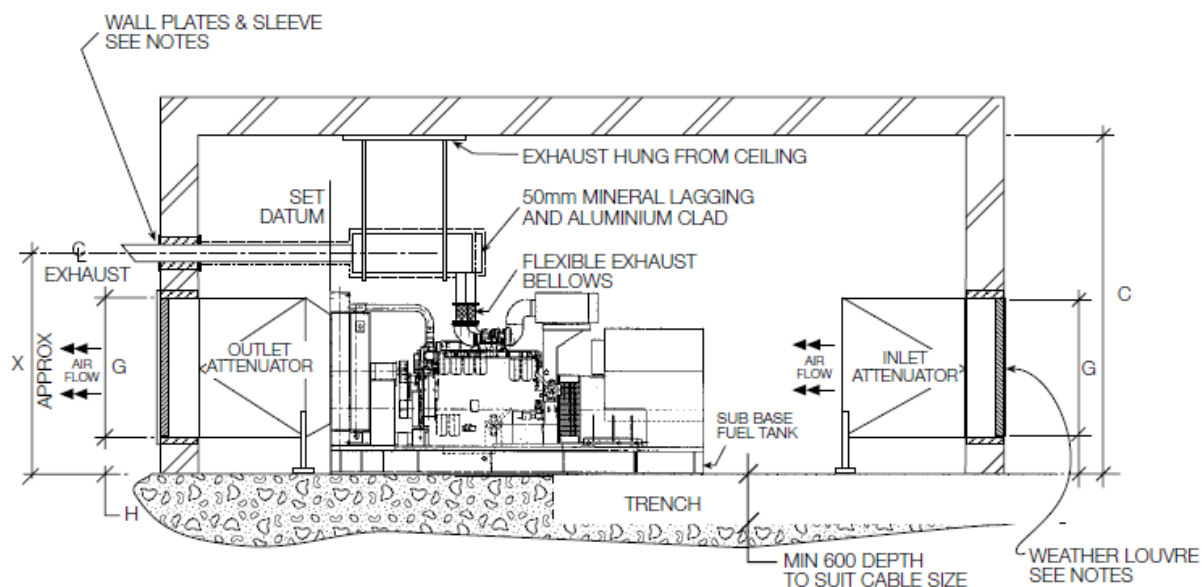
rated power (kVA) (1) (*)	160	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150
dimensions (mm)	A	1070	1140	1170	1230	1300	1340	1400	1560	1610	1700	1950	2200
B	680	690	795	795	795	800	805	945	945	945	1195	1195	1195
C	1320	1350	1510	1490	1580	1690	1720	1920	2030	2170	2380	2440	2600
D	520	520	670	670	670	670	670	820	820	820	1070	1070	1070
E	650	650	800	800	800	800	800	950	950	950	1200	1200	1200
H	160	150	220	210	190	190	180	230	220	210	290	290	300
I	360	370	370	380	400	400	410	430	440	460	450	460	460
J	360	380	390	410	440	450	470	510	530	560	630	640	690
L	180	180	190	200	210	210	220	250	250	260	310	320	380
M	890	930	1090	1070	1110	1210	1240	1410	1510	1650	1770	1750	1750
weights (kg)		780	950	1140	1290	1520	1730	1990	2480	2810	3430	4720	7300

DIESEL GENERATOR	
Illustration	Basic Information
	A diesel generator (also known as diesel genset) is the combination of a diesel engine with an electric generator to generate electrical energy. This is a specific case of engine-generator. A diesel compression-ignition engine is usually designed to run on diesel fuel, but some types are adapted for other liquid fuels or natural gas.
	Technological Description Generator sets in emergency power applications are required to start and pick up all emergency loads within 10 seconds of a power failure Prime Power Output available with varying load for an unlimited time. Average power output is 70% of the prime power rating. Typical peak demand of 100% of prime-rated kW with 10% of overload capability for emergency use for a maximum of 1 hour in 12. Overload operation cannot exceed 25 hours per year.

Technical Data

Prime Rating KVA	Type of ENGINE	TA Lift	Generator Model	Room dimensions			Set back D	Set C/L position P	Exhaust		Attenuator Dimensions			Uplift H	Cable trench position		
				Length A	width B	height C			Offset E	Height X	F	Y	G		L	M	N
575	VTA28G5		460DFGA	8400	3450	3450	400	1725	400	2950	1500	1500	2000	400	775	500	5150
640	VTA28G5		512DFGB	8400	3450	3450	400	1725	400	2950	1500	1500	2000	400	775	500	5150
750	VTA28G6		600DFGD	8400	3450	3450	400	1725	400	2950	1500	1500	2000	400	775	500	5150
725	QST30G1	4g	580DFHA	8400	3640	3700	500	1820	400	3150	2400	1200	2400	400	920	500	5100
800	QST30G2	4g	640DFHB	8400	3640	3700	500	1820	400	3150	2400	1200	2400	400	920	500	5100
939	QST30G3		751DFHC	8400	3640	3700	500	1820	400	3150	2400	1200	2400	400	920	500	5100
1000	QST30G4		800DFHD	8450	3640	3800	500	1820	450	3150	2700	1200	2400	200	920	500	5100
725	QST30G6	2g	580DFHE	8400	3640	3700	500	1820	400	3150	2400	1200	2400	400	920	500	5100
800	QST30G7	2g	640DFHF	8400	3640	3700	500	1820	400	3150	2400	1200	2400	400	920	500	5100
939	QST30G8	2g	751DFHG	8400	3640	3700	500	1820	400	3150	2400	1200	2400	400	920	500	5100
936	KTA38G3		748DFJC	9500	3800	3800	500	1900	450	3100	1950	1800	2200	200	920	500	3655
1019	KTA38G5		815DFJD	9500	3800	3800	500	1900	450	3100	1950	1800	2200	200	920	600	3655
1256	KTA50G3		1005DFLC	10360	3800	3800	500	1900	450	3100	1950	1800	2200	200	920	600	4375
1405	KTA50G8		1125DFLE	11700	4000	4500	500	2000	500	3500	2450	2100	2600	200	920	600	5000
1500	KTA50GS8		1200DFLF	11700	3800	3800	500	1900	500	3100	2450	2100	2600	200	920	600	5000
1256	KTA50G6	4g	1005DFLG	10360	3800	3800	500	1900	450	3100	1950	1800	2200	200	920	600	4375
1256	KTA50G7	2g	1005DFLH	10360	3800	3800	500	1900	450	3100	1950	1800	2200	200	920	600	4375
1875	QSK60G3		1500DQKC	12650	4500	4500	600	2250	693	3800	2800	2400	2600	325	645	600	5000
2000	QSK60G4		1600DQKD	12650	4600	4500	600	2250	693	3920	3150	2400	3100	250	645	600	5000
1875	QSK60G3	2g	1500DQKE	11200	4000	4500	800	2000	693	3800	2700	1500	2500	325	645	600	3800
2000	QSK60GS3	2g	1600DQKF	11200	4000	4500	800	2000	693	3800	2700	1500	2600	325	645	600	3800

Basic Dimensional Sketch



UNINTERRUPTIBLE POWER SUPPLY SYSTEM (UPS)

Illustration



Basic Information

Highly efficient, easy-to-deploy 3-phase uninterruptible power supply (UPS)

Technological Description

Robust operation - No power derating in kW up to 40 degrees C

Parallel-capacity capable

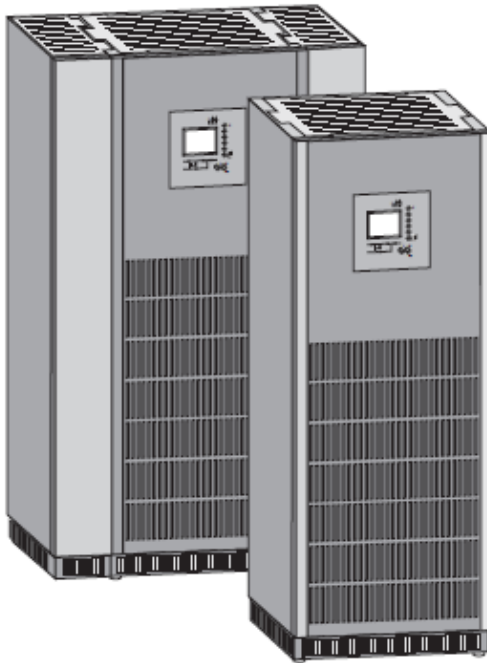
Topology: Double Conversion Online

Technical Data

UPS rating	20 kVA	30 kVA	40 kVA	60 kVA	80 kVA	100 kVA	120 kVA
Input voltage (V)	380 - 400 - 415						
Input voltage range permitted by the standard according to the curve below (V)	250 to 470 for a standard UPS 342 to 470 for a UPS with backfeed protection						
Input frequency (Hz)	45 to 65						
Rated current ¹ Normal AC input (A)	32	45	57	87	115	143	171
Maximum input current (A) for 400 V	33	46	58	88	116	145	173
Input current (A) for 400V, overload=1.25 In limited to 10 min.	39	56	72	108	145	181	217
Input current (A) for 400V, overload=1.5 In limited to 1 min.	47	68	87	130	174	217	260
THDI	< 6% at full load < 8% at 25–75% load						
Maximum short circuit withstand (kA)	20				30		
Input fuse ratings (A)	80	80	80	125	160	315	315

Basic Dimensional Sketch

UPS cabinet



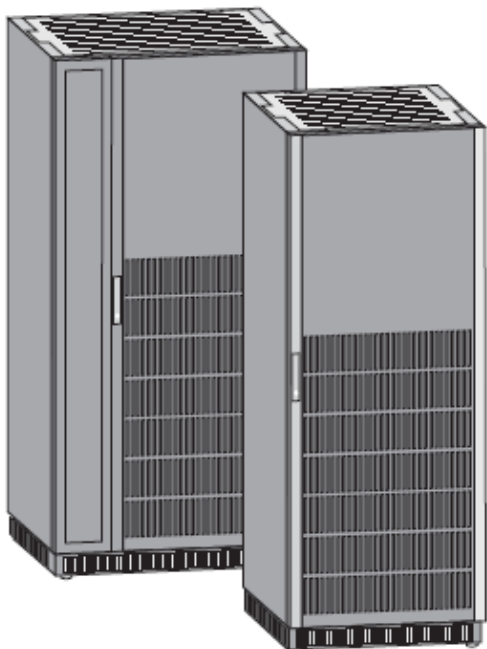
Dimensions

UPS power rating (kVA)	Dimensions (H x W x D)
20/30/40/60 without battery	1900 x 712 x 848 mm
80/100/120 without battery	1900 x 712 x 848 mm
20/30/40/60/80 with internal battery	1900 x 1112 x 848 mm

Weight in kg (UPS without battery or with built-in battery)

Backup time	UPS power rating (kVA)				
	20 30	40	60	80 100	120
Without battery	400	400	400	520	520
5 min	808	808	958	1120	
10 min	808	958	1045		
15 min	958	1045			
30 min	1045				

External battery cabinet / auxiliary cabinet



Dimensions (H x W x D) and weight

Cabinet 710 mm wide	1900 x 712 x 848 mm 135 kg
Cabinet 1000 mm wide	1900 x 1012 x 848 mm 150 kg

Weight in kg (cabinet alone)

Backuptime	UPS power rating (kVA)				
	40	60	80	100	120
Cabinet 710 mm wide without batt	135	135	135	135	135
Cabinet 1000 mm wide without batt	150	150	150	150	150
5 min				885	980
10 min			885	1142	1307
15 min		885	1142	1307	1764
30 min	882	1307	1764	2439	2742

JET FAN**Illustration****Basic Information**

Uni-directional jetfan for longitudinal tunnel ventilation.

The uni-directional jet fans, with asymmetrical blades, are designed to optimize their performance in one direction (forward).

The jet fans are installed inside the tunnel, either hanging them from the ceiling by means of a suspensions system or placing them on top of small base frames fixed to the lateral walls of the tunnel.

The standard configuration of jet fans includes two tubular silencers at both ends of the jet fan unit, so the noise level generated when the jet fans are in operation, especially at full speed, is reduced.

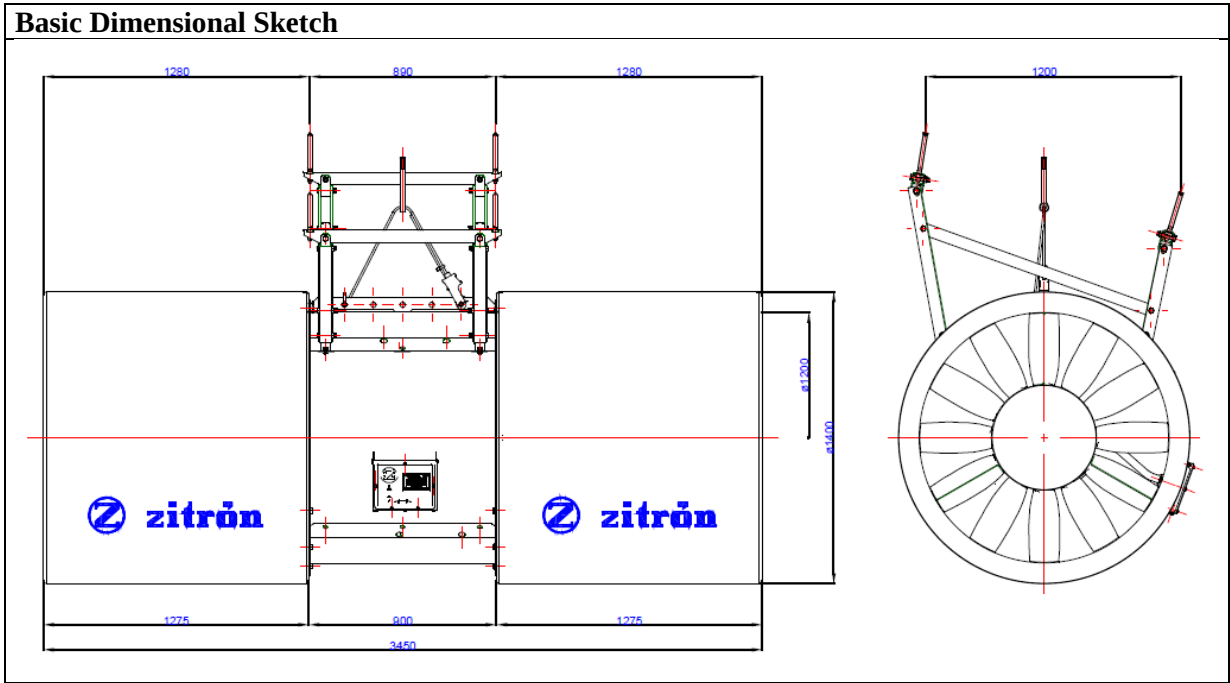
Technological Description

Axial fan (jet-fan type) for installation inside tunnel. Tested and certified to operate at high temperature conditions according to Standard EN 12102-3. High temperature rating: 400°C during 2 hours.

Technical Data

<i>Thrust Nominal</i>	<i>Airflow</i>	<i>Air speed</i>	<i>Fan Diameter</i>	<i>Motor Rating / Rotation speed</i>	<i>Power Supply</i>	<i>High Temperature Rating</i>	<i>Reversibility</i>
<i>[N]</i>	<i>[m³ / s]</i>	<i>[m/s]</i>	<i>[mm]</i>	<i>[kW / rpm]</i>	<i>[Volt/ph/Hz]</i>	<i>[°C / h]</i>	<i>[-]</i>
1441	37.5	33.2	1200	37 / 1500	400/3/50	400 / 2	Unidirectional

- Fan casing made of Carbon steel S-275 JR
- Impeller with aluminium alloy blades
- Electric motor WEG 400 V, 37 kW, 50 Hz, S-1, TEAO, IE1, B30, 4 poles, class H (400°-2h).
- Silencers made of Carbon steel S-275 JR (2 Nos.)
- Suspension system included
- Vibration sensor and anti-condensation heater included
- Dynamic balancing included



COMBINED NO, NO₂, CO AND VISIBILITY MONITOR

Illustration



Basic Information

Single sensor tunnel monitor for measuring visibility, CO, NO, NO₂ and NO_x within a road tunnel or other enclosed space. These measurements can be used to help ensure the effective ventilation of the tunnel and validate its air quality management system.

Technological Description

Sensor that uses a combination of differential optical absorption and infrared spectroscopy to measure nitrogen dioxide (NO₂), nitric oxide (NO) and carbon monoxide (CO), and the standard light transmission obscuration technique to calculate visibility.

Technical Data

NO₂ Measurement Performance

No.	Parameter	Units	Min	Max	Comment
1	Path Length	m	5	12	Optimum 10m
2	Measurement Range	ppm (ppb)	0	10	User selectable (Option)
3	Resolution	ppm		0.01	Display resolution
4	Accuracy	%	-5	+5	Of Reading (at 10m path length)
5	Detection Limit	ppm		0.05	At 10m path length
6	Damping	s	1	999	Default setting is 20s
7	Temperature Stability	ppm	-0.05	+0.05	At 10m path length

Visibility Measurement Performance

No.	Parameter	Units	Min	Max	Comment
8	Measurement Range				User selectable
	Transmission	T	0	1.000	
	Extinction Coefficient (k)	m ⁻¹	0	0.1000	
	Meteorological Optical Range (MOR)	m	0	15000	
	Opacity	%	0	100	
9	Resolution				Display resolution
	Transmission	T		0.001	
	Extinction Coefficient (k)	m ⁻¹		0.0001	
	Meteorological Optical Range (MOR)	m		1	
	Opacity	%		0.1	
10	Accuracy	%			At 10m path length
	Extinction Coefficient (k)	m ⁻¹	-0.0005	+0.0005	
	Opacity	%	-0.5	+0.5	
11	Damping	s	1	999	Default setting is 3s
12	Temperature Stability				At 10m path length
	Extinction Coefficient (k)	m ⁻¹	-0.001	+0.001	
	Opacity	%	-1	+1	

CO/NO (NO_x) Measurement Performance

No.	Parameter	Units	Min	Max	Comment
13	Display range	ppm	0	500	User selectable
14	Resolution	ppm		0.1	Display resolution
15	Accuracy	CO	-5	+5	Of Reading
		NO (NO _x)	-10	+10	Instrument calibrated in-situ
16	Detection Limit	CO		1	
		NO (NO _x)		2	
17	Damping	CO		100	
		NO (NO _x)		200	
18	Temperature Stability	ppm	-2	+2	At 10m path length

Temperature Measurement Performance

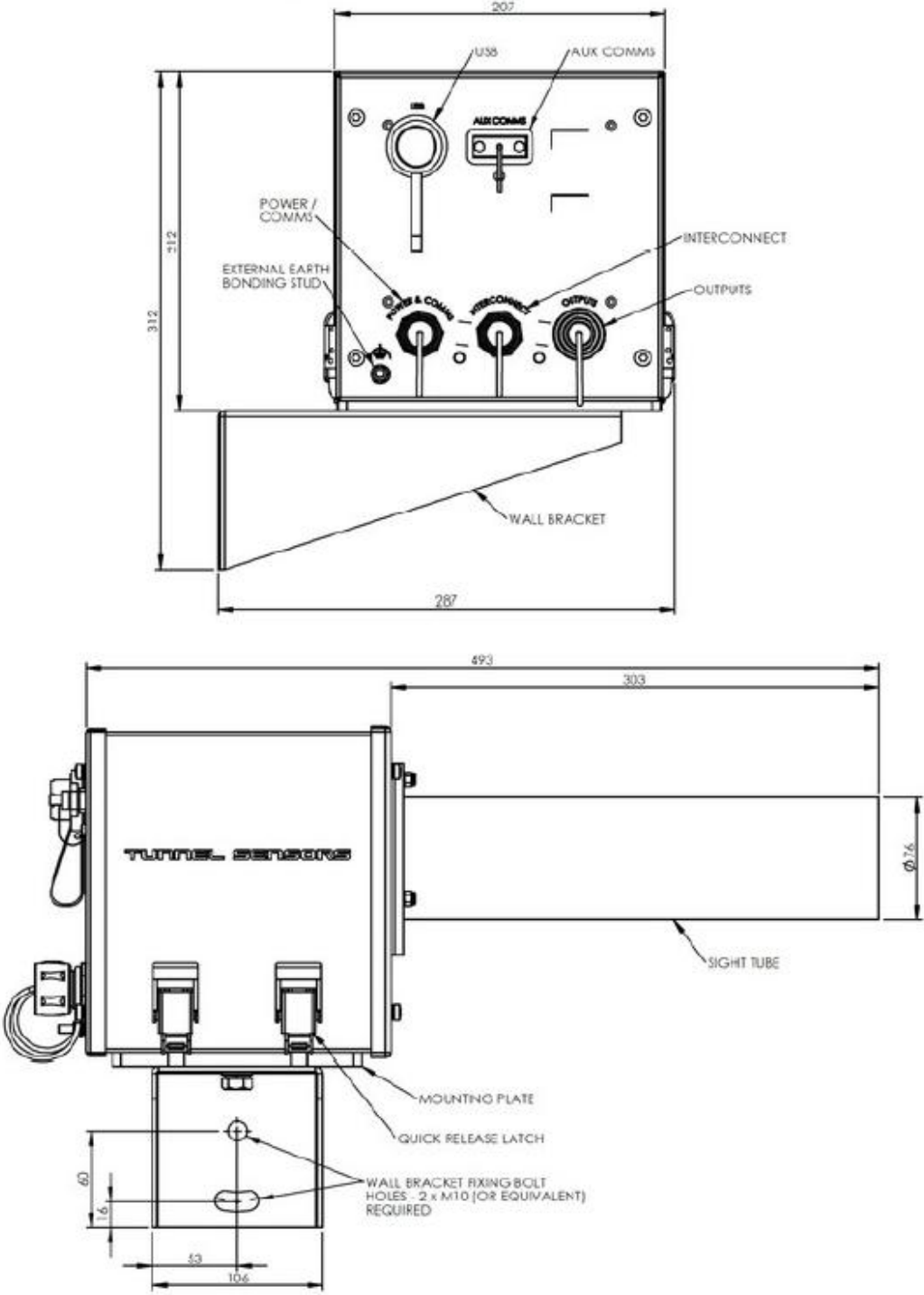
No.	Parameter	Units	Min	Max	Comment
19	Display range	°C	-40	+100	User selectable
20	Resolution	°C		0.1	Display resolution
21	Accuracy	°C	-2	+2	

Power

No.	Parameter	Units	Min	Max	Comment
22	Voltage	Vdc		+24	
23	Voltage Tolerance	%	-10	+10	
24	Nominal Current Consumption	A		2	
25	Power Up Current Consumption	A		3	

Physical					
29	Ingress Protection			IP67	
30	Operating Temperature	°C	-20	+55	
32	Operating Humidity	%		100	
33	Regulatory Compliance				2014/30/EU (Electromagnetic Radiation) 2014/35/EU (Low Voltage)
34	Materials				Stainless Steel (powder coated)
35	Dimensions	mm	180 x 210 x 200		Each head (without sight tubes)
36	Weight	kg	5.3		Each head
37	Warranty	Months	24		Return to base warranty. Extensions available.
Compliance & Design					
27	Design Life	Years	20		
28	MTBF	Years	>10		
29	Warranty	Months	24		Return to base warranty. Extensions available.

Basic Dimensional Sketch



ANEMOMETER	
Illustration	Basic Information
	Tunnel monitor using ultrasound technology to measure the speed and direction of air movement within the tunnel environment. These measurements can be used as part of an air quality management system for ventilation control within a tunnel or other confined space
Technological Description	
Self-contained transceiver which works by measuring the change in transit time of a sound wave due to the flow of air in the direction of the sound wave. The system contains four ultrasound transceivers from which ultrasonic signals are emitted. These ultrasonic signals are bounced off the “reflection roof” and the reflected signals are then received by the transceivers. The time taken for the ultrasound to travel this reflected path is accurately measured, enabling the velocity and direction of moving air to be measured.	

Technical Data

Parameter	Comment
Measuring principle	Ultrasonic transit time (fixed path)
Measurement reading	Air flow in m/s Also available as ft/min or kph (user selected)
Measuring range	± 60 m/s (user configurable)
Resolution	0.01 m/s
Accuracy	± 2 %
Lower detectable limit	0.02 m/s
Response time	1...100 s (user configurable)

Power

Voltage	+24 Vdc (100...240 Vac with optional PSU)
Nominal current consumption	200 mA
Power up current consumption	200 mA

Interface options

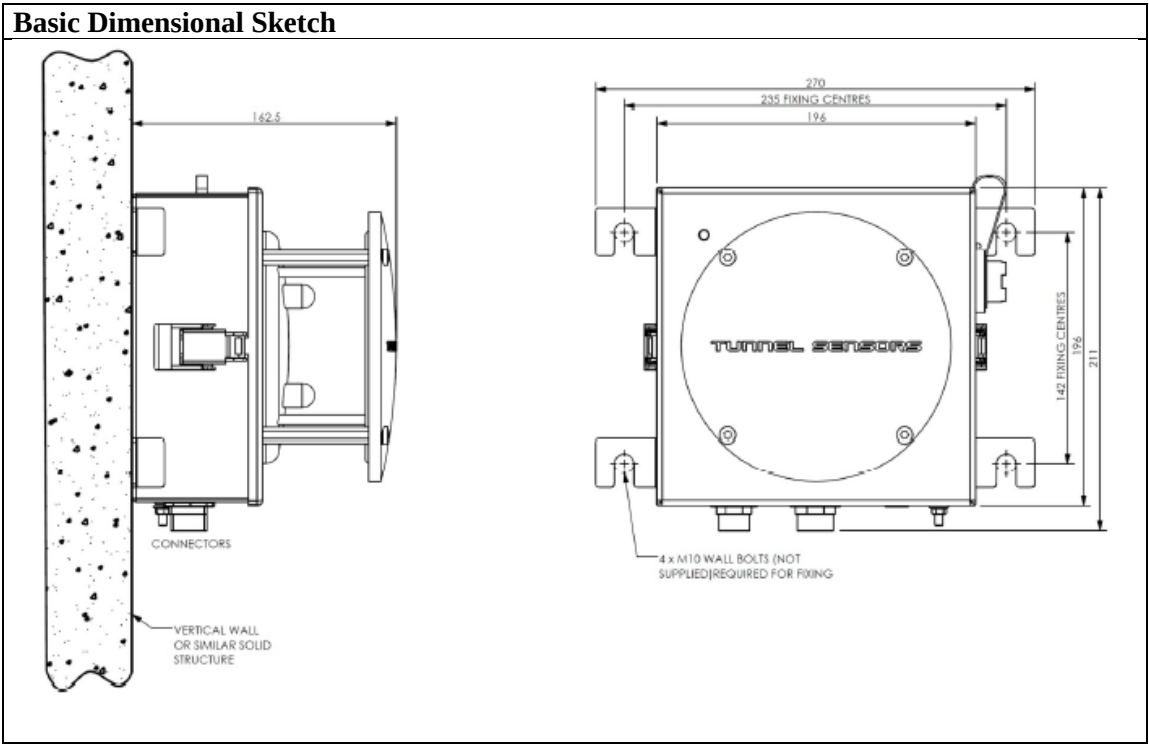
Serial comms	ModBus RTU via RS485 External USB
Analogue output (two)	0/2/4...20.0 mA (isolated and scalable)
Relay contacts (five)	3A @ 30 Vdc (programmable)

Physical

Ambient operating temperature	-20...+70 °C
Ambient operating humidity	0...100 %
Ingress protection	IP67
Materials Enclosure Transceiver	316 stainless steel Flame retardant UL rated polycarbonate
Dimensions	200 x 200 x 160 mm
Weight	2.4 kg

Compliance & design

Electrical compliance	CE mark 2014/30/EU (electromagnetic radiation) 2006/95/EC (low voltage)
Design life	> 20 years
MTBF	> 10 years
Warranty	24 months



WEATHER STATION	
Illustration	Basic Information
	Compact weather station with measurement of temperature, relative humidity, precipitation intensity, precipitation type, precipitation quantity, air pressure, wind direction, wind speed and radiation.
Technological Description	
- <u>Measurement technology:</u> Ultrasonic/Wind, NTC/T, Capacitive/RH, MEMS capacitive/Pressure, Thermopile/Radiation, Radar/Precipitation - <u>Interfaces</u> RS485 with supported protocols UMB-Binary, UMB-ASCII, Modbus-RTU, Modbus-ASCII, XDR and optional SDI-12	

Technical Data

General	
Dimensions	Ø approx. 150 mm, height approx. 317 mm
Weight	Approx. 1.5 kg
Interface	RS485, 2 - wire, half - duplex
Power supply	4...32 VDC
Operating temperature	-50...60°C
Operating rel. humidity	0...100% RH
Heating	40 VA at 24 VDC
Cable length	10 m
Protection level housing	IP66
Mast mounting suitable for	Mast diameter 60 - 76 mm

Temperature	
Principle	NTC
Measuring range	-50...60 °C
Unit	°C
Accuracy	±0.2°C (-20...50 °C), otherwise ±0.5 °C (> -30 °C)

Relative humidity	
Principle	Capacitive
Measuring range	0 ... 100 % RH
Unit	% RH
Accuracy	±2 % RH

Air pressure	
Principle	MEMS capacitive
Measuring range	300 ... 1200 hPa
Unit	hPa
Accuracy	±0.5 hPa (0...40 °C)

Wind direction	
Principle	Ultrasonic
Measuring range	0 ... 359.9 °
Unit	°
Accuracy	< 3° RMSE > 1.0 m/s

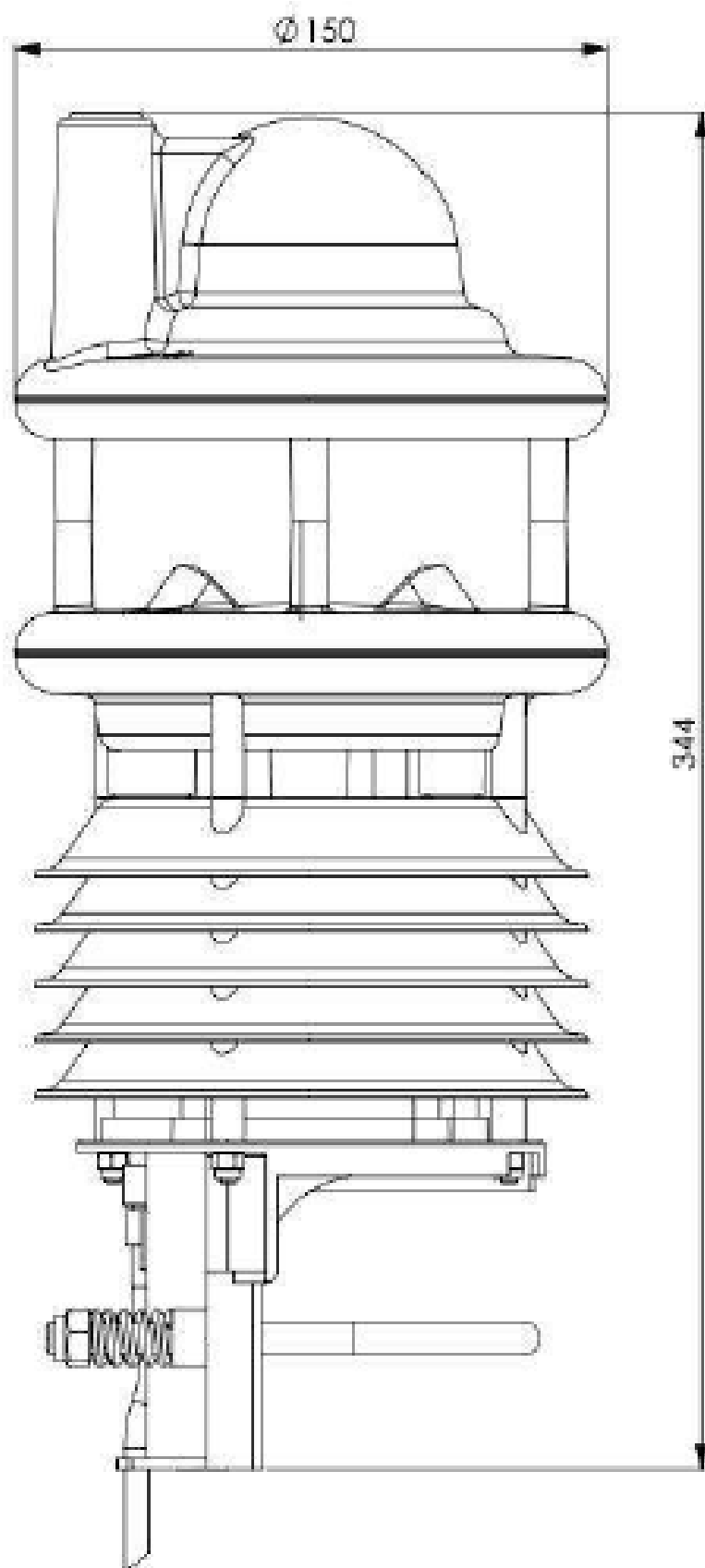
Wind speed	
Principle	Ultrasonic
Measuring range	0 ... 75 m/s
Unit	m/s
Accuracy	±0.3 m/s or ±3 % (0...35 m/s) ±5 % (>35 m/s) RMS
Resolution	0.1

Precipitation intensity	
Resolution	0.1 mm/h

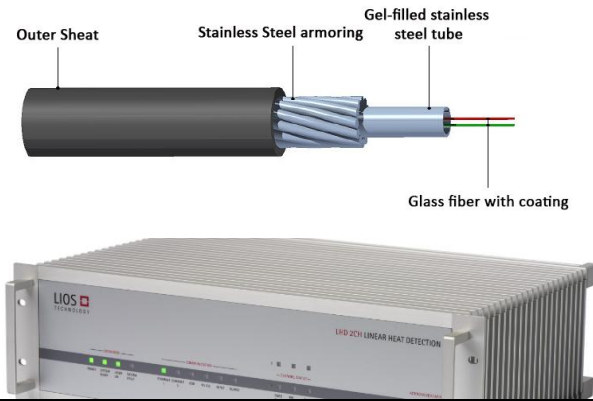
Precipitation quantity	
Resolution	0.01
Reproducibility	Typical >90 %
Measuring range drop size	0.3...5 mm
Type of precipitation	Rain/snow

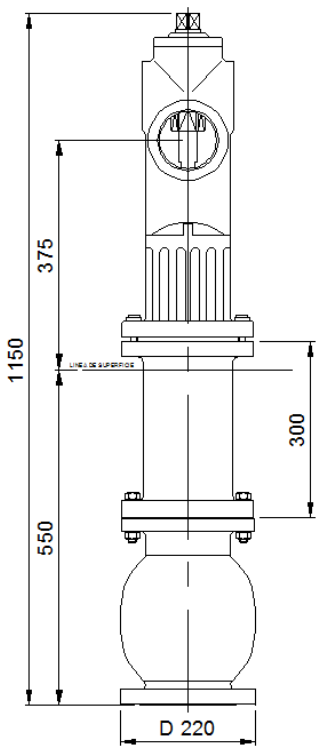
Radiation	
Unit	W/m ²
Accuracy	5%
Response time (95%)	< 1 s
Spectral range	300 to 1100 nm
Measuring range	1400 W/m ²

Basic Dimensional Sketch



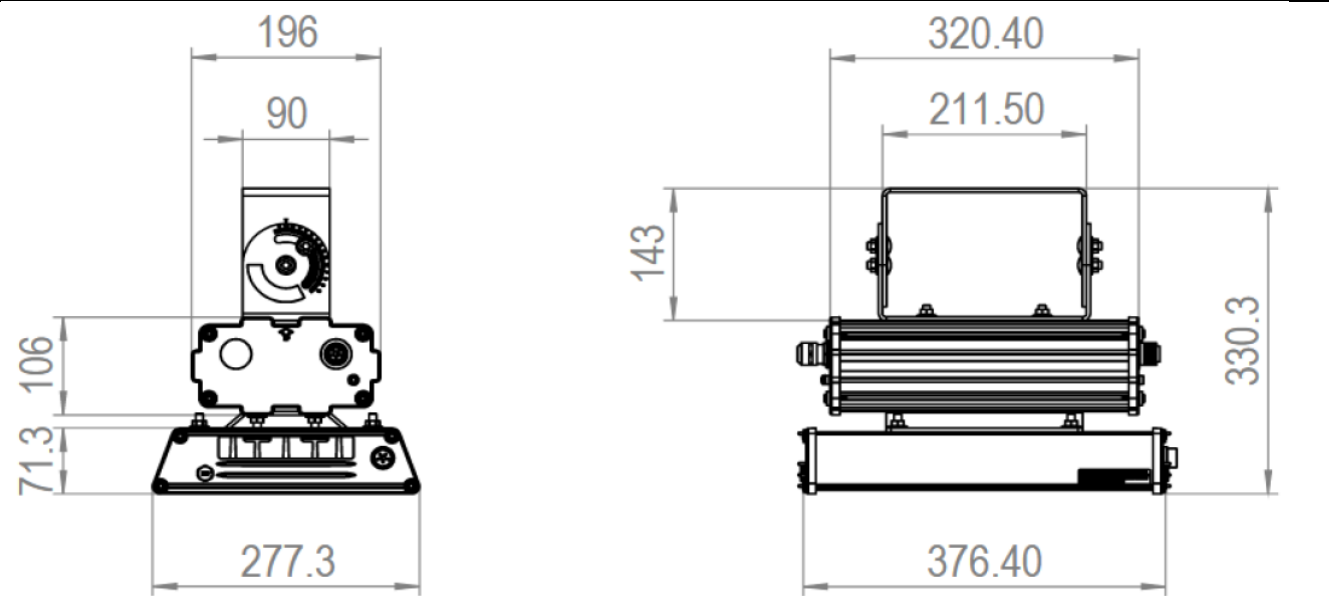
CROSS-PASSAGES VENTILATION	
Illustration	Basic Information
	Fan to manage overpressure in the cross passages with L=800 mm silencer. The motor has C2 painting according to EN ISO 12944-2 standard.
Technological Description	
The motor of the fan has a nominal intensity of 15.5 A, a start intensity that is 8 times higher and a nominal voltage over frequency of 400/50 U/Hz.	
Technical Data	
Fan: Volumetric flux: 6.6 m3/s Immobile wind force: 250 N Mobile wind force: Weight (without motor): 49 kg Flux velocity: 33.4 m/s Motor: Nominal revolution: 2920 1/min Rated power: 7.5 kW Protection: IP55 Weight: 41 kg	
Basic Dimensional Sketch	
	

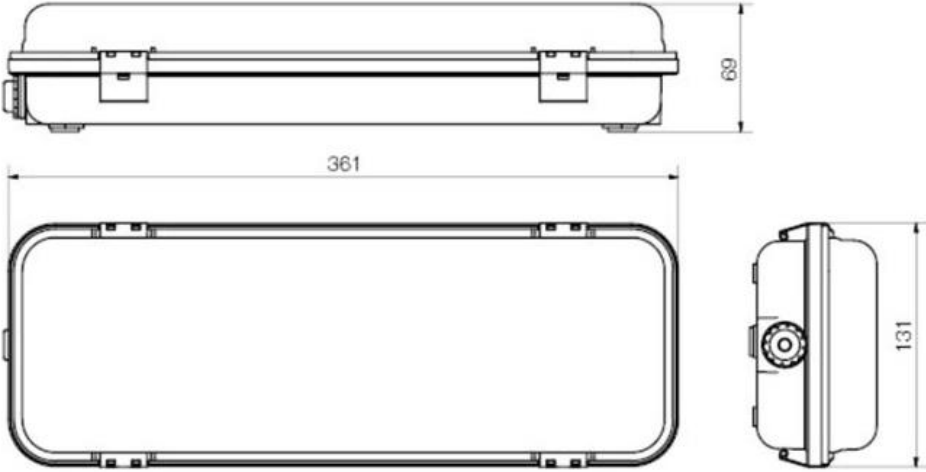
FIRE DETECTION SYSTEM	
Illustration	Basic Information
 The diagram shows a cross-section of the fire detection cable with labels: Outer Sheat, Stainless Steel armoring, Gel-filled stainless steel tube, and Glass fiber with coating. Below the diagram is a photograph of the LIOS 2CH LINEAR HEAT DETECTION controller unit, a 19-inch rack-mountable device with a digital display and status LEDs.	Based on a standard multi-mode and single-mode telecom fibers Quick fire detection and precise localization of the source Information on magnitude and direction of the fire spread Alarm and pre-alarm for each zone Selectable alarm and pre-alarm criteria Maintenance-free (essential for underground inaccessible areas)
Technological Description	
Embedded inside the HV/EHV insulated power cable Small, flexible and purely passive sensor element immune to electromagnetic interference and aggressive atmospheric conditions. Sampling interval down to 0.25 m. 10,000 m detection range	
Technical Data	
MECHANICAL DATA Controller 19" rack / 3 units of height Dimensions (HxWxD) 13.5x44.9x29 cm Weight 13 kg ELECTRICAL DATA Operating Voltage (DC Controller) DC 12 ... 48 V Mains Voltage (AC Controller) Ac 100 ... 240 V Power Consumption (DC Controller) <25W (max. 45 W/60°C) Communication interfaces LON, TCP/IP, Modbus, RS232, USB OPTICAL DATA Fiber type Gradient index 62.5/125 µm multimode Optical Connector E2000 / APC ENVIRONMENT CONDITIONS Storage Temperature -35 ... +75°C Operating Temperature -10 ... +60°C Humidity (non condensing) ≤95% rel. Protections class (IEC 60529) IP51 APPROVALS VdS (pr EN 54-22) G 211030, response classes A1N, BN, CN UL S25135	
Basic Dimensional Sketch	
-	

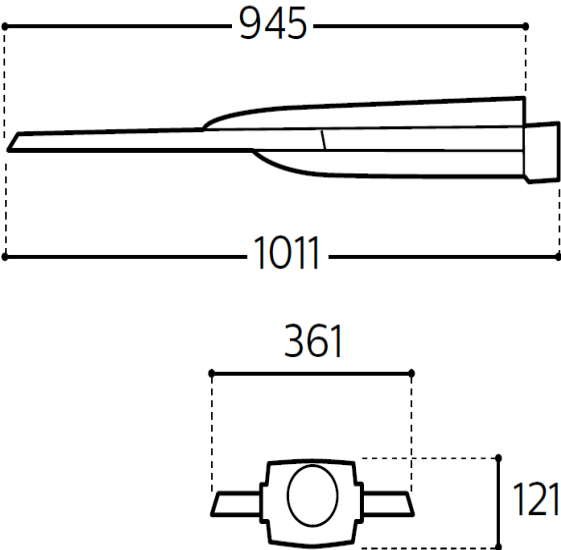
FIRE HYDRANT	
Illustration	Basic Information
	Fire hydrant type C (according to EN 14384 standard) with impact protection. The design and manufacturing favours the robustness of the fire-fighting system.
Technological Description	
Fire hydrant type C (according to EN 14384 standard) with anti-icing system, automatic drainage, helical spring closure and oil bath activation mechanism with waterproof sump.	
Technical Data	
Output connections: 2 x 2 ½ '' + 1 x 4'' Nominal pressure: 16 bar Certificate: EN 14384 Assembly depth: 550 mm Vertical input: BRIDA DIN PN16 MOT: 120 N·m mST: 250 N·m Kv 2 ½'' outputs: 115 Kv 4'' outputs: 200	
Basic Dimensional Sketch	
	

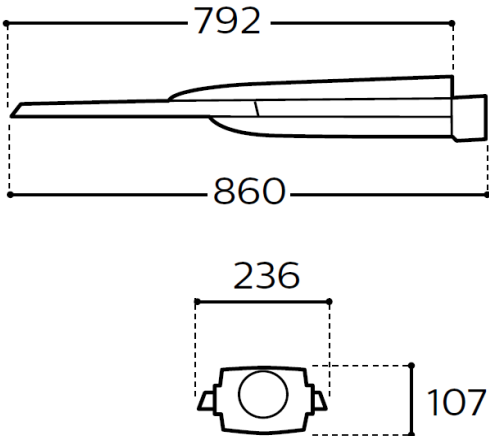
HOSE CONNECTION	
Illustration	Basic Information
	Fire-fighting system equipment with two outputs and one input, coloured in red. It has been designed and manufactured to guarantee high quality conditions, resistant to adverse external conditions such as humidity, low temperatures, etc.
Technological Description	
Hose connection manufactured in cast aluminium alloy with a 70° angle between the two outputs. With a ball valve in each output to regulate the flux	
Technical Data	
2 external thread outputs: 2½'' thread 1 internal thread input: 3'' Body material: Cast aluminium alloy Painting: Red polyester RAL3002 Pressure: 25 bar 70° corner between outputs	
Basic Dimensional Sketch	
-	

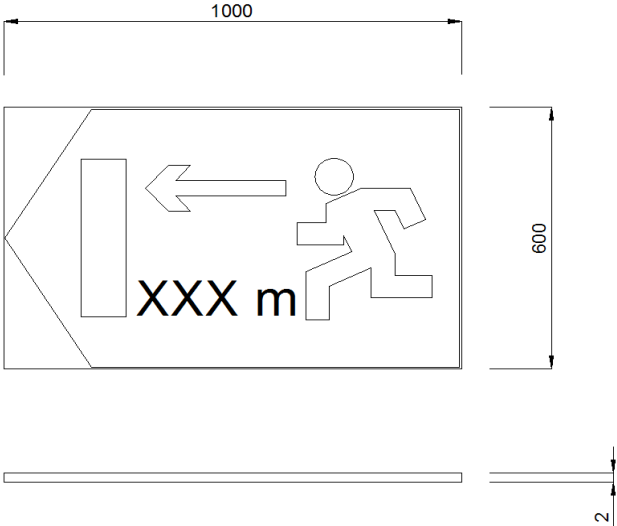
FIRE-FIGHTING PUMPING GROUP	
Illustration	Basic Information
	The projected fire-fighting pumping group is composed of three pumps that have been previously evaluated to meet the requirements of the installation.
Technological Description	
Technical Data	
Components: - Electric Pump: • Axial suction, radial impulsion • Stainless steel shaft • 2 poles three-phase asynchronous motor (400 V, 50 Hz) • Protection: IP55 • Power: 110 kW - Diesel Pump: • Tank capacity: 440 L • Dual battery kit • Power: 110 kW - Auxiliary Jockey Pump: • Linear suction and impulsion • Material: Stainless steel / • Power: 4 kW • Protection: IP55 • Shaft isolation with mechanical closure • 2 poles asynchronous motor - Hydropneumatic tank (24/16): • Metallic bench • Cut valve and check valve in each pump • Impulsion manifold DN150	
Basic Dimensional Sketch	
-	

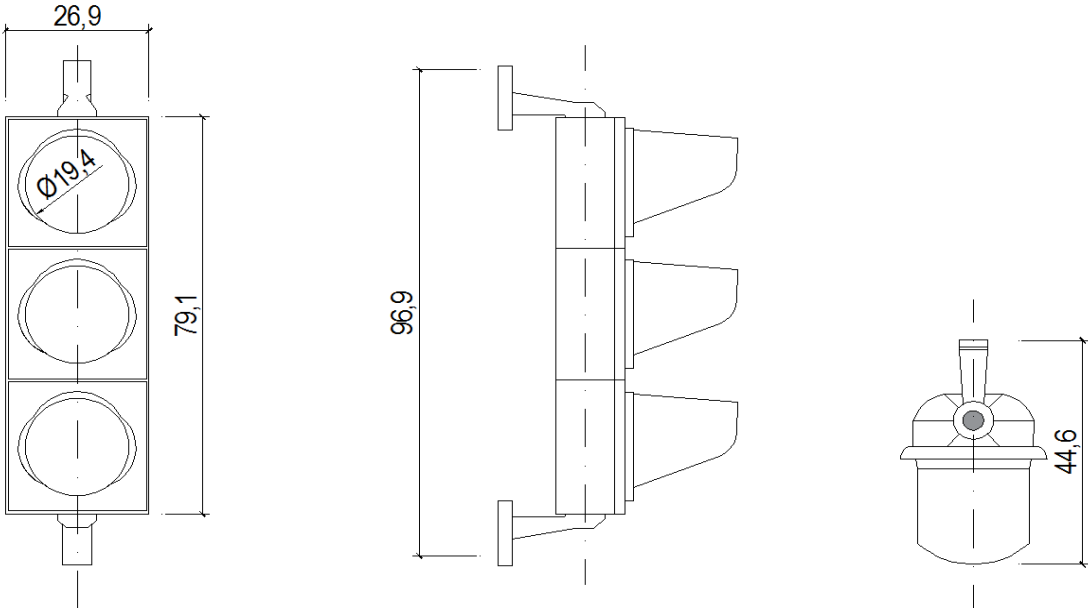
PERMANENT LIGHTING	
Illustration	Basic Information
	LED technology lighting fixture. All components analysed to fulfil high quality standards in order to guarantee a long lifetime of the elements and a high system efficiency.
Technological Description	
LED fixture made in aluminium (resistant to corrosion), with strong design and easy maintenance. Flexible solution for easy installation, overheat protection and long system lifetime (100,000 hrs).	
Technical Data	
Cover: anodize aluminium and injecting aluminium Symmetry: asymmetric Power: 95 W Operating current: 600 mA Flux: 10741 lm Colour temperature: 4000 K Efficiency: 113 lm/W Protection: IP66 Operating temperature: -40°C to 50°C	
Basic Dimensional Sketch	
	

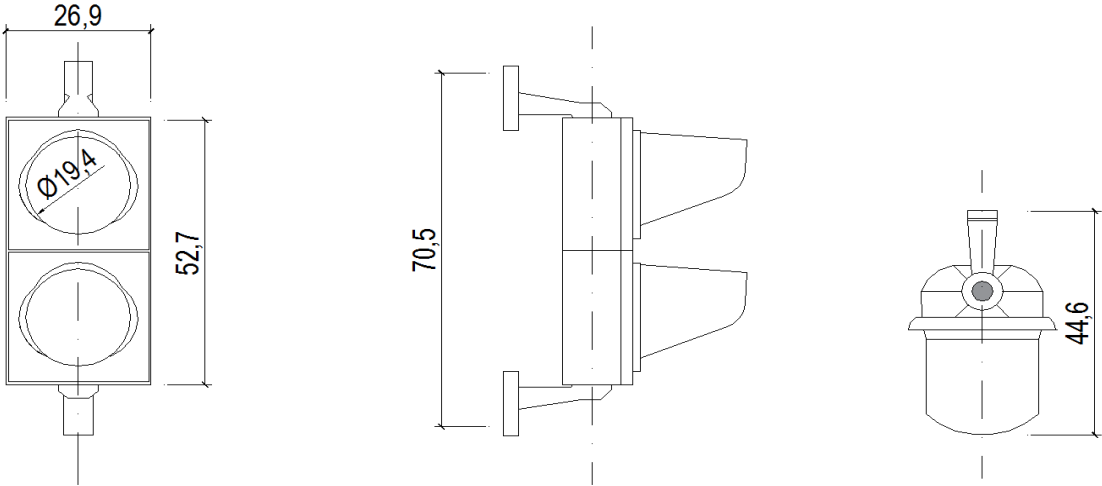
EMERGENCY LIGHTING	
Illustration	Basic Information
	LED fixtures installed in both walls of the tube. They are normally placed every 10 m, at a height of 1 m. The housing of the modules are made of polycarbonate. Its operating mode is no permanent and it has a superficial installation.
Technological Description	
This optical sidewalk indication has been developed to mark the emergency way to exit the tunnel. It consists of a lighting system that will start operating in case there is an emergency in the tunnel. They will be connected to an Uninterruptible Power Supply.	
Technical Data	
Housing material: Polycarbonate Dimensions: 360 x 131 x 69 mm Flux: 110 - 200 lm Autonomy: 1 hour Supply: 230 V, 50 Hz Protection: IP65 Ni-Cd battery, 3.6 V/750 mAh	
Basic Dimensional Sketch	
	

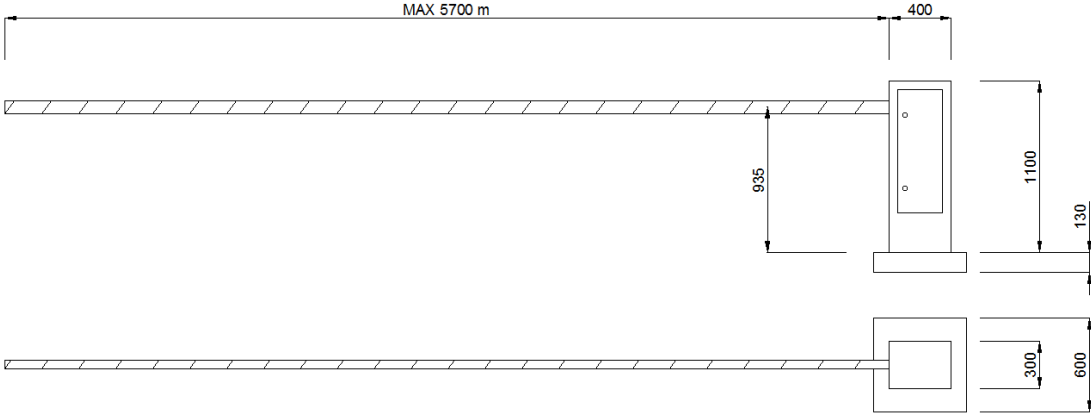
SELF-ILLUMINATING LIGHT MODULES (OUTDOOR LIGHTING_TC Access Roads)	
Illustration	Basic Information
	Optimized solution for outdoor lighting, saving up to 80% energy compared to conventional fixtures. It includes the identification of the fixture with Service tag for a faster and easier maintenance. Valid for any application due to its optimized optical distribution and the LEDGINE-0.21 optical platform. Its design is focused on future integrations, it is functional and it can easily be adapted to high lighting requirements projects.
Technological Description	
LED mast luminaire, aluminium cover, tempered glass closure, 12 meters high, reversible fixation, PMMA optics, symmetric light characteristic, overheat protection, long system lifetime (100,000 hrs).	
Technical Data	
Cover: high pressure aluminium injection Symmetry: symmetric distribution Flux: 29240 lm Colour temperature: 4000 K Overvoltage protection: 4 kV/6 kV, 10 kV Nominal voltage: 230 V, AC, 50Hz Area against wind: 0.0902 m² Approval Protection rating: IP66 Certification: CE, ENEC in preparation	
Basic Dimensional Sketch	
	

SELF-ILLUMINATING LIGHT MODULES (OUTDOOR LIGHTING_TC Surroundings)	
Illustration	Basic Information
	Optimized solution for outdoor lighting, saving up to 80% energy compared to conventional fixtures. It includes the identification of the fixture with Service tag for a faster and easier maintenance. Valid for any application due to its optimized optical distribution and the LEDGINE-0.21 optical platform. Its design is focused on future integrations, it is functional and it can easily be adapted to high lighting requirements projects.
Technological Description	
LED mast luminaire, aluminium cover, tempered glass closure, 6 meters high, reversible fixation, PMMA optics, symmetric light characteristic, overheat protection, long system lifetime (100,000 hrs).	
Technical Data	
Cover: high pressure aluminium injection Symmetry: symmetric distribution Flux: 9680 lm Colour temperature: 4000 K Overvoltage protection: 4 kV/6 kV, 10 kV Nominal voltage: 230 V, AC, 50Hz Area against wind: 0.0726 m² Approval Protection rating: IP66 Certification: CE, ENEC in preparation	
Basic Dimensional Sketch	
	

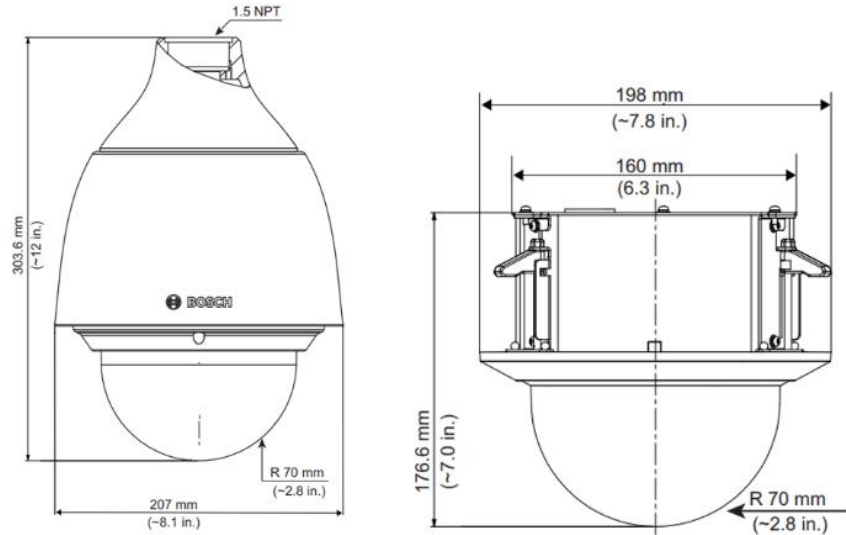
REFLECTIVE EVACUATION SIGN	
Illustration	Basic Information
	Evacuation route signs show people in the tunnel the safe way to escape from the tunnel in the case of an emergency. Therefore, they show the distances to the closest exit in the left and right direction in metres.
Technological Description	
Reflective evacuation route signs are installed on the tunnel walls on both sides of the tunnel, in a height of about 1.0 m above the sidewalk. They are situated in distances of about 25 m to each other. They are made of aluminium to withstand the conditions in the tunnel, like corrosion, exhaust and moisture.	
Technical Data	
Material: Aluminium Dimensions: 1000 x 600 mm Thickness: 2 mm High quality painting (UV rays resistant) Luminance: 215 mcd/m² (10 min) / 30 mcd/m² (60min) Certificate: AENOR, EN 71-3, etc.	
Basic Dimensional Sketch	
	

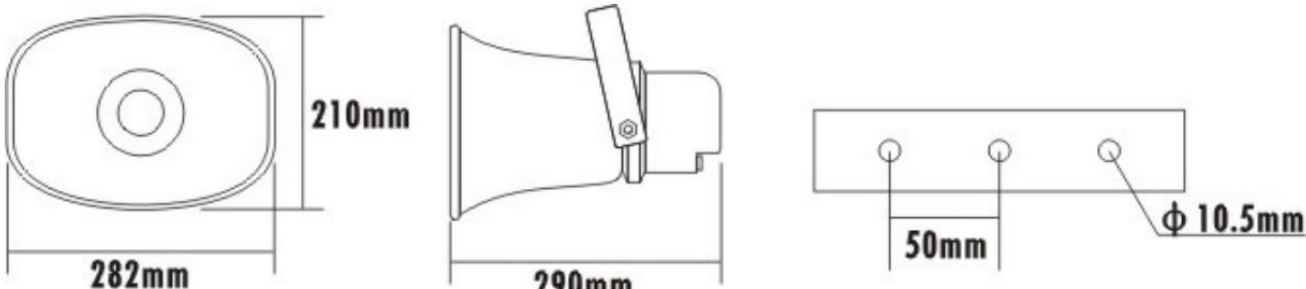
THREE COLOURED TRAFFIC LIGHTS	
Illustration	Basic Information
	3-coloured LED traffic light.
Technological Description	
The optic ensures highest energy efficiency, optimized strength and stability, cannot be opened by unauthorized persons, available in different colours and colour combinations, can be mounted vertically as well as horizontally, available with integrated frame to fix backing boards, LED optic ensures highest energy efficiency.	
Technical Data	
Material: UV-stabilized polycarbonate Diameters: 100, 200, 300 mm 1, 2, 3 as standard; more aspects on request Optic: 100 / 210 / 300 mm Mounting: Two point fixing Backing Boards: fixation via basic frame or ALU/PC Composite Housing colours: black (RAL 9005),light grey (RAL 7032),fir green (RAL 6009),orange (RAL 2000) Impact resistance: acc. to EN60598-1; class IR 3 acc. to EN12368 Change of temperature: EN60068-2-14 passed	
Basic Dimensional Sketch	
	

TWO COLOURED TRAFFIC LIGHTS (A-A)	
Illustration	Basic Information
	2-colored LED traffic light (amber-amber)
Technological Description The optic ensures highest energy efficiency, 5 mm LEDs (high light intensity), LED optic ensures highest energy efficiency, long system lifetime (80,000 hrs), the lights can be seen from 300 m. It includes polycarbonate hooks to affix the traffic lights to any pole or wall.	
Technical Data Material: UV-stabilized polycarbonate Diameters: 200 mm Voltage range: 85-265 VCA Mounting: Two point fixing Power consumption: 7 W Lamps: 61 LED in each lamp Protection: IP54	
Basic Dimensional Sketch 	

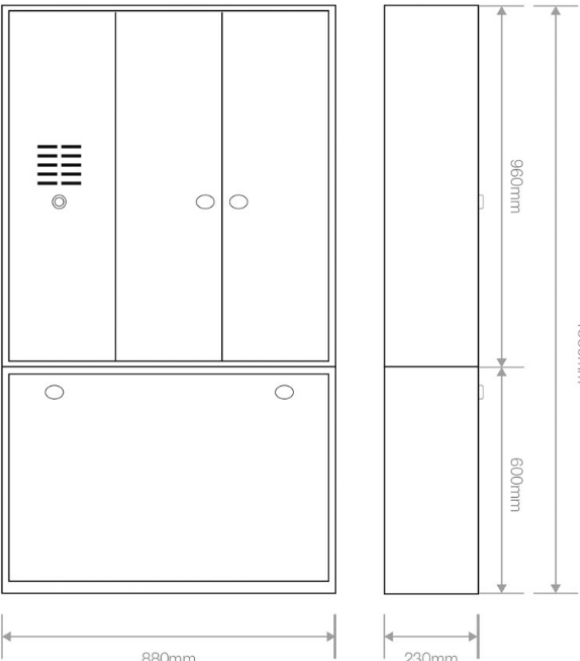
AUTOMATIC BARRIERS	
Illustration	Basic Information
	Automatic barrier designed to operate under hardest and most unfavourable conditions.
Technological Description	
The automatic barriers have a three-phase synchronous motor, power 0.25 CV, and the internal control is conducted by means of relays. The mechanism is protected by an anti-corrosive treatment based on an electrolytic bath. The use of low maintenance materials and the simple and effective mechanical design, provide these barriers incomparable performance in terms of opening speed (1.5 sec), low maintenance, and long equipment life 5,000.000 cycles).	
Technical Data	
Supply voltage: three-phase 380 VAC / 220 VAC, 50-60 Hz Motor velocity: 850 rpm Operational temperature: -20°C to 75°C Weight: 45 kg Opening/closing speed: 1.5 s Maximum length: 5.7 m Protection: IP-44	
Basic Dimensional Sketch	
	

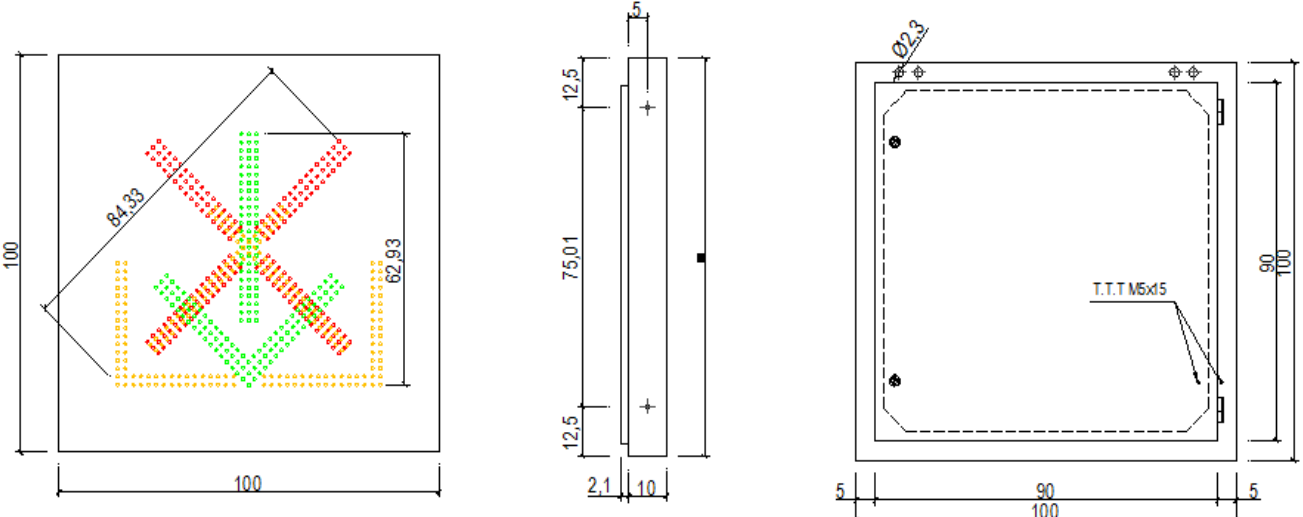
INDOOR CCTV CAMERA WITH AID SYSTEM	
Illustration	Basic Information
	Compact, rugged camera solution for automatic incident detection. Combines full HD visual imaging with advanced video analytics. Generates traffic data and incident detection information for tunnels, including alerts on stopped vehicles, wrong-way drivers, and lost cargo. High quality sensor 1/2.8" Sony CMOS, with high dynamic range to see in both, light and dark spaces. Bilinx communication for remote configuration and control. Easy to install
Technological Description	
Easy installing CCTV system camera with different colour options and a relation signal/noise higher than 54 dB.	
Technical Data	
Image sensor: 1/2.8" Sony CMOS sensor Nominal tension: 12 VCC / 24 VCA Nominal frequency: 50 / 60 Hz Power consumption: Max. 13W heater off Max. 23W heater on Total pixels: 1920 × 1080 Operating temperature: -30 °C to 55°C Housing: 316L stainless steel Protection: IP66 and 67 requirements against dust and water ingress/immersion Certificate: UL, FCC, CSA	
Basic Dimensional Sketch	
190 × 110 × 77mm	

REVOLVE CCTV CAMERA	
Illustration	Basic Information
	Dynamic camera unit with universal qualities, high efficiency in low light conditions. High-quality video technology, the system is capable of detecting a person at a maximum distance of 180 m. Two available models, one suspended and another anchored to the ceiling.
Technological Description	
CCTV camera with a revolving range of 360°, aluminium cover, plastic exterior cover with IP51/IP66 protection. The camera has a shutter speed from 1/1 to 1/10000 s.	
Technical Data	
Certification: CE, FCC, cULus Power Consumption: 14 W/24 W Signal-to-Noise Ratio: >55 dB Day/Night Mode: Colour, Mono, Auto Dimensions (Ø x H): 198 mm x 176.6 mm / 207 mm x 303.6 mm Weight: approx. 2.1 kg / 3.25 kg Temperature range extended: -40 up to +60 °C	
Basic Dimensional Sketch	
	

LOUDSPEAKER (PA/VA SYSTEM)	
Illustration	Basic Information
	The exponential loudspeaker has been designed for noisy zones, this is why it is optimal for indoor and outdoor areas in tunnels. It can resist in the outdoor. The speaker provides a high sound pressure level and a very low distortion.
Technological Description	
The loudspeaker has an integrated transformer (70 V/100 V), a huge scope and a metallic anchoring. It is outdoor resistant and it has a white ABS cover.	
Technical Data	
Power Consumption: 30 W (100 V) Protection: IP66 Dimensions: 282 x 210 x 290 mm Weight: 2.1 kg SPL (1 W/1 m): 103 dB SPL (nominal W/1 m): 118 dB Frequency response (-10 dB): 300 Hz – 13 Hz	
Basic Dimensional Sketch	
	

COAXIAL CABLE	
Illustration	Basic Information
	Foam Coaxial Cable 1/2", corrugated copper, Low Smoke Halogen-free, Fire-retardant (Z).
Technological Description	
1/2" foam coaxial cable with an attenuation from 3.22 dB/100 m (100 MHz) to 20.90 dB/100 m (3000 MHz)	
Technical Data	
Inner conductor material: Copper-Clad Aluminium Wire Dielectric material: Physical Foam Polyethylene Outer conductor material: Corrugated Copper Tube Jacket material: Black PE or Low Smoke Halogen-free Fire-retardant Minimum number of bends: 15 Tensile strength: 650 N Inner conductor diameter: 3.60 mm Dielectric diameter: 8.7 mm Outer conductor diameter: 12.00 mm Diameter over jacket: 13.30 mm Capacitance: 80.0 pF/m Impedance: 50 ± 1 Ω Velocity: 83% Peak power rating: 19 kW Insulation resistance: 5000 MΩ-km	
Basic Dimensional Sketch	
-	

SOS STATION	
Illustration	Basic Information
	The IP SOS tunnel station is an assistance tunnel equipment, useful for help communication. This technological station has hands-free device and high power audio output. Besides, The SOS station presents different models, permitting the installation of extinguishers or hoses.
Technological Description	
The SOS station offers the possibility of having one or two extinguishers. In addition, it is possible to install a camera unit with VGA, QVGA or QQVGA resolution and a SD card for audio recording. The box has security lock and hidden metallic hinges.	
Technical Data	
Housing material: Steel covered by corrosion resistant painting Nominal power consumption: 1 W Supply voltage: 5 V to 24 V Industrial temperature range: -40°C to 85°C Operating IP protocols: ARP, IP v4, ICMP, TCP, UDP, DHCP, DNS, SIP, SNMP, HTTP, Telnet, etc. Body dimensions: 880 x 960 x 230 mm Base dimensions: 880 x 600 x 230 mm	
Basic Dimensional Sketch	
	

TUNNEL VARIABLE LANE SIGN (red cross / green arrow)	
Illustration	Basic Information
	Luminous signal composed by a LED graphic zone showing the symbols: red cross (prohibition of lane) and green arrow (availability of lane). High availability of designs and configurations, adaptable to different projects and necessities. These signs have been designed in order to be easily installed in a metallic framework or fixed to the ceiling. The electronic panels have been developed with low consumption technology and they need very reduced maintenance.
Technological Description	
The tunnel variable lane sign is composed by permanently supervised LEDs, even if switched off; the status can be reported to the traffic center or local control. The brightness can be adjusted in both, automatic and manual way, and the long LED life cycle results in extended maintenance intervals.	
Technical Data	
Light source: High Power LEDs Housing: Aluminium / Galvanised steel Protection: IP65 / IP55 Beam width: B2 / B4 Luminance: L3 Interfaces: Ethernet IP, RS-232, RS-485, optical fiber, GPRS, WiFi Distance between pixels: 14 mm, 20 mm... Power supply: AC single-phase Dimensions: 700 x 650 mm / 1000 x 1000 mm / 1200 x 1200 mm Weight (Galvanised steel): 24 kg / 40 kg / 55 kg Weight (Aluminium): 15 kg / 24 kg / 32 kg Power (high power): 25 W / 40 W / 60 W Power (low power): 7 W / 11 W / 15 W Certification: CE, EN-12966-2005, 2002/95/CE	
Basic Dimensional Sketch	
	

TUNNEL VARIABLE SPEED LIMIT SIGN (red cross / green arrow)

Illustration	Basic Information
	There are three basic models of the VSL, each one with the capability to display two (2D) or three (3D) digits. The models' classification is based on the circle ring dimensions and the displaying digit heights. The model choice is based on the motorway typical speed limit and the required maximum reading distance that depends on the displaying digit heights. Every VSL model can display all possible speed limits in increments of 10.

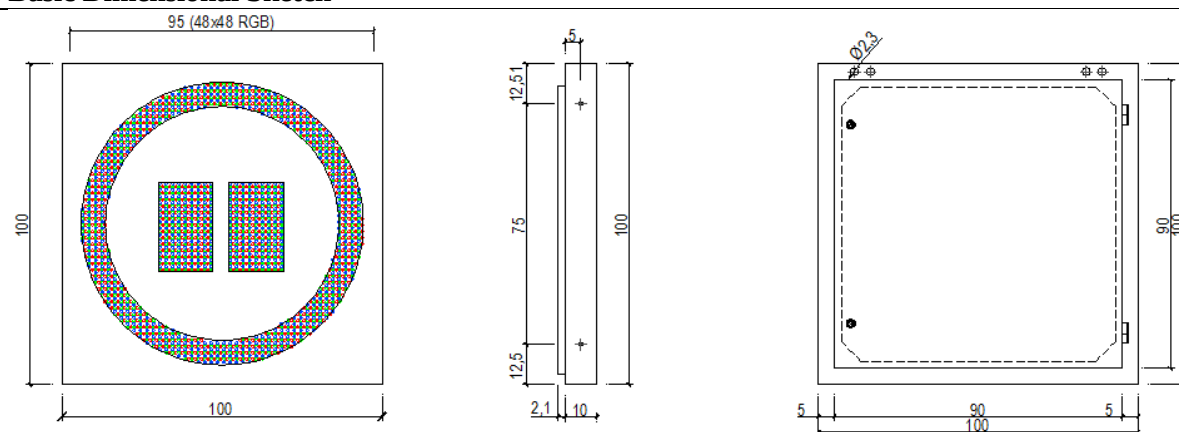
Technological Description

VSL signs are usually integrated in a Traffic Management System (TMS SCADA), where all signs are controlled according to traffic scenarios and automations. Alternatively smaller scale integrations can be easily performed via the relay inputs. The communication method varies according to project network infrastructure and local communication interfaces.

Technical Data

In-Tunnel / Outdoor installation
 SCADA integration
 Automatic fault and error detection and
 Automatic and manual brightness control in 16 discrete levels
 Ability to increase LED gain
 Minimal brightness reduction over lifetime due to strictly controlled LED driving conditions
 Static 1:1 driving
 Ability to display flashing speed limits
 Contrast Enhancement Technology
 Cover: Aluminium / Stainless steel
 Communication interfaces: RS485, RS232, Ethernet, 4 digital inputs for PLC communication
 Certification: CE, EN-12966
 Protection: IP65
 External luminance: 40.000 lux
 Beam width: B4
 Operational Temperature: -20°C to +60°C

Basic Dimensional Sketch



INDOOR VARIABLE MESSAGE PANEL	
Illustration	Basic Information
	LED variable message sign designed with Low Power Technology. It has a mixed configuration formed by an alphanumeric zone and one or two graphic zones.
Technological Description	
These panels have been designed in order to have minimum maintenance procedures and they can be installed in the ceiling or on metallic structures.	
Technical Data	
Usual configurations: - 2 text lines of 12 characters each - 1 graphic zone + 2 text lines of 12characters each (4580 mm x 1000 mm) - 1 text line of 16 characters Graphic area resolution: 32 x 32 pixels RGB / RGBY Character height: 220 mm, 320 mm, 400 mm... Housing: Aluminium / Galvanised steel Protection: IP65 / IP55 Beam width: B2 / B4 Luminance: L3T Interfaces: Ethernet IP, RS-232, RS-485, optical fiber, GPRS, WiFi Distance between pixels: 20 mm, 25 mm, 40 mm... Power supply: AC (single-phase / three-phase), DC	
Basic Dimensional Sketch	

OUTDOOR VARIABLE MESSAGE PANEL

Illustration	Basic Information
	LED variable message sign designed with Low Power Technology. It has a mixed configuration formed by an alphanumeric zone and one or two graphic zones. The graphic area allows the integration of text as an extended part of the alphanumeric area.

Technological Description

These variable message signs have a maximum consume of 350 W, its maintenance procedure is minimum and they can be installed anywhere in the world due to its adaptability to any communications protocol and to the different standards.

Technical Data

Usual configurations:

- 1 graphic zone + 3 text lines with 12/16/18 characters each (5800 mm x 1920 mm)
- 2 graphic zones + 3 text lines with 12/16 characters each (7140 mm x 1920 mm)

Character height: 220 mm, 320 mm, 400 mm...

Housing: Aluminium / Galvanised steel

Protection: IP65 / IP55

Beam width: B2 / B4

Luminance: L3

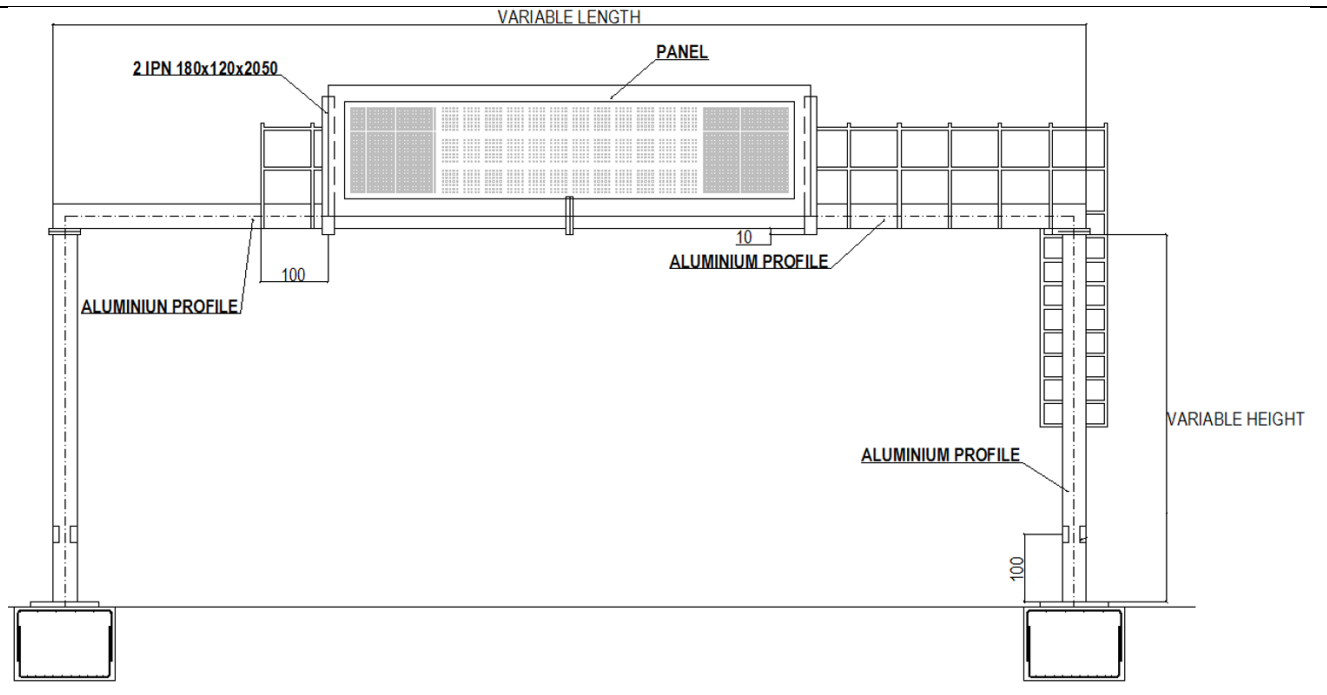
Interfaces: Ethernet IP, RS-232, RS-485, optical fiber, GPRS, WiFi

Distance between pixels: 20 mm, 25 mm, 40 mm...

Power supply: AC (single-phase / three-phase), DC

Certification: CE, EN-12966-2005, 2002/95/CE, EU 305/2001.E13

Basic Dimensional Sketch



Schedule - E

(See Clauses 2.1 and 14.2)

Maintenance Requirements**1. Maintenance Requirements**

- (i) The Contractor shall, at all times maintain the Project Highway in accordance with the provisions of this Agreement, Applicable Laws and Applicable Permits.
- (ii) The Contractor shall repair or rectify any Defect or deficiency set forth in Paragraph 2 of this Schedule-E within the time limit specified therein and any failure in this behalf shall constitute non-fulfilment of the Maintenance obligations by the Contractor. Upon occurrence of any breach hereunder, the Authority shall be entitled to effect reduction in monthly lump sum payment as set forth in Clause 14.6 of this Agreement, without prejudice to the rights of the Authority under this Agreement, including Termination thereof.
- (iii) All Materials works and construction operations shall conform to the MORTH Specifications for Road and Bridge Works, and the relevant IRC publications. Where the specifications for a work are not given, Good Industry Practice shall be adopted.

[Specify all the relevant documents]

2. Repair/rectification of Defects and deficiencies

The obligations of the Contractor in respect of Maintenance Requirements shall include repair and rectification of the Defects and deficiencies specified in Annex - I of this Schedule-E within the time limit set forth therein.

3. Other Defects and deficiencies

In respect of any Defect or deficiency not specified in Annex - I of this Schedule-E, the Authority's Engineer may, in conformity with Good Industry Practice, specify the permissible limit of deviation or deterioration with reference to the Specifications and Standards, and any deviation or deterioration beyond the permissible limit shall be repaired or rectified by the Contractor within the time limit specified by the Authority's Engineer.

4. Extension of time limit

Notwithstanding anything to the contrary specified in this Schedule-E, if the nature and extent of any Defect or deficiency justifies more time for its repair or rectification than the time specified herein, the Contractor shall be entitled to additional time in conformity with Good Industry Practice. Such additional time shall be determined by the Authority's Engineer and conveyed to the Contractor and the Authority with reasons thereof.

5. Emergency repairs/restoration

Notwithstanding anything to the contrary contained in this Schedule-E, if any Defect, deficiency or deterioration in the Project Highway poses a hazard to safety or risk of damage to property, the Contractor shall promptly take all reasonable measures for eliminating or minimizing such danger.

6. Daily inspection by the Contractor

The Contractor shall, through its engineer, undertake a daily visual inspection of the Project Highway and maintain a record thereof in a register to be kept in such form and manner as the Authority's Engineer may specify. Such record shall be kept in safe custody of the Contractor and shall be open to inspection by the Authority and the Authority's Engineer at any time during office hours.

7. Pre-monsoon inspection / Post-monsoon inspection

The Contractor shall carry out a detailed pre-monsoon inspection of all bridges, culverts and drainage system before [1st June] every year in accordance with the guidelines contained in IRC: SP35. Report of this inspection together with details of proposed maintenance works as required on the basis of this inspection shall be sent to the Authority's Engineer before the [10th June] every year. The Contractor shall complete the required repairs before the onset of the monsoon and send to the Authority's Engineer a compliance report. Post monsoon inspection shall be done by the [30th September] and the inspection report together with details of any damages observed and proposed action to remedy the same shall be sent to the Authority's Engineer.

8. Repairs on account of natural calamities

- (a) All damages occurring to the Project Highway on account of a Force Majeure Event or wilful default or neglect of the Authority shall be undertaken by the Authority at its own cost. The Authority may instruct the Contractor to undertake the repairs at the rates agreed between the Parties

Annex -I

(Schedule-E)

Repair/rectification of Defects and deficiencies

The Contractor shall repair and rectify the Defects and deficiencies specified in this Annex-I of Schedule-E within the time limit set forth in the table below.

Table -1: Maintenance Criteria for Pavements:

Table 2: Maintenance Criteria for Pavements								
Asset Type	Performance Parameter	Level of Service (LOS)		Frequency of Inspection	Tools/Equipment	Standards and References for Inspection and Data Analysis	Time limit for Rectification/Repair	Maintenance Specifications
		Desirable	Acceptable					
Flexible Pavement (Pavement of MCW, Service Road, Approaches of Grade structure, approaches of connecting roads, slip roads, lay byes etc. as applicable)	Potholes	Nil	< 0.1 %of area and subject to limit of 10 mm in depth	Daily	Length Measurement Unit like Scale, Tape, odometer etc.	IRC 82: 2015 and Distress Identification Manual for Long Term Pavement Performance Program, FHWA2003(http://www.tfhr.com/pavement/ltp/reports/03031/)	24-48 hours	MORT&H Specification 3004.2
	Cracking	Nil	< 5 %subject to limitof0.5 sq.m for any 50 m length	Daily			7-15 days	MORT&H Specification 3004.3
	Rutting	Nil	< 5 mm	Daily	Straight Edge		15 -30 days	MORT&H Specification 3004.2
	Corrugations and Shoving	Nil	< 0.1% Ofarea	Daily	Length Measurement Unit like		2-7 days	IRC:82- 2015
	Bleeding	Nil	< 1 % of area	Daily	Scale, Tape, odometer etc.		3-7 days	MORT&H Specification 3004.4
	Ravelling/Stripping	Nil	< 1 % of area	Daily			7-15 days	IRC:82- 2015 read with IRC SP 81
	Edge Deformation/ Breaking	Nil	< 1 m for any 100 m section and width <0.1 matanylocation,restricted	Daily		7- 15 days	IRC:82-2015	

Asset Type	Performance Parameter	Level of Service (LOS)		Frequency of Inspection	Tools/Equipment	Standards and References for Inspection and Data Analysis	Time limit for Rectification/Repair	Maintenance Specifications
		Desirable	Acceptable					
			to 30 cm from the edge					
	Roughness BI	2000mm/km	2400mm/km	Bi-Annually	Class I Profilometer SCRIM (Sideway-force Coefficient Routine Investigation Machine or equivalent)	Class I Profilometer: ASTM E950 (98) :2004 –Standard Test Method for measuring Longitudinal Profile of Travelled Surfaces with Accelerometer Established Inertial Profiling Reference ASTM E1656 -94: 2000- Standard Guide for Classification of Automatic Pavement Condition Survey Equipment	180 days	IRC:82-2015
	Skid Number	60SN	50SN	Bi-Annually			180 days	BS: 7941-1: 2006
	Pavement Condition Index	3	2.1	Bi-Annually			180 days	IRC:82- 2015
	Other Pavement Distresses			Bi-Annually			2-7 days	IRC:82- 2015
	Deflection/ Remaining Life			Annually	Falling Weight Deflectometer	IRC 115: 2014	180 days	IRC:115- 2014
Rigid Pavement (Pavement of MCW, Service Road, Grade structure, approaches of connecting road, slip roads, lay byes etc. as applicable)	Roughness BI	2200m m/km	2400mm /Km	Bi-Annually	Class I Profilometer	ASTM E950 (98) :2004 and ASTM E1656 - 94: 2000	180 days	IRC: SP:83- 2018
	Skid	Skid Resistance no. at different speed of vehicles		Bi-Annually	SCRIM (Sideway- force	IRC: SP:83-2018	180 days	IRC: SP:83- 2018
		Minimum SN 36 33 32 31 31		traffic Speed (Km/h) 50 65 80 95 110	Coefficient Routine Investigation Machine or equivalent)			
Embankment / Slope	Edge drop at shoulders	Nil	40m m	Daily	Length Measurement Unit like Scale, Tape, odometer etc.	IRC	7-15 days	MORT&H Specification 408.4
	Slope of camber/cross fall	Nil	<2%variation inprescribedslope of camber/cross				7-15 days	MORT&H Specification 408.4

Asset Type	Performance Parameter	Level of Service (LOS)		Frequency of Inspection	Tools/Equipment	Standards and References for Inspection and Data Analysis	Time limit for Rectification/Repair	Maintenance Specifications
		Desirable	Acceptable					
			fall	Daily				
	Embankment Slopes	Nil	<15 %variation inprescribe side slope	Daily			7-15 days	MORT&H Specification 408.4
	Embankment Protection	Nil	Nil	Daily	NA		7-15 days	MORT&H Specification
	Rain Cuts/ Gullies in slope	Nil	Nil	DailySpecially During Rainy Season	NA		7-15 days	MORT&H Specification

In addition to the above performance criterion, the contractor shall strictly maintain the rigid pavements as per requirements in the following table

Table -2: Maintenance Criteria for Rigid Pavements:

Sr. No.	Type of Distress	Measured Parameter	Degree of Severity	Assessment Rating	Repair Action	
					For the case $d < D/2$	For the case $d > D/2$
CRACKING						
1	Single Discrete Cracks Not intersecting with any joint	w = width of crack L = length of crack d = depth of crack D = depth of slab	0	Nil, not discernible	No Action	Not applicable
			1	w < 0.2 mm. hair cracks		
			2	w = 0.2 - 0.5 mm, discernible from slow-moving car	Seal without delay	Seal, and stitch if L > 1m. Within 7days
			3	w = 0.5 - 1.5 mm, discernible from fast-moving car		
			4	w = 1.5 - 3.0 mm	Seal, and stitch if L > 1 m. Within 7 days	Staple or Dowel Bar Retrofit, FDR for affected portion. Within 15days
			5	w > 3 mm.		
2	Single Transverse (or Diagonal) Crack intersecting with one or more joints	w = width of crack L = length of crack d = depth of crack D = depth of slab	0	Nil, not discernible	No Action	
			1	w < 0.2 mm, hair cracks	Route and seal with epoxy. Within 7 days	Staple or Dowel Bar Retrofit. Within 15days
			2	w = 0.2 - 0.5 mm, discernible from slow vehicle		
			3	w = 0.5 - 3.0 mm, discernible from fast vehicle	Route, seal and stitch, if L > 1m. Within 7 days	
			4	w = 3.0 - 6.0 mm	Dowel Bar Retrofit. Within 15 days	Full Depth Repair Dismantle and reconstruct affected.
			5	w > 6 mm, usually associated with spalling, and/or slab rocking under traffic	Not Applicable, as it may be full depth	Portion with norms and specifications - See Para 5.5 & 9.2 Within 15days
3	Single Longitudinal Crack intersecting with one or more joints	w = width of crack L = length of crack d = depth of crack D = depth of slab	0	Nil, not discernible	No Action	
			1	w < 0.5 mm, discernible from slow moving vehicle	Seal with epoxy, if L > 1 m. Within 7 days	Staple or dowel bar retrofit. Within 15days
			2	w = 0.5 - 3.0 mm, discernible from fast vehicle	Route seal and stitch, if L > 1 m. Within 15 days	
			3	w = 3.0 - 6.0 mm	Staple, if L > 1 m. Within 15 days	Partial Depth Repair with stapling. Within 15 days
			4	w = 6.0 - 12.0 mm, usually associated with spalling	Not Applicable, as it may be full depth	
			5	w > 12 mm, usually associated with		Full Depth Repair Dismantle and

Sr. No.	Type of Distress	Measured Parameter	Degree of Severity	Assessment Rating	Repair Action	
					For the case $d < D/2$	For the case $d > D/2$
				spalling, and/or slab rocking under traffic		reconstruct affected portion as per norms And specifications - See Para 5.6.4 Within 15 days
4	Multiple Cracks intersecting with one or more joints	w = width of crack	0	Nil, not discernible	No Action	
			1	$w < 0.2$ mm, hair cracks	Seal, and stitch if $L > 1$ m. Within 15 days	
			2	$w = 0.2 - 0.5$ mm. discernible from slow vehicle		
			3	$w = 0.5 - 3.0$ mm, discernible from fast vehicle	Full depth repair within 15 days	Dismantle, Reinstall subbase, Reconstruct whole slab as per specifications within 30 days
			4	$w = 3.0 - 6.0$ mm panel broken into 2 or 3 pieces		
			5	$w > 6$ mm and/or panel broken into more than 4 pieces		
5	Corner Break	w = width of crack L = length of crack	0	Nil, not discernible	No Action	-
			1	$w < 0.5$ mm; only 1 corner broken	Seal with low viscosity epoxy to secure broken parts Within 7 days	Seal with epoxy seal with epoxy Within 7 days
			2	$w < 1.5$ mm; $L < 0.6$ m, only one corner broken		
			3	$w < 1.5$ mm; $L < 0.6$ m, two corners broken	Partial Depth (Refer Figure 8.3 of IRC: SP: 83-2008) Within 15 days	Full depth repair Reinstall sub-base, and reconstruct the slab as per norms and specifications within 30 days
			4	$w > 1.5$ mm; $L > 0.6$ m or three corners broken		
			5	three or four corners broken		
6	Punch out (Applicable to Continuous Reinforced Concrete Pavement (CRCP) only)	w = width of crack L = length (m/m ²)	0	Nil, not discernible		No Action
			1	$w < 0.5$ mm; $L < 3$ m/m ²	Applicable, as it may be full depth	Seal with low viscosity epoxy to secure broken parts. Within 15 days
			2	either $w > 0.5$ mm or $L < 3$ m/m ²		
			3	$w > 1.5$ mm and $L < 3$ m/m ²		Full depth repair - Cut out and replace damaged area taking care not to damage reinforcement. Within 30 days
			4	$w > 3$ mm, $L < 3$ m/m ² and deformation		
			5	$w > 3$ mm, $L > 3$ m/m ² and deformation		
7	Ravelling or Honeycomb type surface	a = area damaged surface/total surface of	0	Nil, not discernible	Short Term	Long Term
					No action.	Not Applicable

Sr. No.	Type of Distress	Measured Parameter	Degree of Severity	Assessment Rating	Repair Action	
					For the case $d < D/2$	For the case $d > D/2$
		slab (%) h = maximum depth of damage	1	$r < 2 \%$	Local repair of areas damaged and liable to be damaged. Within 15 days Bonded Inlay, 2 or 3 slabs if affecting. Within 30 days Reconstruct slabs, 4 or more slabs if affecting. Within 30 days	
			2	$r = 2 - 10 \%$		
			3	$r = 10-25\%$		
			4	$r = 25 - 50 \%$		
			5	$r > 50\%$ and $h > 25 \text{ mm}$		
8	Scaling	r = damaged surface/total surface of slab (%) h = maximum depth of damage	0	Nil, not discernible	Short Term No action.	Long Term
			1	$r < 2 \%$	Local repair of areas damaged and liable to be damaged. Within 7 days	Not Applicable
			2	$r = 2 - 10 \%$		
			3	$r = 10 - 20\%$	Bonded Inlay within 15 days Reconstruct slab within 30 days	
			4	$r = 20 - 30 \%$		
			5	$r > 30 \%$ and $h > 25 \text{ mm}$		
9	Polished Surface/Glazing	t = texture depth, sand patch test	0		No action.	Not Applicable
			1	$t > 1 \text{ mm}$		
			2	$t = 1 - 0.6 \text{ mm}$	Monitor rate of deterioration	
			3	$t = 0.6 - 0.3 \text{ mm}$		
			4	$t = 0.3 - 0.1 \text{ mm}$		
			5	$t < 0.1 \text{ mm}$	Diamond Grinding if affecting 50% or more slabs in a continuous stretch of minimum 5 km. Within 30 days	
10	Pop out (Small Hole), Pothole Refer Para 8.4	n = number/ m^2 d = diameter h = maximum depth	0	$d < 50 \text{ mm}$; $h < 25 \text{ mm}$; $n < 1 \text{ per } 5 m^2$	No action.	Not Applicable
			1	$d=50-100\text{mm}$; $h<50\text{mm}$; $n<1\text{per } 5 m^2$	Partial depth repair 65 mm deep.	
			2	$d=50-100\text{mm}$; $h>50\text{mm}$; $n<1\text{per } 5 m^2$	Within 15 days	

Sr. No.	Type of Distress	Measured Parameter	Degree of Severity	Assessment Rating	Repair Action	
					For the case $d < D/2$	For the case $d > D/2$
				m^2		
			3	$d = 100 - 300 \text{ mm}; h < 100 \text{ mm}$ n < 1 per $5m^2$		
			4	$d = 100 - 300 \text{ mm}; h > 100 \text{ mm};$ n < 1 per $5m^2$		
			5	$d > 300 \text{ mm}; h > 100 \text{ mm};$ n > 1 per $5 m^2$		
Joint Defects						
11	Joint Seal Defects	loss or damage L = Length as % total jointlength	0	Difficult to discern.	Short Term No action.	Long Term Not Applicable
			1	Discernible, $L < 25\%$ but of little immediate consequence with regard to ingress of water or trapping incompressible material.	Clean joint, inspect later.	
			3	Notable. $L > 25\%$ insufficient protection against ingress of water and trapping in compressible material.	Clean and reapply sealant in selected locations. Within 7 days	
			5	Severe; $w > 3 \text{ mm}$ negligible protection against ingress of water and trapping incompressible material.	Clean, widen and reseal the joint. Within 7 days	
12	Spalling of Joints	$w =$ width on either side of the joint L = length of spalled portion (as % joint length)	0	Nil, not discernible	No action.	Not Applicable
			1	$w < 10 \text{ mm}$	Apply low viscosity epoxy resin/ mortar in cracked portion. Within 7 days	
			2	$w = 10 - 20 \text{ mm}, L < 25\%$	Partial Depth Repair. Within 15 days	
			3	$w = 20 - 40 \text{ mm}, L > 25\%$	30 - 50 mm deep, $h = w + 20\%$ of w, within 30 days	
			4	$w = 40 - 80 \text{ mm}, L > 25\%$	50 - 100 mm deep repair. $H = w + 20\%$ of w. Within 30 days	
			5	$w > 80 \text{ mm},$ and $L > 25\%$		

Sr. No.	Type of Distress	Measured Parameter	Degree of Severity	Assessment Rating	Repair Action	
					For the case $d < D/2$	For the case $d > D/2$
13	Faulting (or Stepping) in Cracks or Joints	f = difference of level	0	not discernible, < 1 mm	No action.	No action.
			1	$f < 3$ mm		
			2	$f = 3 - 6$ mm	Determine cause and observe, take action for diamond grinding	Replace the slab as appropriate.
			3	$f = 6 - 12$ mm	Diamond Grinding	Within 30 days
			4	$f = 12 - 18$ mm	Raise sunken slab.	Replace the slab as appropriate.
			5	$f > 18$ mm	Strengthen subgrade and sub-base by grouting and raising sunken slab	
14	Blow-up or Buckling	H = vertical displacement from normal profile	0	Nil, not discernible	Short Term	Long Term
			1	$h < 6$ mm	No Action	
			2	$h = 6 - 12$ mm	Install Signs to Warn Traffic	
			3	$h = 12 - 25$ mm	within 7 days	
			4	$h > 25$ mm	Full Depth Repair. Within 30 days	
			5	shattered slabs, i.e. 4 or more pieces	Replace broken slabs. Within 30 days	
15	Depression	H = negative vertical displacement from normal profile L = length	0	Not discernible, $h < 5$ mm	No action.	Not Applicable
			1	$h = 5 - 15$ mm		
			2	$h = 15 - 30$ mm, Nos $< 20\%$ joints	Install Signs to Warn Traffic within 7 days	
			3	$h = 30 - 50$ mm		
			4	$h > 50$ mm or $> 20\%$ joints	Strengthen subgrade. Reinstate pavement at normal level	
			5	$h > 100$ mm	If $L < 20$ m. Within 30 days	
16	Heave	h = positive vertical displacement from normal profile. L = length	0	Not discernible. $h < 5$ mm	Short Term	Long Term
			1	$h = 5 - 15$ mm	No action.	
			2	$h = 15 - 30$ mm, Nos $< 20\%$ joints	Follow up.	
			3	$h = 30 - 50$ mm	Install Signs to Warn Traffic within 7 days	

Sr. No.	Type of Distress	Measured Parameter	Degree of Severity	Assessment Rating	Repair Action	
					For the case $d < D/2$	For the case $d > D/2$
			4	$h > 50$ mm or $> 20\%$ joints	Stabilise subgrade. Reinstatement of pavement at normal level if length < 20 m. Within 30 days	scrabble
			5	$h > 100$ mm		
17	Bump	H =vertical displacement from normal profile	0	$h < 4$ mm	No action	
			1	$h = 4 - 7$ mm	Grind, in case of new construction within 7 days	Construction Limit for New Construction.
			3	$h = 7 - 15$ mm	Grind, in case of ongoing Maintenance within 15 days	Replace in case of new construction. Within 30days
			5	$h > 15$ mm	Full Depth Repair. Within 30 days	Full Depth Repair. Within 30days
18	Lane to Shoulder Drop-off	f = difference of level	0	Nil, not discernible < 3 mm	Short Term No action.	Long Term
			1	$f = 3 - 10$ mm	Spot repair of shoulder within 7 days	
			2	$f = 10 - 25$ mm		
			3	$f = 25 - 50$ mm	Fill up shoulder within 7 days	For any 100 m stretch Reconstruct shoulder, if affecting 25% or more of stretch. Within 30days
			4	$f = 50 - 75$ mm		
			5	$f > 75$ mm		
Drainage						
19	Pumping	quantity of fines and water expelled through open joints and cracks Nos/100 m stretch	0	not discernible	No Action	
			1 to 2	slight/ occasional Nos $< 10\%$	Repair cracks and joints Without delay.	Inspect and repair sub-drainage at distressed sections and upstream.
			3 to 4	appreciable/ Frequent 10 -25%	Lift or jack slab within 30 days.	
			5	abundant,crack development $> 25\%$	Repair distressed pavement sections. Strengthen subgrade and subbase. Replace slab. Within 30 days	
20	Ponding	Ponding on slabs due to blockage of drains	0-2	No discernibleproblem	No action.	
			3 to 4	Blockages observed in drains, but water flowing	Clean drains etc. within 7 days, Follow up	Action required to stop water damaging foundation within 30 days.
			5	Ponding, accumulation of water	do-	

Sr. No.	Type of Distress	Measured Parameter	Degree of Severity	Assessment Rating	Repair Action	
					For the case d < D/2	For the case d > D/2
				observed		

Table -3: Maintenance Criteria for Safety Related Items and Other Furniture Items:

Asset Type	Performance Parameter	Level of Service (LOS)			Frequency of Measurement	Testing Method	Recommended Remedial measures	Time limit for Rectification	Specification and Standards
Highway	Availability of Safe Sight Distance	As per IRC SP: 84-2019, a minimum of safe stopping sight distance shall be available throughout.			Monthly	Manual Measurements with odometer along with video/image backup	Removal of obstruction within 24 hours, in case of sight line affected by temporary objects such as trees, temporary encroachments. In case of permanent structure or design deficiency: Removal of obstruction/improvement of deficiency at the earliest Speed Restriction boards and suitable traffic calming measures such as transverse bar marking, blinkers, etc. shall be applied during the period of rectification.		IRC: SP 84-2019
		Design Speed, kmph	Desirable Minimum Sight Distance (m)	Safe Stopping Sight Distance (m)					
		100	360	180					
		80	260	130					
Pavement Marking	Wear	<70% of marking remaining			Bi- Annually	Visual Assessment as per Annexure-F of IRC:35-2015	Re - painting	Cat-1 Defect – within 24 hours Cat-2 Defect within 2 months-	IRC:35-2015
	Day time Visibility	During expected life Service Time Cement Road - 130mcd/m ² /lux Bituminous Road- 100mcd/m ² /lux			Monthly	As per Annexure-D of IRC:35-2015	Re - painting	Cat-1 Defect – within 24 hours Cat-2 Defect – within 2 months	IRC:35- 2015
	Night Time Visibility	<u>Initial and Minimum Performance for Dry Retro reflectivity during night-time:</u>			Bi-Annually	As per Annexure-E of IRC:35-2015	Re - painting	Cat-1 Defect – within 24 hours Cat-2 Defect – within 2 months	IRC:35-2015
		Design (RL) Retro							

Asset Type	Performance Parameter	Level of Service (LOS)		Frequency of Measurement	Testing Method	Recommended Remedial measures	Time limit for Rectification	Specification and Standards
		Initial Speed	Reflectivity (mcd/m ² /lux)					
			Minimum Threshold level (TL) & warranty period required up to 2 years					
		Up to 65	200					
		65 - 100	250					
		Above 100	350					
		Initial and Minimum Performance for Night Visibility under wet condition(Retro reflectivity):						
		Initial 7 days Retro reflectivity:	100 mcd/m ² /lux					
		Minimum Threshold Level:	50 mcd/m ² /lux					
	Skid Resistance	Initial and Minimum performance for Skid Resistance: Initial (7days): 55BPN Min. Threshold: 44BPN *Note: shall be considered		Bi-Annually	As per Annexure-G of IRC:35-2015		Within 24 hours	IRC:35-2015

Asset Type	Performance Parameter	Level of Service (LOS)	Frequency of Measurement	Testing Method	Recommended Remedial measures	Time limit for Rectification	Specification and Standards
		under urban/city traffic condition encompassing the locations like pedestrian crossings, bus bay, bus stop, cycle track intersection delineation, transverse bar markings etc.					
Road Signs	Shape Position and	Shape and Position as per IRC: 67- 2012. Signboard should be clearly visible for the design speed of the section.	Daily	Visual with video/image backup	Improvement of shape, in case if shape is Damaged. Relocation as per requirement change of signboard	48 hours in case of Mandatory Signs, Cautionary and Informatory Signs (Single and Dual post signs) 15 Days in case of Gantry/Cantilever Sign boards 48 hours in case of Mandatory Signs, Cautionary and Informatory Signs (Single and Dual post signs)	IRC:67-2012
	Retro reflectivity	As per specifications in IRC:67-2012	Bi-Annually	Testing of each Signboard using Retro Reflectivity Measuring Device. In accordance with ASTM D 4956-09.		1 Month in case of Gantry/Cantilever	IRC:67-2012

Asset Type	Performance Parameter	Level of Service (LOS)	Frequency of Measurement	Testing Method	Recommended Remedial measures	Time limit for Rectification	Specification and Standards
						Sign boards	
Kerb	Kerb Height	As per IRC 86:2018 depending upon type of Kerb	Bi-Annually	Use of distance measuring tape	Raising Kerb Height	Within 1 Month	IRC 86:2018
	Kerb Painting	<u>Functionality:</u> Functioning of Kerb painting as intended	Daily	Visual with video/image backup	Kerb Repainting	Within 7-days	IRC 35:2015
Other Road Furniture	Reflective Pavement Markers (Road Studs)	Numbers and Functionality as per specifications in IRC:SP:84-2019 and IRC: 35-2015, unless specified in Schedule-B.	Daily	Counting	New Installation	Within 2 months	IRC:SP:84-2019,IRC:35-2015
	Pedestrian Guardrail	<u>Functionality:</u> Functioning of guardrail as intended	Daily	Visual with video/image backup	Rectification	Within 15 days	IRC:SP:84-2019
	Traffic Safety Barriers	<u>Functionality:</u> Functioning of Safety Barriers as intended	Daily	Visual with video/image backup	Rectification	Within 7 days	IRC:SP:84-2014, IRC:119-2015
	End Treatment of	<u>Functionality:</u> Functioning of End Treatment as intended	Daily	Visual with video/image backup	Rectification	Within 7 days	IRC:SP:84-2019,
	Traffic Safety Barriers			backup			IRC:119-2015
	Attenuators	<u>Functionality:</u> Functioning of Attenuators as intended	Daily	Visual with video/image backup	Rectification	Within 7 days	IRC:SP-2014, IRC:119-2015
	Guard Posts and Delineators	<u>Functionality:</u> Functioning of Guard Posts and Delineators as intended	Daily	Visual with video/image backup	Rectification	Within 15 days	IRC:79-2019
	Overhead	Overhead sign structure	Daily	Visual with video/image backup		Within 15 days	IRC:67-2012

Asset Type	Performance Parameter	Level of Service (LOS)	Frequency of Measurement	Testing Method	Recommended Remedial measures	Time limit for Rectification	Specification and Standards
	Sign Structure	shall be structurally adequate		backup	Rectification		
	Traffic Blinkers	Functionality: Functioning of Traffic Blinkers as intended	Daily	Visual with video/image backup	Rectification	Within 7 days	IRC:SP:84-2019
Highway Lighting System	Highway Lights	Illumination: Minimum 40 Lux illumination on the road surface	Daily	The illumination level shall be measured with luxmeter	Improvement in Lighting System	24 hours	IRC:SP:84-2019
		No major failure in the lighting system	Daily	-	Rectification of failure	24 hours	IRC:SP:84-2019
		No minor failure in the lighting system	Monthly	-	Rectification of failure	8 hours	IRC:SP:84-2019
	Toll Plaza Canopy Lights	Minimum 40 Lux illumination on the road surface	Daily	The illumination level shall be measured with luxmeter	Improvement in Lighting System	24 hours	IRC:SP:84-2019
		No major/minor failure in the lighting system	Daily	-	Rectification of failure	8 hours	IRC:SP:84-2019
Trees and Plantation including median plantation	Obstruction in a minimum head-room of 5.5 m above carriageway or obstruction in visibility of road signs	No obstruction due to trees	Monthly	Visual with video/image backup	Removal of trees	Immediate	IRC:SP:84-2019
	Deterioration in health of trees and bushes	Health of plantation shall be as per requirement of specifications & instructions issued by Authority from time to time	Daily	Visual with video/image backup	Timely watering and treatment. Or Replacement of Trees and Bushes.	Within 90 days	IRC:SP:84-2019
	Vegetation			Visual with video/image backup	Removal of Trees	Immediate	IRC:SP:84-

Asset Type	Performance Parameter	Level of Service (LOS)	Frequency of Measurement	Testing Method	Recommended Remedial measures	Time limit for Rectification	Specification and Standards
	affecting sight line and road structures	Sight line shall be free from obstruction by vegetation	Daily	backup			2019
Rest Areas	Cleaning of toilets	-	Daily	-	-	Every 4 hours	
	Defects in electrical, water and sanitary installations	-	Daily	-	Rectification	24 hours	
Other Project Facilities and Approach roads	Damage or deterioration in Approach Roads, pedestrian facilities, truck lay-bys, bus-bays, bus-shelters, cattle crossings, Traffic Aid Posts, Medical Aid Posts and other works		Daily	-	Rectification	15 days	IRC:SP:84-2019
	Free waterway/unobstructed flowsection	85% of culvert normal flow area to available.	2 times in a year (before and after rainy season)	Inspection by Bridge Engineer as per IRC SP: 35-1990 and recording of depth of silting and area of vegetation.	Cleaning silt up soils and debris in culvert barrel after rainy season, removal of bushes and vegetation, U/s of barrel, under barrel and D/s of barrel before rainy season.	15 days before onset of monsoon and within 30 days after end of rainy season.	IRC:5-2015, IRC:SP:40-2019 and IRC:SP:13-2004
	Leak-proof expansion joints if any	No leakage through expansion joints	Bi-Annually	Physical inspection of expansion joints as per IRC SP: 35- 1990 if any, for leakage strains on walls at joints.	Fixing with sealant suitably	30 days or before onset of rains whichever comes earlier	IRC:SP:40-2019 and IRC SP:69-2011
	Structurally	Spalling of	Bi-Annually	Detailed inspection of all	Repairs to spalling, cracking,	15 days	IRC:SP:40-

Asset Type	Performance Parameter	Level of Service (LOS)	Frequency of Measurement	Testing Method	Recommended Remedial measures	Time limit for Rectification	Specification and Standards
Pipe/box/slab culverts	sound	concrete not more than 0.25 sqm		components of culvert as per IRC SP:35-1990 and recording the defects	delamination, rusting shall be followed as per IRC:SP:40-2019.		2019 and MORTH Specifications clause 2800
		Delamination of concrete not more than 0.25 sq.m.					
		Cracks wider than 0.3 mm not more than 1m aggregate length					
	Protection works in good condition	Damaged of rough stone apron or bank revetment not more than 3 sqm, damage to solid apron (concrete apron) not more than 1 sqm	2 times in a year (before and after rainy season)	Condition survey as per IRC SP:35-1990	Repairs to damaged aprons and pitching	30 days after defect observation or 2 weeks before onset of rainy season whichever is earlier.	IRC: SP 40-2019 and IRC:SP:13-2004.
Bridges including ROB's Flyover etc. as applicable	Riding quality or user comfort	No pothole in wearing coat on bridge deck	Daily	Visual inspection as per IRC SP:35-1990	Repairs to BC or wearing coat	15 days	MORTH Specification 2811
Bridge Super Structure	Bumps	No bump at expansion joint	Daily	Visual inspection as per IRC SP:35-1990	Repairs to BC on either side of expansion joints, profile correction course on approach slab in case of settlement to approach embankment	15 days	MORTH Specification 3004 & 2811.
	User safety (condition of crash barrier and guardrail)	No damaged or missing stretch of crash barrier or pedestrian hand railing	Daily	Visual inspection and detailed condition survey as per IRC SP: 35-1990.	Repairs and replacement of safety barriers as the case may be	3 days	IRC: 5-2015, IRC SP: 84-2019 and IRC SP: 40-2019.
	Rusted reinforcement	Not more than 0.25 sq.m		Detailed condition survey as per IRC SP: 35-1990 using	All the corroded reinforcement shall need to be		

Asset Type	Performance Parameter	Level of Service (LOS)	Frequency of Measurement	Testing Method	Recommended Remedial measures	Time limit for Rectification	Specification and Standards
	Spalling of concrete Delamination	Not more than 0.50 sq.m Not more than 0.50 sq.m	Bi- Annually	Mobile Bridge Inspection Unit	thoroughly cleaned from rusting and applied with anti-corrosive coating before carrying out the repairs to affected concrete portion with epoxy mortar / concrete.	15 days	IRC SP: 40-2019 and MORTH Specification 1600.
	Cracks wider than 0.30 mm	Not more than 1m total length	Bi-Annually	Detailed condition survey as per IRC SP: 35-1990 using Mobile Bridge Inspection Unit	Grouting with epoxy mortar, investigating causes for cracks development and carry out necessary rehabilitation.	48 Hours	IRC SP: 40-2019 and MORTH Specification 2800.
	Rainwater seepage through deck slab	Leakage - nil	Quarterly	Detailed condition survey as per IRC SP: 35-1990 using Mobile Bridge Inspection Unit	Grouting of deck slab at leakage areas, waterproofing, repairs to drainage spouts	1 months	MoRTH specifications 2600 & 2700.
	Deflection due to permanent loads and live loads	Within design limits.	Once in Every 10 Years for spans more than 40 m	Load test method	Carry out major rehabilitation works on bridge to retain original design load capacity	6 months	IRC SP: 51-2015.
	Vibrations in bridge deck due to moving trucks	Frequency of vibrations shall not be more than 5 Hz	Once in every 5 years for spans more than 30m and Every 10 Years for spans between 15 to 30 m	Laser displacement sensors or laser vibro-meters	Strengthening structure of super	4 months	AASHTO LRFD specifications

Asset Type	Performance Parameter	Level of Service (LOS)	Frequency of Measurement	Testing Method	Recommended Remedial measures	Time limit for Rectification	Specification and Standards
	Leakage in Expansion joints	No damage to elastomeric sealant compound in strip seal expansion joint, no leakage of rain water through expansion joint in case of buried and asphalt plug and copper strip joint.	Bi-Annually	Detailed condition survey as per IRC SP:35-1990 using Mobile Bridge Inspection Unit	Replace of expansion joint seal in	15 days	MORTH specifications 2600 and IRC SP: 40-2019.
	Debris and dust in strip seal expansion joint	No dust debris expansion or in joint gap.	Monthly	Detailed condition survey as per IRC SP:35-1990 using Mobile Bridge Inspection Unit	Cleaning of expansion joint gaps thoroughly	3 days	MORTH specifications 2600 and IRC SP: 40-2019.
	Drainage spouts	No down take pipe missing/broken below soffit of the deck slab. No silt, debris, clogging of drainage spout collection chamber.	Monthly	Detailed condition survey as per IRC SP: 35-1990 using Mobile Bridge Inspection Unit	Cleaning of drainage spouts thoroughly. Replacement of missing/broken down take pipes with a minimum pipe extension of 500mm below soffit of slab. Providing sealant around the drainage spout if any leakages observed.	3 days	MORTH specification 2700.
Bridge-substructure	Cracks/spalling of concrete/rusted steel	No cracks, spalling of concrete and rusted steel	Bi-Annually	Detailed condition survey as per IRC SP: 35-1990 using Mobile Bridge Inspection Unit	All the corroded reinforcement shall need to be thoroughly cleaned from rusting and applied with anti-corrosive coating before carrying out repairs to substructure by grouting/guniting and micro concreting expending on type of	30 days	IRC SP: 40-2019 and MORTH specification 2800.

Asset Type	Performance Parameter	Level of Service (LOS)	Frequency of Measurement	Testing Method	Recommended Remedial measures	Time limit for Rectification	Specification and Standards
					defect noticed		
	Bearings	Delamination of bearing reinforcement not more than 5%, cracking or tearing of rubber not more than 2 locations per side, no rupture of reinforcement or rubber	Bi-Annually	Detailed condition survey as per IRC SP: 35-1990 using Mobile Bridge Inspection Unit	In case of failure of even one bearing on any pier/abutment, all the bearings on that pier/abutment shall be replaced, in order to get uniform load transfer on to bearings.	3 months	MORTH specification 2810 and IRC SP: 40-2019.
Bridge Foundations	Scouring around foundations	Scouring shall not be lower than maximum scour level for the bridge	Bi-Annually	Condition survey and visual inspection as per IRC SP:35-1990 Using Mobile Bridge Inspection Unit. In case of doubt, use Underwater camera for inspection of deep wells in major Rivers.	Suitable protection works around pier/abutment	1 month	IRC SP: 40-2019, IRC 83-2014, MORTH specification 2500
	Protection works in good condition	Damaged of rough stone apron or bank revetment not more than 3	2 times in a year (before and after rainy season)	Condition survey as per IRC SP:35- 1990	Repairs to damaged aprons and pitching.	30 days after defect observation or 2	IRC: SP 40-2019 and IRC: SP: 13-2004.
		sq.m, damage to solid apron (concrete apron) not more than 1 sq.m				weeks before onset of rainy season whichever is earlier.	

Note: Any Structure during the entire contract period which is found that does not complies with all requirements of this Table will be prepared, rehabilitated or even reconstructed under the scope of the contractor.

Table 4: Maintenance Criteria for Hill Roads

In addition to above, for hill roads the following provisions for maintenance is also to be done.

Hill Roads		
(i)	Damage to Retaining wall/ Breast wall	7 (Seven) days
(ii)	Landslides requiring clearance	12 (Twelve) hours
(iii)	Snow requiring clearance	24 (Twenty-Four) hours

Note: For all tables 1 to 5 above, latest BIS & IRC standards (even those not indicated herewith) along with MoRT&H specifications shall be binding for all maintenance activities.

A. Flexible Pavement

Nature of Defect or deficiency		Time limit for repair/ rectification
(b) Granular earth shoulders, side slopes, drains and culverts		
(i)	Variation by more than 1 % in the prescribed slope of camber/cross fall (shall not be less than the camber on the main carriageway)	7 (seven) days
(ii)	Edge drop at shoulders exceeding 40 mm	7 (seven) days
(iii)	Variation by more than 15% in the prescribed side (embankment) slopes	30 (thirty) days
(iv)	Rain cuts/gullies in slope	7 (seven) days
(v)	Damage to or silting of culverts and side drains	7 (seven) days
(vi)	Desilting of drains in urban/semi- urban areas	24 (twenty-four) hours
(vii)	Railing, parapets, crash barriers	7 (seven) days (Restore immediately if causing safety hazard)
(c) Roadside furniture including road sign and pavement marking		
(i)	Damage to shape or position, poor visibility or loss of retro-reflectivity	48 (forty-eight) hours
(ii)	Painting of km stone, railing, parapets, crash barriers	As and when required/ Once every year
(iii)	Damaged/missing signs road requiring replacement	7 (seven) days
(iv)	Damage to road mark ups	7 (seven) days
(d) Road lighting		
(i)	Any major failure of the system	24 (twenty-four) hours
(ii)	Faults and minor failures	8 (eight) hours
(e) Trees and plantation		
(i)	Obstruction in a minimum head- room of 5 m above carriageway or obstruction in visibility of road signs	24 (twenty-four) hours
(ii)	Removal of fallen trees from carriageway	4 (four) hours
(iii)	Deterioration in health of trees and bushes	Timely watering and treatment
(iv)	Trees and bushes requiring replacement	30 (thirty) days
(v)	Removal of vegetation affecting sight line and road structures	15 (fifteen) days
(f) Rest area		
(i)	Cleaning of toilets	Every 4 (four) hours
(ii)	Defects in electrical, water and sanitary installations	24 (twenty-four) hours
(g) [Toll Plaza]		
(h) Other Project Facilities and Approach roads		
(i)	Damage in approach roads, pedestrian facilities, truck lay- byes, bus-bays, bus-shelters, cattle crossings, [Traffic Aid Posts, Medical Aid Posts] and service roads	15 (fifteen) days
(ii)	Damaged vehicles or debris on the road	4 (four) hours

(iii)	Malfunctioning of the mobile crane	4 (four) hours
Bridges		
(a) Superstructure		
(i)	Any damage, cracks, spalling/ scaling Temporary measures Permanent measures	within 48 (forty-eight) hours within 15 (fifteen) days or as specified by the Authority's Engineer
(b) Foundations		
(i)	Scouring and/or cavitation	15 (fifteen) days
(c) Piers, abutments, return walls and wingwalls		
(i)	Cracks and damages including settlement and tilting, spalling, scaling	30 (thirty) days
(d) Bearings (metallic) of bridges		
(i)	Deformation, damages, tilting or shifting of bearings	15 (fifteen) days Greasing of metallic bearings once in a year
(e) Joints		
(i)	Malfunctioning of joints	15 (fifteen) days
(f) Other items		
(i)	Deforming of pads in elastomeric bearings	7 (seven) days
(ii)	Gathering of dirt in bearings and joints; or clogging of spouts, weep holes and vent-holes	3 (three) days
(iii)	Damage or deterioration in kerbs, parapets, handrails and crash barriers	3 (three) days (immediately within 24 hours if posing danger to safety)
(iv)	Rain-cuts or erosion of banks of the side slopes of approaches	7 (seven) days
(v)	Damage to wearing coat	15 (fifteen) days
(vi)	Damage or deterioration in approach slabs, pitching, apron, toes, floor or guide bunds	30 (thirty) days
(vii)	Growth of vegetation affecting the structure or obstructing the waterway	15 (fifteen) days
(g) Hill Roads		
(i)	Damage to retaining wall/breast wall	7 (seven) days
(ii)	Landslides requiring clearance	12 (twelve) hours
(iii)	Snow requiring clearance	24 (twenty-four) hours

[Note: Where necessary, the Authority may modify the time limit for repair/rectification, or add to the nature of Defect or deficiency before issuing the bidding document, with the approval of the competent authority.]

Schedule - F

(See Clause 4.1 (vii) (a))

Applicable Permits

1. Applicable Permits

- (i) The Contractor shall obtain, as required under the Applicable Laws, the following Applicable Permits:
 - (a) Permission of the State Government for extraction of boulders from quarry;
 - (b) Permission of Village Panchayats and Pollution Control Board for installation of crushers;
 - (c) Licence for use of explosives;
 - (d) Permission of the State Government for drawing water from river/reservoir;
 - (e) Licence from inspector of factories or other competent Authority for setting up batching plant;
 - (f) Clearance of Pollution Control Board for setting up batching plant;
 - (g) Clearance of Village Panchayats and Pollution Control Board for setting up asphalt plant;
 - (h) Permission of Village Panchayats and State Government for borrow earth; and
 - (i) Any other permits or clearances required under Applicable Laws.
- (ii) Applicable Permits, as required, relating to environmental protection and conservation shall have been procured by the Authority in accordance with the provisions of this Agreement.

Schedule – G

(See Clauses 7.1 and 19.2)

Annex-I

(See Clause 7.1)

Form of Bank Guarantee

[Performance Security/Additional Performance Security]

[MD, National Highways & Infrastructure Development Corporation Limited, New Delhi] WHEREAS:

- (A) ____ [name and address of contractor] (Hereinafter called the “**Contractor**”) and [name and address of the authority], (hereinafter called the “**Authority**”) have entered into an agreement (hereinafter called the “**Agreement**”) for the Construction of Uni-directional Singhpora - Vailoo Tunnel (Under Sinthan pass) of length 10.331km/10.363km (Tube-1/Tube-2) and its approach road from Km 111+067 (at Chhatroo km 140.870 on NH-244) to 149+678 (at vailoo Junction with NH -244 i.e., existing km 235.07) of total length 38.611 km in Union Territory of Jammu & Kashmir on Engineering, Procurement and Construction (the “**EPC**”) basis, subject to and in accordance with the provisions of the Agreement
- (B) The Agreement requires the Contractor to furnish a Performance Security for due and faithful performance of its obligations, under and in accordance with the Agreement, during the {Construction Period/ Defects Liability Period and Maintenance Period}(as defined in the Agreement)in a sum of Rs.....cr.(Rupees..... crore) (the “**Guarantee Amount**”).
- (C) We, through our branch at ____ (the “**Bank**”) have agreed to furnish this bank guarantee (hereinafter called the “**Guarantee**”) by way of Performance Security.

NOW, THEREFORE, the Bank hereby, unconditionally and irrevocably, guarantees and affirms as follows:

1. The Bank hereby unconditionally and irrevocably guarantees the due and faithful performance of the Contractor’s obligations during the {Construction Period/ Defects Liability Period and Maintenance Period} under and in accordance with the Agreement, and agrees and undertakes to pay to the Authority, upon its mere first written demand, and without any demur, reservation, recourse, contest or protest, and without any reference to the Contractor, such sum or sums up to an aggregate sum of the Guarantee Amount as the Authority shall claim, without the Authority being required to prove or to show grounds or reasons for its demand and/or for the sum specified therein.
2. A letter from the Authority, under the hand of an officer not below the rank of [General Manager in the National Highways Authority of India], that the Contractor has committed default in the due and faithful performance of all or any of its obligations under and in accordance with the Agreement shall be conclusive, final and binding on the Bank. The Bank further agrees that the Authority shall be the sole judge as to whether the Contractor is in default in due and faithful performance of its obligations during and under the Agreement and its decision that the Contractor is in default shall be final and binding on the Bank, notwithstanding any differences between the Authority and the Contractor, or any dispute between them pending before any court, tribunal, arbitrators or any other authority or body, or by the discharge of the Contractor for any reason whatsoever.
3. In order to give effect to this Guarantee, the Authority shall be entitled to act as if the Bank were the principal debtor and any change in the constitution of the Contractor and/or the Bank, whether by their absorption with any other body or corporation or otherwise, shall not in any way or manner affect the liability or obligation of the Bank under this Guarantee.
4. It shall not be necessary, and the Bank hereby waives any necessity, for the Authority to proceed against the Contractor before presenting to the Bank its demand under this Guarantee.
5. The Authority shall have the liberty, without affecting in any manner the liability of the Bank under this Guarantee, to vary at any time, the terms and conditions of the Agreement or to extend the time or period for the compliance with, fulfilment and/ or performance of all or any of the obligations of the Contractor contained in the Agreement or to postpone for any time, and from time to time, any of the rights and powers exercisable by the Authority against the Contractor, and either to enforce or forbear from enforcing any of the terms and conditions contained in the Agreement and/or the securities available to the Authority, and the Bank shall not be released from its liability and obligation under these

presents by any exercise by the Authority of the liberty with reference to the matters aforesaid or by reason of time being given to the Contractor or any other forbearance, indulgence, act or omission on the part of the Authority or of any other matter or thing whatsoever which under any law relating to sureties and guarantors would but for this provision have the effect of releasing the Bank from its liability and obligation under this Guarantee and the Bank hereby waives all of its rights under any such law.

6. This Guarantee is in addition to and not in substitution of any other guarantee or security now or which may hereafter be held by the Authority in respect of or relating to the Agreement or for the fulfilment, compliance and/or performance of all or any of the obligations of the Contractor under the Agreement.
7. Notwithstanding anything contained hereinbefore, the liability of the Bank under this Guarantee is restricted to the Guarantee Amount and this Guarantee will remain in force for the period specified in paragraph 8 below and unless a demand or claim in writing is made by the Authority on the Bank under this Guarantee all rights of the Authority under this Guarantee shall be forfeited and the Bank shall be relieved from its liabilities hereunder.
8. The Guarantee shall cease to be in force and effect on ****\$. Unless a demand or claim under this Guarantee is made in writing before expiry of the Guarantee, the Bank shall be discharged from its liabilities hereunder.
9. The Bank undertakes not to revoke this Guarantee during its currency, except with the previous express consent of the Authority in writing and declares and warrants that it has the power to issue this Guarantee and the undersigned has full powers to do so on behalf of the Bank.
10. Any notice by way of request, demand or otherwise hereunder may be sent by post addressed to the Bank at its above referred branch, which shall be deemed to have been duly authorised to receive such notice and to effect payment thereof forthwith, and if sent by post it shall be deemed to have been given at the time when it ought to have been delivered in due course of post and in proving such notice, when given by post, it shall be sufficient to prove that the envelope containing the notice was posted and a certificate signed by an officer of the Authority that the envelope was so posted shall be conclusive.
11. This Guarantee shall come into force with immediate effect and shall remain in force and effect for up to the date specified in paragraph 8 above or until it is released earlier by the Authority pursuant to the provisions of the Agreement.

Signed and sealed this day of, 20..... at

SIGNED, SEALED AND DELIVERED

For and on behalf of the Bank by:

(Signature) (Name) (Designation) (Code Number) (Address)

NOTES:

- (i) The bank guarantee should contain the name, designation and code number of the officer(s) signing the guarantee.

The address, telephone number and other details of the head office of the Bank as well as of issuing branch should be mentioned on the covering letter of issuing branch.

Annex – II

(Schedule - G)
(See Clause 19.2)

Form for Guarantee for Advance Payment

[National Highways & Infrastructure Development Corporation Limited, New Delhi] WHEREAS:

- (A) [name and address of contractor] (hereinafter called the “**Contractor**”) has executed an agreement (hereinafter called the “**Agreement**”) with the [name and address of the authority], (hereinafter called the “**Authority**”) for Construction of Uni-directional Singhpora - Vailoo Tunnel (Under Sinthan pass) of length 10.331km/10.363km (Tube-1/Tube-2) and its approach road from Km 111+067 (at Chhatroo km 140.870 on NH-244) to 149+678 (at vailoo Junction with NH -244 i.e., existing km 235.07) of total length 38.611 km in Union Territory of Jammu & Kashmiron Engineering, Procurement and Construction (the “**EPC**”) basis, subject to and in accordance with the provisions of the Agreement
- (B) In accordance with Clause 19.2 of the Agreement, the Authority shall make to the Contractor an interest bearing @Bank Rate + 3% advance payment (herein after called “**AdvancePayment**”) equal to 10% (ten percent) of the Contract Price; and that the Advance Payment shall be made in two instalments subject to the Contractor furnishing an irrevocable and unconditional guarantee by a scheduled bank for an amount equivalent to 110% (one hundred and ten percent) of such instalment to remain effective till the complete and full repayment of the instalment of the Advance Payment as security for compliance with its obligations in accordance with the Agreement. The amount of {first/second} instalment of the Advance Payment is Rs. ----- cr. (Rupees crore) and the amount of this Guarantee is Rs. ----- cr. (Rupees ----- crore) (the “**Guarantee Amount**”) \$.
- (C) We, ... through our branch at (the “**Bank**”) have agreed to furnish this bank guarantee (hereinafter called the “**Guarantee**”) for the Guarantee Amount.

NOW, THEREFORE, the Bank hereby, unconditionally and irrevocably, guarantees and affirms as follows:

The Bank hereby unconditionally and irrevocably guarantees the due and faithful repayment on time of the aforesaid instalment of the Advance Payment under and in accordance with the Agreement, and agrees and undertakes to pay to the Authority, upon its mere first written demand, and without any demur, reservation, recourse, contest or protest, and without any reference to the Contractor, such sum or sums up to an aggregate sum of the Guarantee Amount as the Authority shall claim, without the Authority being required to prove or to show grounds or reasons for its demand and/or for the sum specified therein.

1. A letter from the Authority, under the hand of an officer not below the rank of [General Manager in the National Highways Authority of India], that the Contractor has committed default in the due and faithful performance of all or any of its obligations for the repayment of the instalment of the Advance Payment under and in accordance with the Agreement shall be conclusive, final and binding on the Bank. The Bank further agrees that the Authority shall be the sole judge as to whether the Contractor is in default in due and faithful performance of its obligations during and under the Agreement and its decision that the Contractor is in default shall be final and binding on the Bank, notwithstanding any differences between the Authority and the Contractor, or any dispute between them pending before any court, tribunal, arbitrators or any other authority or body, or by the discharge of the Contractor for any reason what soever.
2. In order to give effect to this Guarantee, the Authority shall be entitled to act as if the Bank were the principal debtor and any change in the constitution of the Contractor and/or the Bank, whether by their absorption with any other body or corporation or otherwise, shall not in any way or manner affect the liability or obligation of the Bank under this Guarantee.
3. It shall not be necessary, and the Bank hereby waives any necessity, for the Authority to proceed against the Contractor before presenting to the Bank its demand under this Guarantee.

\$ The Guarantee Amount should be equivalent to 110% of the value of the applicable instalment.

4. The Authority shall have the liberty, without affecting in any manner the liability of the Bank under this Guarantee, to vary at any time, the terms and conditions of the Advance Payment or to extend the time or period of its repayment or to postpone for any time, and from time to time, any of the rights and powers exercisable by the Authority against the Contractor, and either to enforce or forbear from enforcing any of the terms and conditions contained in the Agreement and/or the securities available to the Authority, and the Bank shall not be released from its liability and obligation under these presents by any exercise by the Authority of the liberty with reference to the matters aforesaid or by reason of time being given to the Contractor or any other forbearance, indulgence, act or omission on the part of the Authority or of any other matter or thing whatsoever which under any law relating to sureties and guarantors would but for this provision have the effect of releasing the Bank from its liability and obligation under this Guarantee and the Bank hereby waives all of its rights under any such law.
5. This Guarantee is in addition to and not in substitution of any other guarantee or security now or which may hereafter be held by the Authority in respect of or relating to the Advance Payment.
6. Notwithstanding anything contained hereinbefore, the liability of the Bank under this Guarantee is restricted to the Guarantee Amount and this Guarantee will remain in force for the period specified in paragraph 8 below and unless a demand or claim in writing is made by the Authority on the Bank under this Guarantee all rights of the Authority under this Guarantee shall be forfeited and the Bank shall be relieved from its liabilities hereunder.
7. The Guarantee shall cease to be in force and effect on ****\$ unless a demand or claim under this Guarantee is made in writing on or before the aforesaid date, the Bank shall be discharged from its liabilities hereunder.
8. The Bank undertakes not to revoke this Guarantee during its currency, except with the previous express consent of the Authority in writing and declares and warrants that it has the power to issue this Guarantee and the undersigned has full powers to do so on behalf of the Bank.
9. Any notice by way of request, demand or otherwise hereunder may be sent by post addressed to the Bank at its above referred branch, which shall be deemed to have been duly authorised to receive such notice and to effect payment thereof forthwith, and if sent by post it shall be deemed to have been given at the time when it ought to have been delivered in due course of post and in proving such notice, when given by post, it shall be sufficient to prove that the envelope containing the notice was posted and a certificate signed by an officer of the Authority that the envelope was so posted shall be conclusive.
10. This Guarantee shall come into force with immediate effect and shall remain in force and effect up to the date specified in paragraph 8 above or until it is released earlier by the Authority pursuant to the provisions of the Agreement.

Signed and sealed this day of, 20..... at

SIGNED, SEALED AND DELIVERED

For and on behalf of the Bank by:

(Signature) (Name) (Designation) (Code Number) (Address)

NOTES:

- (i) The bank guarantee should contain the name, designation and code number of the officer(s) signing the guarantee.

\$ Insert a date being 90 (ninety) days after the end of one year from the date of payment of the Advance payment to the Contractor (in accordance with Clause 19.2 of the Agreement).

- (ii) The address, telephone number and other details of the head office of the Bank as well as of issuing branch should be mentioned on the covering letter of issuing branch.

Annex – III

(Schedule - G)

(See Clause 7.5.v)

Form for Guarantee for Withdrawal of Retention Money

The Managing Director,
National Highways & Infrastructure Development Corporation Limited
New Delhi

WHEREAS:

- (A) [name and address of contractor] (hereinafter called the “**Contractor**”) has executed an agreement (hereinafter called the “**Agreement**”) with the [name and address of the authority], (hereinafter called the “**Authority**”) for the construction of the ***** section of [National Highway No. **] on Engineering, Procurement and Construction (the “**EPC**”) basis, subject to and in accordance with the provisions of the Agreement.
- (B) In accordance with Clause 7.5.3 of the Agreement, the Contractor may withdraw the retention money (hereinafter called the “**Retention Money**”) after furnishing to the Authority a bank guarantee for an amount equal to the proposed withdrawal.
- (C) We, ... through our branch at (the “**Bank**”) have agreed to furnish this bank guarantee (hereinafter called the “**Guarantee**”) for the amount of Rs. ----- cr. (Rs.-----crore) (the “**Guarantee Amount**”).

NOW, THEREFORE, the Bank hereby unconditionally and irrevocably guarantees and affirms as follows:

1. The Bank hereby unconditionally and irrevocably undertakes to pay to the Authority, upon its mere first written demand, and without any demur, reservation, recourse, contest or protest, and without any reference to the Contractor, such sum or sums up to an aggregate sum of the Guarantee Amount as the Authority shall claim, without the Authority being required to prove or to show grounds or reasons for its demand and/or for the sum specified therein.
2. A letter from the Authority, under the hand of an officer not below the rank of General Manager in the National Highways & Infrastructure Development Corporation Limited (NHIDCL) , that the Contractor has committed default in the due and faithful performance of all or any of its obligations for under and in accordance with the Agreement shall be conclusive, final and binding on the Bank. The Bank further agrees that the Authority shall be the sole judge as to whether the Contractor is in default in due and faithful performance of its obligations during and under the Agreement and its decision that the Contractor is in default shall be final, and binding on the Bank, notwithstanding any differences between the Authority and the Contractor, or any dispute between them pending before any court, tribunal, arbitrators or any other authority or body, or by the discharge of the Contractor for any reason whatsoever.
3. In order to give effect to this Guarantee, the Authority shall be entitled to act as if the Bank were the principal debtor and any change in the constitution of the Contractor and/or the Bank, whether by their absorption with any other body or corporation or otherwise, shall not in any way or manner affect the liability or obligation of the Bank under this Guarantee.

4. It shall not be necessary, and the Bank hereby waives any necessity, for the Authority to proceed against the Contractor before presenting to the Bank its demand under this Guarantee.
5. The Authority shall have the liberty, without affecting in any manner the liability of the Bank under this Guarantee, to vary at any time, the terms and conditions of the Retention Money and any of the rights and powers exercisable by the Authority against the Contractor, and either to enforce or forbear from enforcing any of the terms and conditions contained in the Agreement and/or the securities available to the Authority, and the Bank shall not be released from its liability and obligation under these presents by any exercise by the Authority of the liberty with reference to the matters aforesaid or by reason of time being given to the Contractor or any other forbearance, indulgence, act or omission on the part of the Authority or of any other matter or thing whatsoever which under any law relating to sureties and guarantors would but for this provision have the effect of releasing the Bank from its liability and obligation under this Guarantee and the Bank hereby waives all of its rights under any such law.
6. This Guarantee is in addition to and not in substitution of any other guarantee or security now or which may hereafter be held by the Authority in respect of or relating to the Retention Money.
7. Notwithstanding anything contained hereinbefore, the liability of the Bank under this Guarantee is restricted to the Guarantee Amount and this Guarantee will remain in force for the period specified in paragraph 8 below and unless a demand or claim in writing is made by the Authority on the Bank under this Guarantee all rights of the Authority under this Guarantee shall be forfeited and the Bank shall be relieved from its liabilities hereunder.
8. The Guarantee shall cease to be in force and effect 90 (ninety) days after the date of the Completion Certificate specified in Clause 12.4 of the Agreement.
9. The Bank undertakes not to revoke this Guarantee during its currency, except with the previous express consent of the Authority in writing, and declares and warrants that it has the power to issue this Guarantee and the undersigned has full powers to do so on behalf of the Bank.
10. Any notice by way of request, demand or otherwise hereunder may be sent by post addressed to the Bank at its above referred branch, which shall be deemed to have been duly authorized to receive such notice and to effect payment thereof forthwith, and if sent by post it shall be deemed to have been given at the time when it ought to have been delivered in due course of post and in proving such notice, when given by post, it shall be sufficient to prove that the envelope containing the notice was posted and a certificate signed by an officer of the Authority that the envelope was so posted shall be conclusive.
11. This Guarantee shall come into force with immediate effect and shall remain in force and effect up to the date specified in paragraph 8 above or until it is released earlier by the Authority pursuant to the provisions of the Agreement.
12. This guarantee shall also be operatable at our.....Branch at New Delhi, from whom, confirmation regarding the issue of this guarantee or extension / renewal thereof shall be made available on demand. In the contingency of this guarantee being invoked and payment thereunder claimed, the said branch shall accept such invocation letter and make payment of amounts so demanded under the said invocation.
13. The guarantor/bank hereby confirms that it is on the SFMS (Structural Finance Messaging System)

platform & shall invariably send an advice of this Bank Guarantee to the designated bank of NHIDCL, details of which is as under:

S.No	Particulars	Details
1	Name of Beneficiary	National Highways & Infrastructure Development Corporation Limited
2	Beneficiary Bank Account No.	90621010002610
3	Beneficiary Bank Branch	IFSC SYNB0009062
4	Beneficiary Bank Branch Name	Transport Bhawan, New Delhi
5	Beneficiary Bank Address	Canara Bank (erstwhile Syndicate Bank) transport Bhawan, 1st Parliament Street, New Delhi-110001

Signed and sealed this day of, 20..... at

SIGNED, SEALED AND DELIVERED For and on behalf
of the Bank by:

(Signature)

(Name)

(Designation) (Code Number)

(Address) NOTES:

- (i) The bank guarantee should contain the name, designation and code number of the officer(s) signing the guarantee.
- (ii) The address, telephone number and other details of the head office of the Bank as well as of issuing branch should be mentioned on the covering letter of issuing branch.

Schedule - H

See Clauses 10.1 (iv) and 19.3

Contract Price Weightages

The Contract Price for this Agreement is **Rs.***** Crores**

Proportions of the Contract Price for different stages of Construction of the Project Highway shall be as specified below:

Item	Weightage in percentage to the Contract Price	Stage of Payment	Percentage Weightage
1	2	3	4
Road works including culverts, widening and repair of culverts and Site Clearance	4.202%	B.1 - Reconstruction/New 2-lane realignment/bypass (Flexible pavement)	
		1) Earthwork up to top of Sub-grade	38.166%
		2) Sub-Base Course	10.262%
		3) Non-Bituminous Base Course	18.654%
		4) Bituminous Base Course	1.797%
		5) Wearing Coat	13.313%
		D - Re-Construction and New culverts on existing road, realignments, bypasses:	
		(1) Culverts (length < 6m)	17.808%
Minor Bridges/ Under passes/ Overpasses including at Major Jun. location	0.945%	A.2- New Minor bridges	
		1) Foundation +Sub-Structure:	69.997%
		2) Super-structure:	26.371%
		3) Approaches:	1.031%
		4) Guide Bunds and River Training Works:	
		B.2- Underpasses/overpasses	
		1) Foundation +Sub-Structure:	1.580%
		2) Super-structure:	0.832%
Major Bridge (Length > 60m) works and ROB/RUB/Elevated sections /Flyovers including Viaducts if any	10.153%	A.2 – Major Bridge/Viaduct cum Bridge / Viaduct	
		(i) Foundation	21.170%
		(ii) Sub-structure	22.853%
		(iii) Super-structure (including bearings)	53.206%
		(iv) Wearing Coat including expansion joints.	1.415%
		(v) Miscellaneous Items like handrails, crash barriers, road markings etc.	1.211%
		(vi) Wing walls/return walls	0.000%
		(vii) Approaches (including Retaining walls, stone pitching and protection works)	0.145%
Tunnel	59.855%	1. Tunnel	
		A1- Temporary Dewatering Arrangement	0.216%
		A2- Underground Excavation for tunnel in Support Category dominating the Face Area including Drilling and Grouting	
		ESC-1, ESC-10 & ESC 11	30.154%

Item	Weightage in percentage to the Contract Price	Stage of Payment	Percentage Weightage
1	2	3	4
		ESC-2	0.000%
		ESC-3	1.983%
		ESC-4	6.906%
		ESC-5	4.440%
		A3- Permanent Dewatering Arrangement, (PVC pipes, perforated PVC pipes, precast concrete slots channel elements, dimpled sheets between permanent lines of C&C tunnel length and backfill material, water-proofing membrane etc.)	3.786%
		A4- Primary Support Measures	
		1. SFRS/Shotcrete with Wire mesh	
		ESC-1, ESC-10 & ESC 11	4.924%
		ESC-2	0.000%
		ESC-3	0.768%
		ESC-4	3.704%
		ESC-5	2.066%
		2. Rock bolt/Fore poling/Pipe roofing	
		ESC-1, ESC-10 & ESC 11	0.892%
		ESC-2	0.000%
		ESC-3	0.179%
		ESC-4	7.304%
		ESC-5	4.062%
		3. Steel Ribs/Lattice Girder	
		ESC-1, ESC-10 & ESC 11	0.000%
		ESC-2	0.000%
		ESC-3	0.000%
		ESC-4	1.169%
		ESC-5	0.733%
		A5-Concrete Works	22.210%
		A6-Instrumentation and Monitoring	0.393%
		A7-Pavement	4.111%
	2.359%	2. Portals	
		A1- Temporary Dewatering Arrangement	0.977%
		A2- Open Excavation and Earthwork (Loose excavation, rock excavation, rip rap layer on embankment, Gabion etc.)	65.312%
		A3- Primary support measures	
		1. SFRS/Shotcrete with Wire-mesh	13.314%
		2. Rock Bolts/Fore-poling/Pipe-roofing	3.886%
		A4- Permanent Dewatering (PVC pipes, perforated PVC pipes, precast concrete slots channel elements, dimpled sheets between permanent lines of C&C tunnel length and backfill material, water-proofing membrane etc.)	2.865%
		A5-Concrete Works at portal	6.134%
	1.083%	A6- Pavement	1.855%
		A7-Construction of buildings	5.657%
		3. Investigation & Design	100%

Item	Weightage in percentage to the Contract Price	Stage of Payment	Percentage Weightage
1	2	3	4
	12.633%	4. Electro and Mechanical Equipment & Power supply	
		(a) Electro and Mechanical Equipment	94.000%
		(b) Construction of 2 nos. of 1x 10 MVA, 33/11 kv substation, 33 kva line from nearest source i/c pole, gantry, conductor and applicable supervision charges of utility owing department.	6.000%
	0.999%	5. Ventilation System	100%
Other Works	7.108%	(i) Toll plaza	0.000%
		(ii) Roadside drains	5.647%
		(iii) Road signs, markings, km stones, safety device	8.369%
		(iv) Project Facilities	
		a) Bus bays	0.222%
		b) Truck lay-byes	0.000%
		c) Utility Duct& Plantation of trees	3.558%
		d) Junctions	2.198%
		(v)Environment management and Muck disposal Management	
		a. Disposal of muck at suitable locations	9.046%
		b. Construction of engineering structure at disposal locations	9.613%
		(vii) Protection works	
		a) RRM Wall/Retaining wall/Toe wall & Gabion Wall	21.594%
		b) Wire mesh with Bio engineering	0.350%
		c) Breast Wall	38.413%
		d) Rock Bolts, Shotcreting and Drainage Holes	0.495%
		(viii) Safety and traffic management during construction	0.495%
Utility Shifting	0.663%	Electrical 11Kva/33Kva JPDCL	42.069%
		Waterpipe line from Jal shakti	57.931%

1.3 Procedure of estimating the value of work done

1.3.1 Road works

Procedure for estimating the value of road work done shall be as follows:

Table 1.3.1

Stage of Payment	Percentage - Weightage	Payment Procedure
B.1 - Reconstruction/New 2-lane realignment/bypass (Flexible pavement)		Unit of measurement is linear length. Payment of each stage shall be made on pro rata basis on completion of a stage in full length
Site Clearance		

Stage of Payment	Percentage - Weightage	Payment Procedure
(1) Earthwork up to top of the sub-grade	38.166%	or 5 (five) km. length, whichever is less.
(2) Sub-Base Course	10.262%	
(3) Non-Bituminous Course	18.654%	
(4) Bituminous Base Course	1.797%	
(5) Wearing Coat	13.313%	
D - Re-Construction and New culverts on existing road, realignments, bypasses:		
(1) Culverts (length < 6m)	17.808%	Cost of each culvert shall be determined on pro rata basis with respect to the total number of culverts. Payment shall be made on the completion of all or five culverts, whichever is less.

For example, if the total length of bituminous work to be done is 100 km, the cost per km of bituminous work shall be determined as follows:

Cost per km = $P \times \text{weightage for road work} \times \text{weightage for bituminous work} \times (1/L)$

Where P= Contract Price

L = Total length in km

Similarly, the rates per km for other stages shall be worked out accordingly.

Note: The length affected due to law and order problems or litigation during execution due to which the Contractor is unable to execute the work, may be deducted from the total project length for payment purposes. The total length calculated here is only for payment purposes and will not affect and referred in other clauses of the Contract Agreement.

1.3.2 Minor Bridges and Underpasses/Overpasses.

Procedure for estimating the value of Minor bridge and Underpasses/Overpasses shall be as stated in table 1.3.2:

Table 1.3.2

Stage of Payment	Weightage	Payment Procedure
1	2	3
A.1-Widening and repair of minor bridges	0.000%	Cost of each minor bridge shall be determined on pro rata basis with respect to the total linear length of the minor bridges. Payment shall be made on the completion of widening & repair works of a minor bridge.
(length > 6m and < 60m)		
A.2- New minor bridges		
(i) Foundation +Sub- Structure: On completion of the foundation work including foundations for wing and return walls, abutments, piers up to the abutment/pier cap.	69.997%	(i) Foundation +Sub-Structure: Cost of each minor bridge shall be determined on pro rata basis with respect to the total linear length (m) of the minor bridges. Payment against foundation + sub-structure shall be made on pro-rata basis on completion of a stage i.e., not less than 25% of the scope of foundation+ substructure of each bridge subject to completion of at least two foundations along with sub-structure up to abutment/pier cap level of each bridge. In case where load testing is required for foundation, the trigger of first payment shall include load testing also where specified.
(ii) Super-structure: On completion of the superstructure in all respects	26.371%	(ii) Super-structure: Payment shall be made on pro-rata basis on

<u>Stage of Payment</u>	<u>Weightage</u>	<u>Payment Procedure</u>
1	2	3
including wearing coat, bearings, expansion joints, handrails, crash barriers, road signs & markings, tests on completion etc. complete in all respect.		completion of a stage i.e., completion of super-structure of at least one span in all respects as specified in the column of “Stage of Payment” in this sub-clause.
(iii) Approaches: On completion of approaches including Retaining walls, stone pitching, protection works complete in all respect and fit for use.	1.031%	(iii) Approaches: Payment shall be made on pro-rata basis on completion of a stage i.e., completion of approaches in all respect as specified in the column of “Stage of Payment” in this sub-clause.
B.2- New Underpasses/ Overpasses		
(i) Foundation +Sub- Structure: On completion of the foundation work including foundations for wing and return walls, abutments, piers up to the abutment/pier cap.	1.580%	(i) Foundation +Sub- Structure: Cost of each minor bridge shall be determined on pro rata basis with respect to the total linear length (m) of the minor bridges. Payment against foundation + sub-structure shall be made on pro-rata basis on completion of a stage i.e., not less than 25% of the scope of foundation+ substructure of each bridge subject to completion of at least two foundations along with sub-structure up to abutment/pier cap level of each bridge. In case where load testing is required for foundation, the trigger of first payment shall include load testing also where specified.
(ii) Super-structure: On completion of the superstructure in all respects including wearing coat, bearings, expansion joints, handrails, crash barriers, road signs & markings, tests on completion etc. complete in all respect.	0.832%	(ii) Super-structure: Payment shall be made on pro-rata basis on completion of a stage i.e., completion of super-structure of at least one span in all respects as specified in the column of “Stage of Payment” in this sub-clause.
(iii) Approaches: On completion of approaches including Retaining walls, stone pitching, protection works complete in all respect and fit for use.	0.189%	(iii) Approaches: Payment shall be made on pro-rata basis on completion of a stage i.e., completion of approaches in all respect as specified in the column of “Stage of Payment” in this sub-clause.

1.3.3 Major Bridge works, ROB/RUB and Structures.

Procedure for estimating the value of Major Bridge works, ROB/RUB and Structures shall be as stated in table 1.3.3:

Table 1.3.3

Stage of Payment	Weightage	Payment Procedure
1	2	3
A.2- Major Bridge/ Viaduct cum Bridge / Viaduct		
(i) Foundation	21.170%	(i) Foundation: Cost of each Major Bridge shall be determined on pro rata basis with respect to the total linear length (m) of the Major Bridge. Payment against foundation shall be made on prorata basis on completion of a stage i.e., not less than 25% of the scope of foundation of the major Bridge subject to completion of at least two foundations of the major Bridge.
(ii) Sub-structure	22.853%	(ii) Sub-Structure: Payment against Substructure shall be made on pro-rata basis on completion of a stage i.e., not less than 25% of the scope of substructure of the major bridge subject to completion of at least two sub-structures of abutments/piers up to abutment/pier cap level of the major bridge.
(iii) Wing walls/return walls	0.000%	(iii) Wing walls/return walls: Payments shall be made on completion of all wing walls/return walls complete in all respects as specified.
(iv) Super-structure: (including bearings)	53.206%	(iv) Super-structure: Payment shall be made on pro-rata basis on completion of a stage i.e., completion of super-structure including bearings of at least one span in all respects as specified.
(v) Wearing Coat including expansion joints	1.415%	(v) Wearing Coat: Payment shall be made on completion of wearing coat including expansion joints complete in all respects as specified.
(v) Miscellaneous Items like handrails, crash barriers, road markings etc.	1.211%	(vi) Miscellaneous: Payments shall be made on completion of all miscellaneous works like handrails, crash barriers, road markings etc. complete in all respects as specified.
(vi) Guide Bunds, River Training works etc.	0.000%	(vii) Guide Bunds, River Training works: Payments shall be made on completion of all guide bunds/river training works etc. complete in all respects as specified.

<u>Stage of Payment</u>	<u>Weightage</u>	<u>Payment Procedure</u>
1	2	3
(viii) Approaches (including Retaining walls, stone pitching and protection works)	0.145%	(viii) Approaches: Payments shall be made on completion of both approaches including stone pitching, protection works, etc. complete in all respects as specified.

Note:

- (1) In case of innovate Major Bridge projects like cable suspension/cable stayed/ Extra Dozed and exceptionally long span bridges, the schedule may be modified as per site requirements before bidding with due approval of Competent Authority.**
- (2) The Schedule for exclusive tunnel projects may be prepared as per site requirements before bidding with due approval of Competent Authority.**

1.3.4 Tunnel

Proportions of the Contract Price for different stages of Construction of the Project Tunnel shall be as specified below:

Table 1.3.4

Stage of Payment	Percentage - weightage	Payment Procedure
A-Investigation and Design		Unit of measurement in submission of Detailed Design and Investigation report complete payment shall be made on the completion and approval of the same.
A-Investigation & Detail Design	1.083%	
B-Tunnel Portals		Unit of measurement is completion of portal. The payment shall be made on the completion of portals.
A1- Temporary Dewatering Arrangement	0.977%	
A2- Open Excavation and Earthwork (Loose excavation, rock excavation, rip rap layer on embankment, Gabion etc.)	65.312%	
A3- Primary support measures		
1. SFRS/Shotcrete with Wire-mesh	13.314%	
2. Rock Bolts/Fore-poling/Pipe-roofing	3.886%	
A4- Permanent Dewatering (PVC pipes, perforated PVC pipes, precast concrete slots channel elements, dimpled sheets between permanent lines of C&C tunnel length and backfill material, water-proofing membrane etc.)	2.865%	
A5-Concrete Works at portal	6.134%	
A6- Pavement	1.855%	Unit of measurement is linear length-meter. Payment of each stage shall be made on pro rata basis of completion of a stage in a continuous length of 50meter of induvial tube.
A7-Construction of buildings	5.657%	
C- Main Tunnel		
A1- Temporary Dewatering Arrangement	0.216%	
A2- Underground Excavation for tunnel in Support Category dominating the Face Area including Drilling and Grouting		
ESC-1, ESC-10 & ESC 11	30.154%	
ESC-2	0.000%	
ESC-3	1.983%	
ESC-4	6.906%	
ESC-5	4.440%	

Stage of Payment	Percentage - weightage	Payment Procedure
A3- Permanent Dewatering Arrangement, (PVC pipes, perforated PVC pipes, precast concrete slots channel elements, dimpled sheets between permanent lines of C&C tunnel length and backfill material, water-proofing membrane etc.)	3.786%	
A4- Primary Support Measures		
a. SFRS/Shotcrete with Wire mesh		
ESC-1, ESC-10 & ESC 11	4.924%	
ESC-2	0.000%	
ESC-3	0.768%	
ESC-4	3.704%	
ESC-5	2.066%	
b. Rock Bolts/Fore poling/Pipe roofing		
ESC-1, ESC-10 & ESC 11	0.892%	
ESC-2	0.000%	
ESC-3	0.179%	
ESC-4	7.304%	
ESC-5	4.062%	
c. Steel ribs/Lattice Girder		
ESC-1, ESC-10 & ESC 1	0.000%	
ESC-2	0.000%	
ESC-3	0.000%	
ESC-4	1.169%	
ESC-5	0.733%	
A5-Concrete Works	22.210%	
A6-Instrumentation and Monitoring	0.393%	
A7-Pavement	4.111%	
C-Ventilation	0.999%	On delivery, installation and commissioning of E&M equipment in the ratio of 20:20:60.
D- Electro and Mechanical Equipment and Power Supply	12.633%	On delivery, installation and commissioning of E&M equipment in the ratio of 20:40:40&Construction of 2 nos. of 1x 10 MVA, 33/11 kv substation, 33 kva line from nearest source i/c pole, gantry, conductor and applicable supervision charges of utility owing department.

1.3.5 Other works.

Procedure for estimating the value of other works done shall be as stated in table 1.3.4.

Table 1.3.5

Stage of Payment	Weightage	Payment Procedure
(i) Toll plaza	0.000%	Payment shall be made on pro rata basis for completed facilities.
(ii) Road-side drains (PCC drain & Catch Water drain)	5.647%	Unit of measurement is linear length in km./Nos./sqm Payment shall be made on prorata basis on completion of a stage in a lengthof not less than 5 % (Five per cent) of the scope of work.
(iii) Road signs, markings, km stones, safety devices	8.369%	
(iv) Project Facilities		
a) Bus Shelter/Bus Stop	0.222%	Payment shall be made on pro rata basis for completed facilities.
b) Truck lay byes	0.000%	
c) Utility Ducts& Plantation	3.558%	
d) Junctions	2.198%	
v)Environment Management& Muck Disposal Management		
a) Disposal of muck at suitable locations	9.046%	Payment shall be made on pro rata basis on completion of stage in a length/ height and volume of not less than 20% of total length/ height and volumeof quantity of muck at 2 locations out of 15 nos. or more as specified in Schedule-B.
b)Construction of engineering structures at disposal locations	9.613%	
(vi) Protection works		Payment shall be made on pro rata basis on completion of a stage in a length of not less than 5% (Five per cent) of the total length.
a) RRM Wall/Retaining wall/Toe wall & Gabion Wall	21.594%	
b) Breast wall	38.413%	
c) Special Slope Stabilization Works (Site suitable engineering measures such as shotcrete with wire mesh & bio engineering measures such as hydro seeding	0.350%	
d) Rock Bolts, Shotcreting and Drainage Holes	0.495%	
(viii) Safety and traffic management during construction	0.495%	Every quarter after duly certified the work by the AE as per Contractual requirement at site.
b) clearance of land slide & snow		

1.3.6 Utility Shifting

Procedure for estimating the value of Utility Shifting done shall be as stated in table 1.3.6.

Table 1.3.6

Stage of payment	Weightage	Payment procedure
(i) EHT line	Nil	Unit of measurement is as per completed activities. Cost per activity shall be determined on pro-rata basis as per its weightage with reference to total cost of EHT line. Payment shall be made for completed activity, (The average weightage of major activities (only for payment purpose) in shifting work is (i) Erection of Poles-20%, (ii) Conductor stringing including Laying of cable-30%, (iii) DTR erection (if involved)-15% and (iv) Charging of line including dismantling and site clearance-35% (with DTR) and 50% without DTR)
(ii) EHT crossings		Cost of each crossing shall be determined on pro-rata basis with reference to total no. of crossings. Payment shall be made for not less than 25% of the crossings subject to a minimum of 4
(iii) HT/LT line (including Transformers if any)	42.069%	Unit of measurement is as per completed activities. Cost per activity shall be determined on pro-rata basis as per its weightage with reference to total cost of LT/HT line. Payment shall be made for completed activity. (The average weightage of major activities (only for payment purpose) in shifting work is (i) Erection of Poles-20%, (ii) Conductor stringing including laying of cable-30%, (iii) DTR erection (if involved)-10% and (iv) Charging of line including dismantling and site clearance-40% (with DTR) and 50% without DTR)
(iv) HT/LT crossings		Cost of each crossing shall be determined on pro-rata basis with reference to total no, of crossings. Payment shall be made for not less than 25% of the crossings subject to a minimum of 10 crossings.
(v) Water pipeline	57.931%	Unit of measurement is as per completed activities. Cost per activity shall be determined on pro-rata basis as per its weightage with reference to total cost of pipeline. Payment shall be made for completed activity. (The average weightage of major activities (only for payment purpose) in shifting work is laying of pipe-50%, Charging of line including all miscellaneous works and dismantling and site clearance-
(vi) Water pipeline crossing		Cost of each crossing shall be determined on pro-rata basis with reference to total no. of crossings. Payment shall be Trade for not less than 25% of the crossings subject to a minimum of 8 crossings.

2. Procedure for payment for Maintenance

2.1 The cost for maintenance shall be as stated in Clause 14.1.1.

2.2 Payment for Maintenance shall be made in quarterly instalments in accordance with the provisions of Clause 19.7.

Schedule - I

(See Clause 10.2 (iv))

Drawings

1. Drawings

In compliance of the obligations set forth in Clause 10.2 of this Agreement, the Contractor shall furnish to the Authority's Engineer, free of cost, all Drawings listed in Annex-I of this Schedule-I.

2. Additional Drawings

If the Authority's Engineer determines that for discharging its duties and functions under this Agreement, it requires any drawings other than those listed in Annex-I, it may by notice require the Contractor to prepare and furnish such drawings forthwith. Upon receiving a requisition to this effect, the Contractor shall promptly prepare and furnish such drawings to the Authority's Engineer, as if such drawings formed part of Annex-I of this Schedule-I.

Annex – I

(Schedule - I)

List of Drawings

1. The Project drawings, as defined in Clause 1.1, Definitions, Article 1, Definitions and Interpretation, Part-I: Preliminary, of the Contract Agreement shall consist:
 - (a) Working Drawings of all the components/elements of the Project as determined by Authority Engineer/Authority, and
 - (b) As-built drawings for the Project components/elements as determined by AE/Authority. As-built drawings shall be duly certified by Authority Engineer.
2. A minimum list of the drawings of the various components/elements of the Project and project facilities required to be submitted by the Contractor is given below:

A. GENERAL LAYOUT PLAN
Tunnel Layout Plan and L-Section
Tunnel Cross Section
B. TUNNEL GEOLOGICAL DRAWINGS
Geological Layout Plan
Geological L-Section
Geological Cross Section
C. TUNNEL CIVIL & MEP DRAWINGS
Excavation and Support Drawings
Portal Development Drawings
Instrumentation Details
Detailed Drawing of Concrete Outline and Reinforcement
Drawings of clearance profile and installations without invert slab
Drawings of clearance profile and installations with invert slab
Detailed Drawings of Tunnel lighting.
Drawings of Tunnel system and installations
Tunnel MEP Drawings
D. BRIDGE
General Arrangement Drawing
Detailed Drawings of Structures/Bridges
E. ROAD (PLAN & PROFILE)
Plan & Profile
Cross Sections
Drawings of horizontal alignment, vertical profile and cross sections
Drawings of cross drainage works
Drawings of traffic diversion plans and traffic control measures
Drawings of road drainage measures
Drawings of typical details slope protection measures
Drawings of landscaping and horticulture
Drawings of street lighting
F. STANDARD DRAWINGS
Detail of Mandatory Regulatory Signs

Detail of Mandatory Regulatory Signs & Compulsory Direction Control and Other Signs
Detail of Informatroy Signs
Detail of Cautionary Signs-TS
Detail of cautionary warning signs
Detail of cautionary warning signs
Details of route marking (chevron marking)
Details of road marking
Details of directional signs
Details Toe drain
Details of pitching, filtermaterial, chute drain and energy dissipation basin-std
Details of double head metal beam crash barrier
Details for 200meter 1 km & km post
Detail for boundary stone & guard post
Drain retaining wall & kerb
Gabion wall
D. Utility shifting Plan.

Schedule - J

(See Clause 10.3 (ii))

Project Completion Schedule

1. Project Completion Schedule

During Construction period, the Contractor shall comply with the requirements set forth in this Schedule-J for each of the Project Milestones and the **Scheduled Completion Date**. Within 15 (fifteen) days of the date of each Project Milestone, the Contractor shall notify the Authority of such compliance along with necessary particulars thereof.

2. Project Milestone-I

- (i) Project Milestone-I shall occur on the date falling on the **640th (Six Hundred and Forty)** day from the Appointed Date (the “**Project Milestone-I**”).
- (ii) Prior to the occurrence of Project Milestone-I, the Contractor shall have commenced construction of the Project Highway and submitted to the Authority duly and validly prepared Stage Payment Statements for an amount not less than 10% (ten per cent) of the Contract Price.

3. Project Milestone-II

- (i) Project Milestone-II shall occur on the date falling on the **1095th (One Thousand and Ninety-Five)** day from the Appointed Date (the “**Project Milestone- II**”).
- (ii) Prior to the occurrence of Project Milestone-II, the Contractor shall have continued with construction of the Project Highway and submitted to the Authority duly and validly prepared Stage Payment Statements for an amount not less than 35% (thirty-five per cent) of the Contract Price and should have started construction of all bridges.

4. Project Milestone-III

- (i) Project Milestone-III shall occur on the date falling on the **1552nd (One Thousand Five Hundred and Fifty-Two)** day from the Appointed Date (the “**Project Milestone- III**”).
- (ii) Prior to the occurrence of Project Milestone-III, the Contractor shall have continued with construction of the Project Highway and submitted to the Authority duly and validly prepared Stage Payment Statements for an amount not less than 70% (seventy per cent) of the Contract Price and should have started construction of all project facilities.

5. Scheduled Completion Date

- (i) The Scheduled Completion Date shall occur on the **1826th (One Thousand Eight Hundred and Twenty-Six)** day from the Appointed Date.
- (ii) On or before the Scheduled Completion Date, the Contractor shall have completed construction in accordance with this Agreement.

6. Extension of time

Upon extension of any or all of the aforesaid Project Milestones or the Scheduled Completion Date, as the case may be, under and in accordance with the provisions of this Agreement, the Project Completion Schedule shall be deemed to have been amended accordingly.

Schedule - K

(See Clause 12.1 (ii))

Tests on Completion**1. Schedule for Tests**

- (i) The Contractor shall, no later than 30 (thirty) days prior to the likely completion of construction, notify the Authority's Engineer and the Authority of its intent to subject the Project Highway to Tests, and no later than 10(ten) days prior to the actual date of Tests, furnish to the Authority's Engineer and the Authority detailed inventory and particulars of all works and equipment forming part of Works.
- (ii) The Contractor shall notify the Authority's Engineer of its readiness to subject the Project Highway to Tests at any time after 10 (ten) days from the date of such notice, and upon receipt of such notice, the Authority's Engineer shall, in consultation with the Contractor, determine the date and time for each Test and notify the same to the Authority who may designate its representative to witness the Tests. The Authority's Engineer shall thereupon conduct the Tests itself or cause any of the Tests to be conducted in accordance with Article 12 and this Schedule-K.

2. Tests**A. Road and Bridge**

- (i) Visual and physical test: The Authority's Engineer shall conduct a visual and physical check of construction to determine that all works and equipment forming part thereof conform to the provisions of this Agreement. The physical tests shall include [***].
- (ii) Riding quality test: Riding quality of each lane of the carriageway shall be checked with the help of a Network Survey Vehicle (NSV) fitted with latest equipment and the maximum permissible roughness for purposes of this Test shall be [2,000 (two thousand)] mm for each kilometre.
- (iii) Tests for bridges: All major and minor bridges shall be subjected to the rebound hammer and ultrasonic pulse velocity tests, to be conducted in accordance with the procedure described in Special Report No. 17: 1996 of the IRC Highway Research Board on Non-destructive Testing Techniques, at two spots in every span, to be chosen at random by the Authority's Engineer. Bridges with a span of 15 (fifteen) metres or more shall also be subjected to load testing.
- (iv) Other tests: The Authority's Engineer may require the Contractor to carry out or cause to be carried additional tests, in accordance with Good Industry Practice, for determining the compliance of the Project Highway with Specifications and Standards, except tests as specified in clause 5, but shall include measuring the reflectivity of road markings and road signs; and measuring the illumination level (lux) of lighting using requisite testing equipment.

B. Tunnel

- (i) Visual and physical test: The Authority's Engineer shall conduct a visual and physical check of construction to determine that all works and equipment forming part thereof conform to the provisions of this Agreement. The physical tests shall include [***].
- (ii) Riding quality test: Riding quality of each lane of the carriageway shall be checked with the help of a Network Survey Vehicle (NSV) fitted with latest equipments and the maximum permissible roughness for purposes of this Test shall be [2,000 (two thousand)] mm for each kilometer.
- (iii) Other tests: The Authority's Engineer may require the Contractor to carry out or cause to be carried additional tests, in accordance with Good Industry Practice, for determining the compliance of the Project Highway with Specifications and Standards, except tests as specified in clause 5, but shall include measuring the reflectivity of road

markings and road signs; and measuring the illumination level (lux) of lighting using requisite testing equipment.

C. Other Tests

- (i) Environmental audit: The Authority's Engineer shall carry out a check to determine conformity of the Project Highway with the environmental requirements set forth in Applicable Laws and Applicable Permits.
- (ii) Safety Audit: The Authority's Engineer shall carry out, or cause to be carried out, a safety audit to determine conformity of the Project Highway with the safety requirements and Good Industry Practice.

3. Agency for conducting Tests

All Tests set forth in this Schedule-K shall be conducted by the Authority's Engineer or such other agency or person as it may specify in consultation with the Authority.

4. Completion Certificate

Upon successful completion of Tests, the Authority's Engineer shall issue the Completion Certificate in accordance with the provisions of Article 12.

- 5.** The Authority Engineer will carry out tests with following equipment at his own cost in the presence of contractor's representative.

Sr. No.	Key metrics of Asset	Equipment to be used	Frequency of condition survey
1	Surface of defects pavement	Network Survey Vehicle (NSV)	At least twice a year (As per survey months defined for the state basis rainy season)
2	Roughness of pavement	Network Survey Vehicle (NSV)	At least twice a year (As per survey months defined for the state basis rainy season)
3	Strength of pavement	Falling Weight Deflectometer(FWD)	At least once a year
4	Bridges	Mobile Bridge Inspection Unit(MBU)	At least twice a year (As per survey months defined for the state basis rainy season)
5	Road signs	Retro-reflectometer	At least twice a year (As per survey months defined for the state basis rainy season)

The first testing with the help of NSV shall be conducted at the time of issue of Completion Certificate.

Schedule - L

(See Clause 12.2)

Completion Certificate

- 1 I, ... (Name of the Authority's Engineer), acting as the Authority's Engineer, under and in accordance with the Agreement dated(the "**Agreement**"), ...(the "**Project Highway**") on Engineering, Procurement and Construction(EPC)basis through(Name of Contractor),here by certify that the Tests in accordance with Article 12 of the Agreement have been successfully undertaken to determine compliance of the Project Highway with the provisions of the Agreement, and I am satisfied that the Project Highway can be safely and reliably placed in service of the Users thereof.
- 2 It is certified that, in terms of the aforesaid Agreement, all works forming part of Project Highway have been completed, and the Project Highway is hereby declared fit for entry into operation on this the.....day of.....20..., Scheduled Completed

Date for which was the day of 20.....

SIGNED, SEALED AND DELIVERED

For and on behalf of the Authority's Engineer by:

(Signature)

(Name) (Designation)(Address)

Schedule - M

(See Clauses 14.6, 15.2 and 19.7)

Payment Reduction for Non-Compliance**1. Payment reduction for non-compliance with the Maintenance Requirements**

- (i) Monthly lump sum payments for maintenance shall be reduced in the case of non-compliance with the Maintenance Requirements set forth in Schedule-E.
- (ii) Any deduction made on account of non-compliance with the Maintenance Requirements shall not be paid even after compliance subsequently. The deductions shall continue to be made every month until compliance is done.
- (iii) The Authority's Engineer shall calculate the amount of payment reduction on the basis of weightage in percentage assigned to non-conforming items as given in Paragraph 2.

2. Percentage reductions in lump sum payments on monthly basis

- (i) The following percentages shall govern the payment reduction:

S. No.	Item/Defect/Deficiency	Percentage
(a)	Carriageway/Pavement	
(i)	Potholes, cracks, other surface defects	15%
(ii)	Repairs of Edges, Rutting	5%
(b)	Road, Embankment, Cuttings, Shoulders	
(i)	Edge drop, inadequate cross fall, undulations, settlement, potholes, ponding, obstructions	10%
(ii)	Deficient slopes, rain cuts, disturbed pitching, vegetation growth, pruning of trees	5%
(c)	Bridges and Culverts	
(i)	Desilting, cleaning, vegetation growth, damaged pitching, flooring, parapets, wearing course, footpaths, any damage to foundations	20%
(ii)	Any Defects in superstructures, bearings and sub-structures	10%
(iii)	Painting, repairs/replacement kerb, railings, parapets, guideposts/crash barriers	5%
(d)	Roadside Drains	
(i)	Cleaning and repair of drains	5%
(e)	Road Furniture	
(i)	Cleaning, painting, replacement of road signs, delineators, road markings, 200 m/km/5th km stones	5%
(f)	Miscellaneous Items	
(i)	Removal of dead animals, broken down/accidental vehicles, fallen trees, road blockades or malfunctioning of mobile crane	10%
(ii)	Any other Defects in accordance with paragraph 1.	5%
(g)	Defects in Other Project Facilities	5%

- (ii) The amount to be deducted from monthly lump-sum payment for non-compliance of particular item shall be calculated asunder:

$$R = \frac{P}{100} \times (M1 \text{ or } M2) \times \frac{L1}{L}$$

Where,

P= Percentage of particular item/Defect/deficiency for deduction

M1= Monthly lump-sum payment in accordance para 1.2 above of this Schedule M2= Monthly lump-sum payment in accordance para 1.2 above of this Schedule L1= Non-complying length L = Total length of the road,

R= Reduction (the amount to be deducted for non-compliance for a particular item/Defect/deficiency

The total amount of reduction shall be arrived at by summation of reductions for such items/Defects/deficiency or non-compliance.

For any Defect in a part of one kilometer, the non-conforming length shall be taken as one kilometer.

Schedule - N

(See Clause 18.1 (i))

Selection of Authority's Engineer

1. Selection of Authority's Engineer

- (i) The provisions of the Model Request for Proposal for Selection of Technical Consultants, issued by the Ministry of Finance in May 2009, or any substitute thereof shall apply for selection of an experienced firm to discharge the functions and duties of an Authority's Engineer.
- (ii) In the event of termination of the Technical Consultants appointed in accordance with the provisions of Paragraph 1.1, the Authority shall appoint another firm of Technical Consultants forthwith and may engage a government-owned entity in accordance with the provisions of Paragraph 3 of this Schedule-N.

2. Terms of Reference

The Terms of Reference for the Authority's Engineer (the "**TOR**") shall substantially conform with Annex 1 to this Schedule N.

3. Appointment of Government entity as Authority's Engineer

Notwithstanding anything to the contrary contained in this Schedule, the Authority may in its discretion appoint a government-owned entity as the Authority's Engineer; provided that such entity shall be a body corporate having as one of its primary functions the provision of consulting, advisory and supervisory services for engineering projects; provided further that a government-owned entity which is owned or controlled by the Authority shall not be eligible for appointment as Authority's Engineer.

Annex – I

(Schedule - N)

Terms of Reference for Authority's Engineer

1. Scope

- (i) These Terms of Reference (the “**TOR**”) for the Authority's Engineer are being specified pursuant to the EPC Agreement dated (the “**Agreement**”), which has been entered into between the [name and address of the Authority] (the “**Authority**”) and (the “**Contractor**”) # on Engineering, Procurement, Construction (EPC) basis, and a copy of which is annexed hereto and marked as Annex-A to form part of this TOR.

- In case the bid of Authority's Engineer is invited simultaneously with the bid of EPC project, then the status of bidding of EPC project only to be indicated

- (ii) The TOR shall apply to construction and maintenance of the Project Highway.

2. Definitions and interpretation

- (i) The words and expressions beginning with or in capital letters and not defined herein but defined in the Agreement shall have, unless repugnant to the context, the meaning respectively assigned to them in the Agreement.
- (ii) References to Articles, Clauses and Schedules in this TOR shall, except where the context otherwise requires, be deemed to be references to the Articles, Clauses and Schedules of the Agreement, and references to Paragraphs shall be deemed to be references to Paragraphs of this TOR.
- (iii) The rules of interpretation stated in Article 1 of the Agreement shall apply, mutatis mutandis, to this TOR.

3. General

- (i) The Authority's Engineer shall discharge its duties in a fair, impartial and efficient manner, consistent with the highest standards of professional integrity and Good Industry Practice.
- (ii) The Authority's Engineer shall perform the duties and exercise the authority in accordance with the provisions of this Agreement, but subject to obtaining prior written approval of the Authority before determining:
- (a) any Time Extension;
 - (b) any additional cost to be paid by the Authority to the Contractor;
 - (c) the Termination Payment; or
 - (d) issuance of Completion Certificate or
 - (e) any other matter which is not specified in (a), (b), (c) or (d) above and which creates a financial liability on either Party.
- (iii) The Authority's Engineer shall submit regular periodic reports, at least once every month, to the Authority in respect of its duties and functions under this Agreement. Such reports shall be submitted by the Authority's Engineer within 10 (ten) days of the beginning of every month.
- (iv) The Authority's Engineer shall inform the Contractor of any delegation of its duties and responsibilities to its suitably qualified and experienced personnel; provided, however, that it shall not delegate the authority to refer any matter for the Authority's prior approval in accordance with the provisions of Clause 18.2.
- (v) The Authority's Engineer shall aid and advise the Authority on any proposal for Change of Scope under Article 13.
- (vi) In the event of any disagreement between the Parties regarding the meaning, scope and nature of Good Industry Practice, as set forth in any provision of the Agreement, the Authority's Engineer

shall specify such meaning, scope and nature by issuing a reasoned written statement relying on good industry practice and authentic literature.

4. Construction Period

- (i) During the Construction Period, the Authority's Engineer shall review and approve the Drawings furnished by the Contractor along with supporting data, including the geo-technical and hydrological investigations, characteristics of materials from borrow areas and quarry sites, topographical surveys, and the recommendations of the Safety Consultant in accordance with the provisions of Clause 10.1 (vi). The Authority's Engineer shall complete such review and approval and send its observations to the Authority and the Contractor within 15 (fifteen) days of receipt of such Drawings; provided, however that in case of a Major Bridge or Structure, the aforesaid period of 15 (fifteen) days may be extended upto 30 (thirty) days. In particular, such comments shall specify the conformity or otherwise of such Drawings with the Scope of the Project and Specifications and Standards.
- (ii) The Authority's Engineer shall review and approve any revised Drawings sent to it by the Contractor and furnish its comments within 10 (ten) days of receiving such Drawings.
- (iii) The Authority's Engineer shall review and approve the Quality Assurance Plan submitted by the Contractor and shall convey its comments to the Contractor within a period of 21 (twenty-one) days stating the modifications, if any, required thereto.
- (iv) The Authority's Engineer shall complete the review and approve of the methodology proposed to be adopted by the Contractor for executing the Works and convey its comments to the Contractor within a period of 10 (ten) days from the date of receipt of the proposed methodology from the Contractor.
- (v) The Authority's Engineer shall grant written approval to the Contractor, where necessary, for interruption and diversion of the flow of traffic in the existing lane(s) of the Project Highway for purposes of maintenance during the Construction Period in accordance with the provisions of Clause 10.4.
- (vi) The Authority's Engineer shall review the monthly progress report furnished by the Contractor and send its comments thereon to the Authority and the Contractor within 7 (seven) days of receipt of such report.
- (vii) The Authority's Engineer shall inspect the Construction Works and the Project Highway and shall submit a monthly Inspection Report bringing out the results of inspections and the remedial action taken by the Contractor in respect of Defects or deficiencies. In particular, the Authority's Engineer shall include in its Inspection Report, the compliance of the recommendations made by the Safety Consultant.
- (viii) The Authority's Engineer shall conduct the pre-construction review of manufacturer's test reports and standard samples of manufactured Materials, and such other Materials as the Authority's Engineer may require.
- (ix) For determining that the Works conform to Specifications and Standards, the Authority's Engineer shall require the Contractor to carry out, or cause to be carried out, tests at such time and frequency and in such manner as specified in the Agreement and in accordance with Good Industry Practice for quality assurance. For purposes of this Paragraph 4 (ix), the tests specified in the IRC Special Publication-11 (Handbook of Quality Control for Construction of Roads and Runways) and the Specifications for Road and Bridge Works issued by MORTH (the "Quality Control Manuals") or any modification/substitution thereof shall be deemed to be tests conforming to Good Industry Practice for quality assurance.
- (x) The Authority's Engineer shall test check at least 50 (fifty) percent of the quantity or number of tests prescribed for each category or type of test for quality control by the Contractor.
- (xi) The timing of tests referred to in Paragraph 4 (ix), and the criteria for acceptance/ rejection of their results shall be determined by the Authority's Engineer in accordance with the Quality Control Manuals. The tests shall be undertaken on a random sample basis and shall be in addition to, and independent of, the tests that may be carried out by the Contractor for its own

quality assurance in accordance with Good Industry Practice.

- (xii) In the event that results of any tests conducted under Clause 11.10 establish any Defects or deficiencies in the Works, the Authority's Engineer shall require the Contractor to carry out remedial measures.
- (xiii) The Authority's Engineer may instruct the Contractor to execute any work which is urgently required for the safety of the Project Highway, whether because of an accident, unforeseeable event or otherwise; provided that in case of any work required on account of a Force Majeure Event, the provisions of Clause 21.6 shall apply.
- (xiv) In the event that the Contractor fails to achieve any of the Project Milestones, the Authority's Engineer shall undertake a review of the progress of construction and identify potential delays, if any. If the Authority's Engineer shall determine that completion of the Project Highway is not feasible within the time specified in the Agreement, it shall require the Contractor to indicate within 15 (fifteen) days the steps proposed to be taken to expedite progress, and the period within which the Project Completion Date shall be achieved. Upon receipt of a report from the Contractor, the Authority's Engineer shall review the same and send its comments to the Authority and the Contractor forthwith.
- (xv) The Authority's Engineer shall obtain from the Contractor a copy of all the Contractor's quality control records and documents before the Completion Certificate is issued pursuant to Clause 12.2.
- (xvi) Authority's Engineer may recommend to the Authority suspension of the whole or part of the Works if the work threatens the safety of the Users and pedestrians. After the Contractor has carried out remedial measure, the Authority's Engineer shall inspect such remedial measures forthwith and make a report to the Authority recommending whether or not the suspension hereunder may be revoked.
- (xvii) In the event that the Contractor carries out any remedial measures to secure the safety of suspended works and Users, and requires the Authority's Engineer to inspect such works, the Authority's Engineer shall inspect the suspended works within 3 (three) days of receiving such notice, and make a report to the Authority forthwith, recommending whether or not such suspension may be revoked by the Authority.
- (xviii) The Authority's Engineer shall carry out, or cause to be carried out, all the Tests specified in Schedule-K and issue a Completion Certificate, as the case may be. For carrying out its functions under this Paragraph 4 (xviii) and all matters incidental thereto, the Authority's Engineer shall act under and in accordance with the provisions of Article 12 and Schedule-K.

5. Maintenance Period

- (i) The Authority's Engineer shall aid and advise the Contractor in the preparation of its monthly Maintenance Programme and for this purpose carry out a joint monthly inspection with the Contractor.
- (ii) The Authority's Engineer shall undertake regular inspections, at least once every month, to evaluate compliance with the Maintenance Requirements and submit a Maintenance Inspection Report to the Authority and the Contractor.
- (iii) The Authority's Engineer shall specify the tests, if any, that the Contractor shall carry out, or cause to be carried out, for the purpose of determining that the Project Highway is in conformity with the Maintenance Requirements. It shall monitor and review the results of such tests and the remedial measures, if any, taken by the Contractor in this behalf.
- (iv) In respect of any defect or deficiency referred to in Paragraph 3 of Schedule- E, the Authority's Engineer shall, in conformity with Good Industry Practice, specify the permissible limit of deviation or deterioration with reference to the Specifications and Standards and shall also specify the time limit for repair or rectification of any deviation or deterioration beyond the permissible limit.
- (v) The Authority's Engineer shall examine the request of the Contractor for closure of any lane(s)

of the Project Highway for undertaking maintenance/repair thereof, and shall grant permission with such modifications, as it may deem necessary, within 5 (five) days of receiving a request from the Contractor. Upon expiry of the permitted period of closure, the Authority's Engineer shall monitor the reopening of such lane(s), and in case of delay, determine the Damages payable by the Contractor to the Authority under Clause 14.5.

6. Determination of costs and time

- (i) The Authority's Engineer shall determine the costs, and/or their reasonableness, that are required to be determined by it under the Agreement.
- (ii) The Authority's Engineer shall determine the period of Time Extension that is required to be determined by it under the Agreement.
- (iii) The Authority's Engineer shall consult each Party in every case of determination in accordance with the provisions of Clause 18.5.

7. Payments

- (i) The Authority's Engineer shall withhold payments for the affected works for which the Contractor fails to revise and resubmit the Drawings to the Authority's Engineer in accordance with the provisions of Clause 10.2 (iv)(d).
- (ii) Authority's Engineer shall-
 - (a) within 10 (ten) days of receipt of the Stage Payment Statement from the Contractor pursuant to Clause 19.4, determine the amount due to the Contractor and recommend the release of 90 (ninety) percent of the amount so determined as part payment, pending issue of the Interim Payment Certificate; and
 - (b) within 15 (fifteen) days of the receipt of the Stage Payment Statement referred to in Clause 19.4, deliver to the Authority and the Contractor an Interim Payment Certificate certifying the amount due and payable to the Contractor, after adjustments in accordance with the provisions of Clause 19.10.
- (iii) The Authority's Engineer shall, within 15 (fifteen) days of receipt of the Monthly Maintenance Statement from the Contractor pursuant to Clause 19.6, verify the Contractor's monthly statement and certify the amount to be paid to the Contractor in accordance with the provisions of the Agreement.
- (iv) The Authority's Engineer shall certify final payment within 30 (thirty) days of the receipt of the final payment statement of Maintenance in accordance with the provisions of Clause 19.16.

8. Other duties and functions

The Authority's Engineer shall perform all other duties and functions as specified in the Agreement.

9. Miscellaneous

- (i) A copy of all communications, comments, instructions, Drawings or Documents sent by the Authority's Engineer to the Contractor pursuant to this TOR, and a copy of all the test results with comments of the Authority's Engineer thereon, shall be furnished by the Authority's Engineer to the Authority forthwith.
- (ii) The Authority's Engineer shall retain at least one copy each of all Drawings and Documents received by it, including 'as-built' Drawings, and keep them in its safe custody.
- (iii) Within 90 (ninety) days of the Project Completion Date, the Authority's Engineer shall obtain a complete set of as-built Drawings, in 2 (two) hard copies and in micro film form or in such other medium as may be acceptable to the Authority, reflecting the Project Highway as actually designed, engineered and constructed, including an as-built survey illustrating the layout of the Project Highway and setback lines, if any, of the buildings and structures forming part of Project Facilities; and shall hand the mover to the Authority against receipt thereof.

- (iv) The Authority's Engineer, if called upon by the Authority or the Contractor or both, shall mediate and assist the Parties in arriving at an amicable settlement of any Dispute between the Parties.
- (v) The Authority's Engineers shall inform the Authority and the Contractor of any event of Contractor's Default within one week of its occurrence.

Schedule - O

(See Clauses 19.4 (i), 19.6 (i), and 19.8 (i))

Forms of Payment Statements

1. Stage Payment Statement for Works

The Stage Payment Statement for Works shall state:

(a) the estimated amount for the Works executed in accordance with Clause 19.3

(i) subsequent to the last claim;

(b) amounts reflecting adjustments in price for the aforesaid claim;

(c) the estimated amount of each Change of Scope Order executed subsequent to the last claim;

(d) amounts reflecting adjustment in price, if any, for (c) above in accordance with the provisions of Clause 13.2 (iii)(a);

(e) total of (a), (b), (c) and (d) above;

(f) Deductions:

i. Any amount to be deducted in accordance with the provisions of the Agreement except taxes;

ii. Any amount towards deduction of taxes; and

iii. Total of (i) and (ii) above.

(g) Net claim: (e) – (f)(iii);

(h) The amounts received by the Contractor up to the last claim:

i. For the Works executed (excluding Change of Scope orders);

ii. For Change of Scope Orders, and

iii. Taxes deducted

2. Monthly Maintenance Payment Statement

The monthly Statement for Maintenance Payment shall state:

(a) the monthly payment admissible in accordance with the provisions of the Agreement;

(b) the deductions for maintenance work not done;

(c) net payment for maintenance due, (a) minus (b);

(d) amounts reflecting adjustments in price under Clause 19.12; and

(e) amount towards deduction of taxes

3. Contractor's claim for Damages

Note: The Contractor shall submit its claims in a form acceptable to the Authority.

Schedule - P

(See Clause 20.1)

Insurance

1. Insurance during Construction Period

- (i) The Contractor shall effect and maintain at its own cost, from the Appointed Date till the date of issue of the Completion Certificate, the following insurances for any loss or damage occurring on account of Non Political Event of Force Majeure, malicious act, accidental damage, explosion, fire and terrorism:
 - (a) insurance of Works, Plant and Materials and an additional sum of [15 (fifteen)] per cent of such replacement cost to cover any additional costs of and incidental to the rectification of loss or damage including professional fees and the cost of demolishing and removing any part of the Works and of removing debris of whatsoever nature; and
 - (b) insurance for the Contractor's equipment and Documents brought onto the Site by the Contractor, for a sum sufficient to provide for their replacement at the Site.
- (ii) The insurance under sub para (a) and (b) of paragraph 1(i) above shall cover the Authority and the Contractor against all loss or damage from any cause arising under paragraph 1.1 other than risks which are not insurable at commercial terms.

2. Insurance for Contractor's Defects Liability

The Contractor shall effect and maintain insurance cover of not less than 15% of the Contract Price for the Works from the date of issue of the Completion Certificate until the end of the Defects Liability Period for any loss or damage for which the Contractor is liable and which arises from a cause occurring prior to the issue of the Completion Certificate. The Contractor shall also maintain other insurances for maximum sums as may be required under the Applicable Laws and in accordance with Good Industry Practice.

3. Insurance against injury to persons and damage to property

- (i) The Contractor shall insure against its liability for any loss, damage, death or bodily injury, or damage to any property (except things insured under Paragraphs 1 and 2 of this Schedule or to any person (except persons insured under Clause 20.9), which may arise out of the Contractor's performance of this Agreement. This insurance shall be for a limit per occurrence of not less than the amount stated below with no limit on the number of occurrences.

The insurance cover shall be not less than: Rs. 2,00,00,000/- (Two Crore only)
- (ii) The insurance shall be extended to cover liability for all loss and damage to the Authority's property arising out of the Contractor's performance of this Agreement excluding:
 - (a) the Authority's right to have the construction works executed on, over, under, in or through any land, and to occupy this land for the Works; and
 - (b) damage which is an unavoidable result of the Contractor's obligations to execute the Works.

4. Insurance to be in joint names

The insurance under paragraphs 1 to 3 above shall be in the joint names of the Contractor and the Authority.

Schedule-Q

(See Clause 14.10)

Tests on Completion of Maintenance Period

1. Riding Quality test

Riding quality test: Riding quality of each lane of the carriageway shall be checked with the help of a calibrated bump integrator and the maximum permissible roughness for purposes of this Test shall be 2,200 (two thousand and two hundred only) mm for each kilometer.

2. Visual and physical test

The Authority's Engineer shall conduct a visual and physical check of construction to determine that all works and equipment forming part thereof conform to the provisions of this Agreement. The physical tests shall include measurement of cracking, rutting, stripping and potholes and shall be as per the requirement of maintenance mentioned in Schedule-E.

Schedule-R

(See Clause 14.10)

Taking Over Certificate

I, ... (Name and designation of the Authority's Representative) under and in accordance with the Agreement dated (the "**Agreement**"), ... (the "**Project Highway**") on Engineering, Procurement and Construction (EPC) basis through (Name of Contractor), hereby certify that the Tests on completion of Maintenance Period in accordance with Article 14 of the Agreement have been successfully undertaken to determine compliance of the Project Highway with the provisions of the Agreement and I hereby certify that the Authority has taken over the Project highway from the Contractor on this day.....

SIGNED, SEALED AND DELIVERED

(Signature)

(Name and designation of Authority's Representative)

(Address)

SCHEDULE-S
SAFETY AND HEALTH MANUAL
POLICY AND PROCEDURES

1.0 STATEMENT OF INTENT

It is the intention of the National Highways & Infrastructure Development Corporation Limited (NHIDCL) to build a number of tunnels in the difficult terrains of Jammu & Kashmir, Ladakh, Himachal Pradesh, Uttarakhand, Assam and other states in a way that will further raise the standards of health and safety on construction sites to a level that will be recognised as the best in India and comparable to the highest standards achieved worldwide.

This can only be achieved if there is a commitment from all parties involved in the construction and management of the Project, from the most senior level of managers within the NHIDCL and the Contractors, to the workers on the sites.

This document shall have the full support of all of the NHIDCL Project Team and any officer failing to give support to it shall be subject to internal discipline.

The National Highways & Infrastructure Development Corporation Limited shall actively support the efforts and initiatives that are instigated by the Contractors and sub-contractors in their efforts for achieving high standards of health and safety on the Project.

The ingredients that are needed to make and achieve a high standard of health and safety, are well known to most of us, it is however the level of commitment that is demonstrated that shall determine whether or not we succeed.

This manual represents the minimum standards that the National Highways & Infrastructure Development Corporation Limited will accept on matters of Safety and Health. The Corporation will use its best endeavours to ensure that all of the Contractors employed on the Project achieve these Standards.

2.0 References and distribution of this manual

2.1 References

2.1.1 The procedures in this manual should be read in conjunction with;

- (a) **The Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act 1996. Delhi Rules, 2002**
- (b) **The Factories Act, 1948**
- (c) **Other Laws of India, Regulations, Rules and Codes of Practice on Safety Health and the Environment that may be applicable.**
- (d) **The Conditions of Contract in respect of Health and Safety, that apply to the specific Contract under which the Contractor is employed.**
- (e) **The Contract Agreement for the work to which this manual is to be applied.**
- (f) **The important Indian and International Standards.**

3.0 Definition of terms

3.1 Introduction

3.1.1 The following terms used in this manual are defined as follows and shall be construed accordingly.

- (a) Safety means the freedom from unacceptable risks of personal harm, i.e. the avoidance of accidents and incidents.
- (b) Health means the physical wellbeing of a person and the freedom from any illness caused working conditions.
- (c) Hazard means a situation with the potential to cause harm including human injury, damage to property, plant or equipment, damage to the environment, or economic loss.

- (d) Risk means the chance of something adverse happening and its severity. It is a combination of the probability, or frequency, of the occurrence of a defined hazard and the magnitude of the consequences of the occurrence.
- (e) Foreseeable means that which is likely or possible.
- (f) Chief Safety Officer means an officer nominated by NHIDCL as Chief Safety Officer
- (g) Site Safety Plan means the contract specific safety plan that the Contractor has produced from his Outline Safety Plan.
- (h) Outline Safety Plan means the contract specific outline safety plan that the Contractor will prepare as part of his tender submission.
- (i) Reportable Accident / Incident means an Accident or Incident that is reportable to the Employer's Representative. It shall include all fatalities, major injury accidents, dangerous occurrences and all accidents, which result in incapacity for more than Forty Eight hours or more immediately following the accident.
- (j) Major Injury Accident is defined as:
 - (1) any fracture, other than to the fingers or toes;
 - (2) any loss of a limb or part of a limb;
 - (3) dislocation of the shoulder, hip, knee or spine;
 - (4) loss of sight (whether temporary or permanent);
 - (5) penetrating injury to the eye; or
 - (6) any other injury that:
 - leads to unconsciousness
 - requires resuscitation;
 - requires admittance to hospital for more than 24 hours;
 - or which causes more than 10 days absence from work.
- (k) Dangerous Occurrence is defined as:
 - (1) collapse or failure of lifting appliances or hoist or conveyors or other similar ;
 - (2) collapse or failure of a crane, derrick, winch, hoist or other appliance used in raising or lowering persons or goods or any part thereof (except the breakage of chain or rope slings), or the overturning of a crane;
 - (3) explosion or fire causing damage to the structure of any room or place in which persons are employed, or to any machine or plant, resulting in the complete suspension of ordinary work;
 - (4) electrical short circuit or failure of electrical machinery, plant or apparatus, attended by explosion or fire, causing structural damage involving its stoppage or disuse;
 - (5) explosion of a receiver or container used for the storage at a pressure greater than atmospheric pressure of any gas or gases (including air) or any liquid or solid resulting from the compression of gas;
 - (6) collapse in whole or part from any cause whatsoever of any roof, wall, floor, structure or foundation forming part of the construction site in which persons are employed;
 - (7) total or partial collapse of any overburden, face, tip or embankment on the construction site;
 - (8) the overturning of, or collision with any object by any bulldozer, dumper, excavator, grader, lorry or shovel loader, or any mobile machine used for the handling of any substance on the

construction site.

4.0 General

4.1 Introduction

- 4.1.1 It is the objective of the NHIDCL to ensure that the Contract is completed on time, within budget, and to conforming standards of Health and Safety.
- 4.1.2 This manual has system wide application, and therefore not all of the sections will apply to all Contractors. Each Contractor shall develop his own contract specific Site Safety Plan, which will represent his approach to the management of safety on his work, sites under the Contract with NHIDCL.
- 4.1.3 It is the intention of NHIDCL to levy fines against contractors who do not comply with the requirements of this Manual. The fines levied will be donated to the NHIDCL Labour Welfare Fund to assist those who have suffered as a result of this Project.

4.2 Purpose of the Manual

- 4.2.1 This manual has been produced in order to outline the minimum health and safety, standards that shall be required by NHIDCL during the construction of various projects entrusted to NHIDCL. Furthermore the manual has been developed to give guidance and assistance to the respective Contractors in the development and production of their Site Safety Plans, to satisfy the required health and safety standards established by the Conditions of Contract Agreement. This manual represents the minimum standards required and each Contractor is encouraged to expand and improve upon it.
- 4.2.2 This manual is not intended to replace existing standards that are currently in force in India. However, it is intended to support the standards and to highlight to Contractors the areas of concern that shall be addressed in their respective Site Safety Plans in order to establish good health and safety practices.
- 4.2.3 This document is intended to supplement the Section on Safety Measures as is contained in the Contract Agreement.
- 4.2.4 The obligations and requirements for Health and Safety set out within this document are entirely without prejudice and do not derogate from the Contractor's obligations with respect to the Contract and his statutory obligations with respect to Health and Safety.

4.3 Scope of the Manual

- 4.3.1 The Contractor is fully responsible for the safety of the Works, his personnel, subcontractors' personnel, the public and all persons directly or indirectly associated with the Works or on or in the vicinity of the Site.
- 4.3.2 This manual provides relevant information and procedures to assist the Contractor to ensure that his employees and sub-contractors work within a safety-conscious and safety- regulated environment. Compliance with the procedures set out in this manual shall not relieve the Contractor of any of his Statutory Duties or his responsibilities under the Contract.

4.4 Policy Objectives

- 4.4.1 Every Contract should aim at zero fatal accidents.
- 4.4.2 Every Contract should aim at zero dangerous occurrences (see section 3.1.1.(i) for the definition of 'dangerous occurrence').
- 4.4.3 Every Contract should aim at an Accident Frequency Rate (AFR) of less than 0.5 per 100,000 hours worked on the Contract.

4.5 Implementation of Policy Objectives

- 4.5.1 The following general approach has been adopted by NHIDCL with a view to achieving the policy objectives set out above

- (a) Secure a commitment to safe and healthy working practices by all parties involved in the construction process, including consultants, Contractors, sub-contractors, workers' unions, and utility providers.
- (b) Develop contract provisions that require Contractors to prepare, implement and monitor safety plans, and ensure that sub-contractors are also obliged to comply with the same. (Copies of the provisions relating to Health and Safety are contained in the Conditions of Contract Agreement, are reproduced in Schedule 1 of this Manual.)
- (c) Arrange accident prevention, safety management training for all site staff supervising Contracts.
- (d) Establish Site Safety Management Committees to monitor the implementation of safety plans and keep a record of the Meetings of the Committees.
- (e) Build up a database of accidents and dangerous occurrences, as defined in Section 9 of this manual, for the purpose of monitoring trends, analysing data, and formulating measures for accident prevention.
- (f) Publish this Manual to assist in the administration of construction safety matters of the Authority's contracts.
- (g) Oversee the safety performance of the Contractors and sub-contractors to ensure that their duties and responsibilities on health and safety under the Contract, this Manual, and other relevant Authority and Government requirements are fully discharged.
- (h) To publish and issue any further instruction / appendices needed for any specific requirement of the Contract.

5.0 General Duties of Contractors and Others

5.1 Introduction

- 5.1.1 Securing safe, healthy places of work requires the full co-operation of Contractors and sub-contractors and the persons employed by them. It is imperative that there is no ambiguity with regard to the responsibilities of any individuals in connection with duties relating to health and safety.
- 5.1.2 The responsibilities shall be clearly detailed in the Site Safety Plan from the level of the most Senior Manager downwards, these duties shall be explained to the individuals concerned in order to ensure that they clearly and concisely understand them.
- 5.1.3 Responsibilities for safety, health and the environment shall be allocated amongst others to the following personnel of the contractors and sub-contractors:
 - (a) CEO / Managing Director:
 - (b) Project Manager:
 - (b) Site Agent/Manager:
 - (c) Engineers:
 - (d) Safety Officer:
 - (e) Supervisors:
 - (f) General Workers

5.2 General Duties of Persons Employed

- 5.2.1 Every person employed by Contractors and sub-contractors on construction sites are obliged to comply with the general duties imposed on them under the Contract. Every person employed should, not only avoid careless or reckless behaviour, but should also take positive steps to understand workplace hazards. They must follow all necessary safety and environment rules and procedures and ensure that their acts or omissions at work do not put the health and safety of self or others at risk.

5.3 Contractors and Sub-contractors: Responsibilities

- 5.3.1 Contractors and sub-contractors are responsible for complying with all statutory and contractual requirements on construction safety, health and environment including the general duties imposed on them under the Laws and Regulations of the Government of India and other relevant authorities.
- 5.3.2 NHIDCL shall only deal with health and safety matters through the Contractor and shall hold the Contractor responsible for all his, and his Sub-contractors, actions. All Sub-contractors shall be responsible to the Contractor.
- 5.3.3 For the guidance of Contractors, a list of some of applicable Legislation and Codes of Practices in India is contained in Schedule 2. Contractors should however note that the purpose of the list is for guidance only and it is not exhaustive. This list shall not relieve the Contractor in whole or in part of his contractual or legal liabilities.
- 5.3.4 All Contractors and Sub-contractors shall ensure that an adequate level of competent supervision is maintained at the workplace at all times with all supervisory staff having the relevant knowledge, training, and experience to enable them to supervise the work in a proper manner.
- 5.3.5 Contractors shall ensure that all sub-contractors are able to demonstrate a successful track record with regard to the management of health and safety. The type of information that shall be requested from the sub-contractors during the tendering process in order to determine their suitability shall include amongst other things the following information relating to their activities over the last five years
- (a) Fatal accidents**
 - (b) Major lost time accidents**
 - (c) Accidents involving members of the public**
 - (d) Dangerous Occurrences**
- 5.3.6 Contractors and sub-contractors are responsible for submitting written statements on their policies relating to construction safety within fourteen days of a requirement to do so by NHIDCL.
- 5.3.7 Contractors and sub-contractors are responsible for providing comprehensive safety and environment plans for the review by NHIDCL, and for subsequent implementation of the measures detailed in the safety and environment plans.
- 5.3.8 Contractors and sub-contractors are responsible for the provision of suitably trained and qualified safety staff to carry out regular safety inspections, safety promotion, and safety audits and for retention of records of all such activities for inspection by NHIDCL.
- 5.3.9 Contractors and sub-contractors are responsible for providing safety and environment training to all workers and supervisors on site, and for retention of records of such activities for inspection by the NHIDCL.
- 5.3.10 Contractors and sub-contractors are responsible for organising site safety committees which shall meet at least monthly.
- 5.3.11 Contractors and sub-contractors are responsible for reporting dangerous occurrences and accidents to the Authority's Representative by the quickest practicable means.

5.4 Discipline

Any major breaches of the Site Safety Plan, relevant Statutory Provisions and Safety Codes, or any other blatant disregard for the health and safety by any person directly or indirectly associated with the works may result in the NHIDCL exercising their authority in requiring the removal from the Site of the Contractor's Site Manager and/or other personnel.

- 5.4.1 The Contractors shall develop a system of disciplinary measures and procedures, which shall be implemented immediately that the site activities commence. These measures and procedures should

S-V Tunnel

include amongst other things:

(a) **The issue of Warning Notices.**

(b) The removal from site of personnel who disregard safety instructions.

5.4.2 Any person who is removed from the site for breach of safety measures shall not be allowed to be re-employed on any other NHIDCL worksite.

6.0 Safety Training and Safety Promotion

6.1 Safety Training

6.1.1 Safety Training is an important factor in managing safety on construction sites. All contractors shall provide as a minimum the following types of training:

6.1.2 **Induction Training** shall be given to all persons prior to permitting them to go to the worksite. The workers ID Card should not be issued until this training has been given. This training should include at least the following:

(a) **General safety awareness**

(b) **First aid**

(c) **Emergency procedures**

(d) **Use of personal protective equipment**

(e) **Specific site hazards**

6.1.3 **Refresher Training** shall be conducted at least every three months to ensure that all workers on site are kept up to date with safety requirements on site.

6.1.4 **Specific Training** shall be provided to persons with safety related tasks, such as Crane Operators, Banksmen, Slingers and Plant Operators etc.

6.1.5 **Toolbox Talks** shall be conducted so that every worker on site receives at least two toolbox talks every week. These talks should be designed to highlight relevant safety and industrial health issues to the workforce on a regular basis in order to raise their level of awareness. These should be prepared so that they can be presented by the Site Supervisors. Examples of Toolbox Talks are given in Schedule 4 of this Manual.

6.1.6 All training that is carried out shall be formally recorded on dated and signed attendance records, with copies of the records being kept on the sites for inspection by the Authority's Representative. Details of the respective training course programmes shall be produced, on demand or as per intervals prescribed, which include the following information:

(a) **Course Title.**

(b) **Course Duration.**

(c) **Course Content.**

(d) **Target Audience.**

(e) **Actual Audience with record of attendance. (Use form SAF 031)**

6.1.7 The Contractor shall keep detailed records of all training undertaken, and shall keep such records available for inspection by the Authority's Representative.

6.2 Safety Promotion

6.2.1 The Contractors at each of their sites in the interests of promoting safety awareness amongst the workforce shall devise and implement practical Safety Promotion schemes. The objective of these schemes should be to recognise and reward individuals who continually endeavour to work in a safe manner.

S-V Tunnel

- 6.2.2 Suggestions for such promotions may include such items as the issue of the following as rewards to individuals for good safety performance:
- (a) Key Rings.**
 - (b) T-Shirts**
 - (c) Holdall Bags**
- 6.2.3 Other safety award and safety incentive schemes should be considered
- 6.2.4 Regular Safety and Industrial Health Poster Campaigns / Billboards / Banners / Glowsigns should be devised, with posters displaying safety and industrial health related issues being displayed around the worksites as part of the effort to raise Safety Awareness amongst the workforce. Posters should be in Hindi, English and other suitable language deemed appropriate. Posters / Billboards / Banners / Glowsigns should be changed at least once a month to maintain their impact.
- 7.0 Safety Inspections and follow up action**
- 7.1 Inspections by Contractor's Safety Supervisory Staff**
- 7.1.1 The Contractor's Project Manager and supervisory staff are required to carry out weekly site safety inspections and prepare reports of such inspections. Copies of the completed inspection reports shall be kept on site and available for inspection by the Authority's Representative.
- 7.1.2 The frequency of the inspections shall be determined by site activities and general conditions. However, the inspections should be conducted at a minimum of once a week. Where high-risk activities are being carried out inspections should be carried at least once daily.
- 7.1.3 The inspection reports should be discussed with the relevant Site Managers. These shall also be discussed with the sub-contractors and other levels of site management in the Site Safety Meetings as detailed in Section 8 of this Manual.
- 7.1.4 For each Contract the Contractor shall prepare a comprehensive safety inspection checklist, as a requirement of the Safety Plan. This check-list can then be used for:
- (a) inspections by the Contractor's Safety Officers;**
 - (b) monitoring of the Contractors' safety inspections by the Site Safety Management Committee.**
- 7.1.5 The Authority 's Representative Staff may carry out site safety inspections, which shall be attended by the Contractors' Site Manager and Safety Manager.
- 7.1.6 In relation to Works Contracts, the insurers providing insurance cover for Contractor's All Risks and Third-Party liability may visit the sites with a view to checking whether the Contractors have taken adequate safety precautions against damage to the works.
- 7.2 Follow up actions**
- 7.2.1 Remedial action to rectify any deficiency identified or unsafe practices discovered during the safety inspections should be implemented immediately. Until the remedial action is taken the task may be discontinued.
- 7.2.2 In cases where the Authority's Representative believe that the Contractor's or sub- contractors' workmen are using unsafe working methods, the Contractor's Representative should be informed by them as soon as possible. If the unsafe activity continues, it shall be reported to the Authority's Chief Safety Officer.
- 7.2.3 If the Contractor's working method is deemed so unsafe as to represent a risk to life, the Authority's Representative may require specific actions by the Contractor, such as proposals on preventive/remedial measures, or suspension of relevant portions of the works, and introduction of measures deemed necessary. All such instructions shall be confirmed in writing and shall include a proviso that the issue of the instruction shall not relieve the Contractor of his responsibilities under the Contract or Statutory

obligations. The Authority's Representative may also invoke a fine on the Contractor in accordance with Section 4.1.3.

8.0 Contactor's Site Safety Committees

8.1 General

8.1.1 All employees should be able to participate in the making and monitoring of arrangements for safety and health at their place of work. The establishment of site safety committees in which employees and Contractor and sub-contractor management are represented can increase the involvement and commitment of employees. The Contractor shall set up such site safety committees to promote and monitor safety and health on their worksites. A copy of the agenda shall be forwarded to the Authority's Representative seven days prior to the meeting date, in order that they can decide if it is necessary for them to attend.

8.2 Composition and Functions of Contractor's Safety Committees

8.2.1 The Contractor should form a safety committee for each contract, however should the situation require more than one committee, or the Authority's Representative so requires, additional committees shall be created.

8.2.2 The Terms of Reference for the committee should be as follows;

- (a) to monitor the adequacy of the Contractor's Site Safety Plan and ensure its implementation;**
- (b) to monitor safety inspection reports;**
- (c) to study accident and incident reports;**
- (d) to study accident statistics and trends so as to identify unsafe practices and conditions;**
- (e) to review the emergency and rescue procedures;**
- (f) to review site safety training;**
- (g) to promote safety and industrial health on site;**
- (h) to discuss the Contractor's monthly safety report;**
- (i) to take follow up actions on minutes of meeting.**

8.2.3 The Membership of the committee should be as follows;

Chairman: The Contractor's most Senior Manager for the Contract. Secretary: The Contractor's Safety Officer

Members: Contractor's and Sub-contractors management representatives and safety staff. In attendance as and when they wish,

Representatives of the Authority and the Authority's Engineer.

8.2.4 Meetings should be held at least once every month

8.2.5 Minutes of the Site Safety Committee shall be sent to all members within two working days of the meeting. Copies of the minutes should be displayed on notice boards so that employees are kept informed of the Site Safety Committee's activities and decisions.

9.0 Reporting of Accidents and Dangerous Occurrences

9.1 Contractors Responsibility

9.1.1 All accidents and dangerous occurrences shall be recorded, regardless of whether or not personnel injury occurs.

9.1.2 The Authority and the Authority's Engineer shall be notified by the quickest possible means, for

example by telephone of the following classifications of accidents and incidents and by subsequent written notification within twenty four hours on the Contractors Accident and Incident Reporting Form (for example of form see Schedule 3) :

- (a) Fatal Accident**
- (b) Major Injury Accident (see definition in 3.1.1)**
- (c) Dangerous Occurrence (see definition in 3.1.1)**
- (d) Any Incident Involving A Member Of The Public**

9.1.3 The Site Safety Officer shall conduct in depth investigations into all fatal accidents, major injury accidents, incidents involving a member of the public, dangerous occurrences, and selected over three-day lost time injury accidents. Copies of these investigations shall be forwarded to the Authority and Authority's Engineer within seven days of the incident.

9.1.4 The Contractor shall report immediately, orally and in writing, all fatal accidents, and other occurrences requiring reporting, to the police, at the police station in whose jurisdiction the accident occurred.

9.2 Reportable Accidents

9.2.1 An accident shall also become reportable to the Authority and Authority's Engineer if it causes incapacity for more than three days excluding the day of the accident. The Contractor must submit a report on form SAF 001 to the Authority and Authority's Engineer within seven days of the incident.

9.2.2 The following information is required in reporting an accident to the Authority and Authority's Engineer.

- (a) particulars of the Contractor or Sub-contractor employing the injured person;**
- (b) particulars of the deceased or injured person: name, address, occupation, sex, and age;**
- (c) the date, cause or circumstances of the accident; and**
- (d) the nature of the injury, stating whether death or incapacity was caused by the injury.**

9.3 Dangerous Occurrences

9.3.1 The Authority requires that all dangerous occurrences on site must be reported in writing to him within 24 hours, irrespective of whether there are casualties or not. The following information has to be provided:

- (a) the time of the occurrence;**
- (b) damage to any building, machinery or plant; and**
- (c) the circumstances in which the accident occurred.**

A copy of the standard 'Dangerous Occurrence Report form' SAF 001(as attached to this Manual) may be used.

9.3.2 If no one is injured, the above notification is sufficient. In the case of death or serious injury, the accident reporting procedure outlined in Section 9.1.2 must also be followed.

9.4 Reporting of Fires by Contractor

9.4.1 The Contractor shall report to the Authority's Representative all fires which occur on site including any fires that have been extinguished by the Contractor himself, and the Authority may send staff to investigate such fires. The following information should be provided:

- (a) time of fire;**
- (b) location of fire;**
- (c) means of extinguishing the fire;**

- (d) injury to any person/damage to any property; and
- (e) the probable cause of fire.

This action is in addition to reporting the incident to the Fire Officer of the District, and Police in accordance with local regulations.

9.5 Reporting to the Authority's Representative

- 9.5.1 The Contractor shall duly complete standard forms on dangerous occurrences and accidents as required by the Authority's Representative to enable the Authority's Engineer to prepare a database on accident statistics. The Contractor shall deliver to the Authority's Representative a copy of any statutory reports he submits to the Relevant Authorities.
- 9.5.2 The Contractor shall send a monthly report to the Authority's Representative of all accidents and dangerous occurrences whether they are of a serious nature or not.

10.0 Accident Investigation

10.1 General

- 10.1.1 Investigations should be conducted in an open and positive atmosphere that encourages the witnesses to talk freely. The primary objective is to ascertain the facts with a view to prevent future and possibly more serious occurrences. Accidents are rarely just the fault of the worker. If the worker has not been trained, instructed or properly supervised then the fault may well lie with management.
- 10.1.2 Accidents and Dangerous Occurrences which result in death, serious injury or serious damage must be investigated by the Contractor immediately to find out the cause of the accident/occurrence so that measures can be formulated to prevent any recurrence. (Refer to the advice contained in 10.2.1 below.)
- 10.1.3 Near misses and minor accidents should also be recorded and investigated by the Contractor as soon as possible as they are signals that there are inadequacies in the safety management system.

10.2 Recommended actions in incident investigation

- 10.2.1 It is important after any Accident or Dangerous Occurrence that information relating to the incident is gathered in an organised way. The following steps are recommended;

- (a) **take photographs and make sketches**
- (b) **examine involved equipment, workpiece or material and the environmental conditions**
- (c) **interview the injured, eye-witnesses and other involved parties**
- (d) **consult expert opinion where necessary**
- (e) **identify the specific Contractor or Sub-contractor involved.**

- 10.2.2 Having gathered information, it is then necessary to make an Analysis of Incident

- (a) **establish the chain of events leading to the accident or incident**
- (b) **find out at what stage the accident took place**
- (c) **consider all possible causes and the interaction of different factors that led up to the accident, and identify the most probable cause**

Note: The cause of an accident should never be classified as carelessness. The specific act or omission that caused the accident must be identified.

- 10.2.3 The next stage is to proceed with the Follow-up Action

- (a) **report on the findings and conclusions**
- (b) **formulate preventive measures to avoid recurrence**
- (c) **publicise the findings and the remedial actions taken**

S-V Tunnel

11.0 Accident Statistics

11.1 Introduction

11.1.1 Accident data, if properly collected and analysed, indicates trends, and can show where and how problems arise. Comprehensive accident information enables accident prevention efforts to be targeted at problem areas.

11.2 Collection of Accident Statistics

11.2.1 The procedures that apply for the reporting and collation of data in respect of accident statistics are set out below.

11.2.2 The Contractors' safety officers are required to send duly completed Report Forms (Refer to Schedule 3 – SAF 002 and SAF 003), to the Authority and Authority's Engineer **within five days after the end of each month**. The Construction Accident Statistics Monthly Report Form must be submitted even if there are no injuries or dangerous occurrences within the current month.

11.2.3 Man-hours' is defined as the man-hours worked by all persons employed on site. (including site supervisory staff, management staff and clerical staff).

11.2.4 'Man-days' is defined as the man-days worked by all persons employed on site. (including site supervisory staff, management staff and clerical staff).

11.3 Calculation of man-days lost - Construction Accident Statistics

11.3.1 When calculating the man-days lost for the Construction Accident Statistics Summary Sheet, the following applies:

The number of man-days lost refers to the total number of man-days lost during the reported month due to :

(a) non-fatal reportable accidents which happened within the reported month

(b) non-fatal reportable accidents which occurred in previous months.

the day on which the reportable accident occurred should be excluded in calculating man-days lost but public holidays within the injured period should be counted.

11.4 Calculation of Accident Frequency Rate (AFR)

The Accident Frequency Rate (AFR) per 100,000 man-hours worked shall be calculated using the following formula

$$\left\{ \frac{\text{No. of reportable accidents}}{\text{Man-hours worked}} \right\} \times \frac{100,000}{\text{Man-hours worked}}$$

A reportable accident is a Fatality, a Major Injury Accident as defined in 9.4.1, and reportable accidents as defined in 9.2.1

12.0 Hazard Identification and Risk Assessment

12.1 General

12.1.1 The purpose of Hazard Identification and Risk Assessment is to identify all the significant hazards, which may occur during the construction phase, and to rank them according to their severity. Having ranked the risks by severity the Contractor shall then introduce measures to mitigate the effects of that risk.

12.1.2 Prior to the commencement of any potential High-Risk operations the Contractor shall conduct a detailed hazard analysis and risk assessment of the task and shall record his findings on appropriate worksheets. Examples of worksheets SAF 020 may be found in Schedule 3.

S-V Tunnel

- 12.1.3 The worksheets should then show what measures the Contractor is going to take to reduce the level of risk to acceptable levels.

12.2 Method Statements

- 12.2.1 As a result of the Hazard Identification and Risk Assessment detailed method statements shall need to be produced for medium and high risk activities including amongst others the following:

- (a) **Craneage of items in excess of 1 tonne**
- (b) **Erection of steel structures.**
- (c) **Excavations deeper than 2m.**
- (d) **Erection and loading of formwork**
- (e) **Demolition.**
- (f) **Tunnelling operations.**
- (g) Inflammable materials – the use and storage
- (h) Use and storage of explosives

A component part of the detailed method statement shall be the inclusion of the completed Hazard and Risk Worksheet as discussed in Section 12.1 above.

- 12.2.2 Method Statements will usually be attached to Design Submissions but should be cross-referenced to the Contractor's Site Safety Plan.

- 12.2.3 A method statement should contain sufficient information to enable the task to be undertaken safely and should contain as a minimum the following information

- (a) **Introduction – A brief outline of the Task**
- (b) Details of the Risks involved
- (c) A step by step description of how the task is to be undertaken detailing
 - what needs to be done;
 - the order in which the task will be carried out;
 - what plant or equipment is required;
 - who the task will be done by;
 - who will supervise the task;
 - where will the task take place;
 - when will the task take place;
 - the precautions which must be taken before the task is undertaken;
 - what to do if things go wrong;

12.3 Permits to Work

- 12.3.1 The Contractor shall develop a permit-to-work system, which is a formal written system used to control certain types of work that are potentially hazardous. A permit-to-work is a document, which specifies the work to be done, and the precautions to be taken. Permits-to-work form an essential part of safe systems of work for many construction activities. They allow work to start only after safe procedures have been defined and they provide a clear record that all foreseeable hazards have been considered. Permits to Work are usually required in high-risk areas as identified by the Risk Assessments.

- 12.3.2 A permit is needed when construction work can only be carried out if normal safeguards are dropped or when new hazards are introduced by the work. Examples of high risk activities include but are not

limited to:

- (a) Work close to 25kV overhead lines**
- (b) Entry into Confined Spaces. (SAF 010)**
- (c) Work in Close Proximity to Overhead Power lines and Telecommunication Cables.**
- (d) Hot Work. (SAF 012)**
- (e) To Dig—where underground services may be located.**
- (f) Work with moving construction locomotives.**
- (g) Working On Electrical Apparatus. (SAF 011)**
- (h) Work with Radioactive isotopes.**

12.3.3 The permit-to-work system should be fully documented, laying down:

- (a) how the system works;**
- (b) the jobs it is to be used for;**
- (c) the responsibilities and training of those involved; and**
- (d) how to check its operation;**

12.3.4 The permit-to-work form must help communication between everyone involved. It should be designed by the Contractor issuing the permit, taking into account individual site conditions and requirements. Separate permit forms may be required for different tasks, such as hot work and entry into confined spaces, so that sufficient emphasis can be given to the particular hazards present and precautions required.

12.3.5 The permit to work form should contain:

- (a) clear identification of who may authorise particular jobs (and any limits to their authority);**
- (b) clear identification of who is responsible for specifying the necessary precautions (e.g. isolation, emergency arrangements, etc);**
- (c) a detailed description of the task clearly identifying the work to be done and the associated hazards;**
- (d) plans and diagrams be used if appropriate to assist in the description of the work to be done, its location and limitations;**
- (e) identity of the hazards and the precautions to be taken;**
- (f) clear rules about how the job should be controlled or abandoned in the case of an emergency;**
- (g) the time limitations should be stated;**
- (h) job specific toolbox talk conducted by the supervisor**

12.3.6 A Permit To Work authorisation form shall be completed with the maximum duration period not exceeding twenty four hours (for example of a Permit To Work authorisation form see Schedule 3)

12.3.7 A copy of each Permit To Work shall be displayed, during its validity, in a conspicuous location in close proximity to the actual works location to which it applies.

12.3.8 A pre-permit activation job specific toolbox talk shall be conducted by the supervisor including amongst others the following.

- (a) All identified hazards are explained;**
- (b) Risk mitigation process clarified;**

S-V Tunnel

- (c) Method of work explained stressing points (a) and (b) above;
- (d) Emergency response procedure is clarified and persons assigned tasks in the event of an emergency;
- (e) PPE requirements including PPE serviceability checks and training if required; All workers and supervision shall attend the toolbox talk and sign the toolbox attendance register. Any person/s coming late to the work site shall be given the toolbox talk and sign the attendance register

A copy of the toolbox talk and attendance register shall be displayed as per section 12.3.7 of this manual.

13.0 Emergency Preparedness Plans

13.1 Emergency Situations

13.1.1 Every Contractor shall formulate an Emergency Preparedness Plan for each of his sites. These plans will address foreseeable emergencies that may arise during the construction activities. Examples of activities for which plans should be prepared include amongst other things:

- (a) An Accident Which Results In Death or Major Injury. (Major Injury as defined in Section 9.1.7)**
- (b) A Serious Fire That Threatens Life.**
- (c) A Flood That Threatens Life.**
- (d) Leakage of Any Dangerous Materials or Chemicals.**
- (e) Leakage / Short Circuit of any Electrical supply.**
- (f) Major Engineering Failures such as:**
 - collapse of tunnels or structures
 - major utility collapse
 - unintended explosions
 - subsidence causing damage to structures or services

13.1.2 An Emergency Preparedness plan should include details of the following;

- (a) The name, location and phone number of the Emergency Co-ordinator;**
- (b) Designated Personnel with locations and phone numbers;**
- (c) Details of the Emergency Response Team with locations and phone numbers;**
- (d) Functions of the Emergency response Team;**
- (e) The means of Escape;**
- (f) Communication with the Emergency Services;**
 - Police
 - Fire Services
 - Ambulance and Hospital Services
- (g) First-Aid Facilities;**
- (h) Site plans;**
- (i) Suppliers of emergency equipment such as sump pumps, lighting, craneage, etc.**

13.1.3 Copies of the emergency procedures and the Contractor's rescue organisation (reviewed without objection by the Authority's Representative) should be displayed at each place of work and notice

S-V Tunnel

boards. This information should be reviewed and updated as often as is required, but at least once annually. Drills should be arranged to test the efficiency in mobilising the necessary personnel and equipment. These Drills should be carried out at least every three months.

- 13.1.4 Regular joint exercises between the Contractor's rescue teams and the Fire and Emergency Services should also be carried out for the major contracts.

14.0 Safety Signage

14.1 Safety Signs

- 14.1.1 All safety signage that is displayed in and around the sites shall be in both Hindi and English, examples of signs that shall be required shall include amongst others the following:

- (a) **Wear Safety Helmets.**
- (b) **Permit to Work areas**
- (c) **Wear Safety Footwear.**
- (d) **Wear Hearing Protection.**
- (e) **Wear Eye Protection.**
- (f) **Danger Electricity.**
- (g) **Danger Crane Overhead.**
- (h) **Stop Look and Listen**
- (i) **No Smoking.**
- (j) **First Aid.**
- (k) **No Entry signs**
- (l) **Fire precautions.**
- (m) **Emergency Exit from underground works**

- 14.1.2 All safety signs shall comply with the internationally recognised Safety Colours as indicated below:

- **Blue** **Mandatory.**
- **Yellow** **Danger.**
- **Red** **Prohibition.**
- **Green** **Safe Condition.**

14.2 References

Indian Standards

IS 9457 Standard for colours of Safety Signs IS 12349: 1988 Fire Protection - Safety Signs

15.0 Industrial Health and welfare

15.1 Introduction

- 15.1.1 Hazards to Health on a construction site can arise from the use of a number of materials, substances and processes if they are not properly controlled. Some of the more serious risks are caused by the inhalation of dusts, fibres, toxic fumes, by the misuse of chemicals, lasers and radioactive isotopes. Excessive vibration and excessive noise can also cause ill health. Many man- days are lost as a result of dermatitis, tenosynovitis, bronchitis and rheumatism.

- 15.1.2 The Contractor shall be responsible for maintaining healthy working conditions for all his, and his sub-

S-V Tunnel

contractors, workers. In particular he shall pay attention to the effects of noise, dust, air pollution and the use of chemicals. If it is not possible to remove the cause of harm then suitable and sufficient Personal Protective Equipment (PPE) should be provided to those workers who could be affected.

- 15.1.3 If the use of PPE is the only means of providing protection the Contractor shall ensure that all the workers affected are properly trained in the use of the PPE and that adequate supervision is provided to ensure its proper use.

15.2 Hazardous Substances

- 15.2.1 The Contractor shall obtain Material Safety Data Sheets (MSDS) for all substances that are deemed to be hazardous to be used on site. An inventory shall be kept of all such materials with the relevant MSDS and shall be available for inspection by the Authority's Representative who may require further MSDS's to be obtained.
- 15.2.2 The Contractor shall conduct an assessment of the substance in relation to its intended usage on site. Particular attention must be given to the actual location of usage as a substance, which is safe for use in the open air, may be extremely hazardous in a confined space. The results of all assessments shall be recorded and method statements produced. (For an example of a Hazardous Substance Assessment Form see Schedule 3)
- 15.2.3 The objective of the assessment is to establish what precautions and control measures shall be implemented in order that a safe system of work can be established for the use of the substance on site.

15.3 Noise

- 15.3.1 Industrial deafness is caused by over exposure to high levels of noise from plant, machinery or construction processes. Once a part of a persons hearing has been lost it can never be recovered. Deafness can also lead to further accidents on site with workers being unable to hear warnings and other instructions.
- 15.3.2 For continuous exposure, i.e. for eight hours in any one-day, the sound level should not exceed 90 dB (A). For non-continuous exposure a calculated equivalent continuous sound level (Leq) should not exceed 90 dB (A). Workers should not be exposed to sound levels exceeding 90 dB (A) unless they are wearing suitable hearing protectors, which effectively reduce the sound level at the user's ear to, or below, 90 dB (A).
- 15.3.3 If Peak noise levels exceed 120 dB (A) then the wearing of suitable hearing protectors shall be Mandatory.
- 15.3.4 The Contractor shall carry out noise assessments to establish what noise levels his workers are being exposed to. If excessive noise levels above 90 dB (A) are found then the contractor shall introduce a noise control programme to protect his workers.
- 15.3.5 Consideration should always be given first to reducing the noise level at source. Examples of noise reduction methods include;
- (a) More efficient silencers on compressors and maintenance of exhaust systems;**
 - (b) Fitting acoustic lining to machinery panels;**
 - (c) Use of Acoustic screens and sheds to protect other workers;**
 - (d) Using noise reduced tools;**
 - (e) Sighting of noisy plant away from the workplace**
- 15.3.6 Where it is not possible to reduce the noise level to which the worker is exposed the Contractor shall provide the workers with suitable and sufficient hearing protection to protect them. The Contractor shall ensure that all the workers affected are properly trained in the use of the Hearing Protection and that adequate supervision is provided to ensure its proper use.

15.4 Ventilation in Shafts and Tunnels

- 15.4.1 The contractor shall assign a Competent Person to perform all air monitoring required to determine proper ventilation and quantitative measurement of potentially hazardous gases. The atmosphere in all underground areas shall be tested quantitatively by the contractor for toxic gases, dust, vapour, mist, and fumes as often as necessary to ensure that prescribed limits given at 15.4.3 below are met. Quantitative tests for methane shall also be performed in order to determine whether an operation is potentially hazardous. For every test carried out the contractor shall maintain a record of the air quality the location, date, time, substances and amount monitored. These records shall be made available to the Authority's Representative on demand.
- 15.4.2 The ventilation system shall be adequate to maintain circulation of air in all parts of tunnels and shafts and following conditions shall be taken care of:
- 15.4.3 Air shall be considered unfit for workmen to breathe if it contains any of the following :
- (a) **Less than 19.5% oxygen by volume.**
 - (b) **More than 0.005% carbon dioxide by volume.**
 - (c) **More than 0.01% carbon monoxide by volume.**
 - (d) **More than 0.001% hydrogen sulphide by volume.**
 - (e) **More than 0.005% oxides of nitrogen.**
 - (f) **More than 0.5% of methane at any place in the tunnel.**
 - (g) **More than 0.0002% of aldehyde.**
 - (h) **Any other poisonous gas in harmful amounts.**

In addition to the requirements given above, 2 m³ of fresh air per minute shall be furnished for each brake horsepower of diesel engine used in the tunnel.

- 15.4.4 The Contractor will ensure the supply of fresh air to all underground work areas in sufficient amount to prevent any harmful accumulation of dust, vapour or gases. The contractor shall provide at least 4.25 m³ of fresh air per minute per employee underground.
- 15.4.5 No inflammable materials or oil and grease shall be stored inside or near the tunnels or shafts and all combustible rubbish from the tunnel or shaft shall be promptly removed. A regular analysis of the gases inside the tunnel should be done with advance of the tunnel.
- 15.4.6 Tools made of light alloys (such as Al and Mg) are not to be used inside the tunnel. They may cause sparks.
- 15.4.7 Regular checking of gas (referred at 15.4.3) at the faces shall be done before each shift. This should be carried out using a multi gas detector.
- 15.4.8 Motive power other than electric, shall not be used without prior authorisation from the Authority's Representative. No petrol engines shall be used underground. Diesel locomotives shall only be used with the prior consent of the Authority's Representative. Diesel engines shall not be used underground unless equipped with a filter that will remove all carbon monoxide and oxides of nitrogen. Such filters shall be tested by the Contractor's chief mechanic and more frequently by the plant operator.

15.5 Toilets

- 15.5.1 The Contractors shall ensure that an adequate number of toilets are made available at the work sites with the ratio being no less than one toilet for every 50 workers or part thereof. The toilets shall be located so that persons do not have to walk more than five hundred metres to use them.
- 15.5.2 The toilets shall have adequate water supply and be kept in a clean and tidy condition at all times.

15.6 Drinking Water

S-V Tunnel

- 15.6.1 The Contractors shall ensure that effective arrangements are made to provide and maintain at suitable points a sufficient supply of wholesome drinking water.
- 15.6.2 All such points shall be legibly marked “Drinking Water” in Hindi and English and no such point shall be situated within six metres of any washing place, urinal or latrine.

15.7 Lifting and Carrying of Excessive Weights

- 15.7.1 All contractors shall ensure that no worker lifts by hand or carries overhead or over his back or shoulders any material, article, tool or appliances exceeding in weight the maximum limits set out below unless aided by another worker or a mechanical device.

Adult – man 55kg

Adult – female 30kg

15.8 References Indian Standards

IS 4756 : 1978 Safety Code for Tunnelling works

IS 1179 : 1967 Specification for equipment for eye and face protection during welding
IS 2925 : 1984 Specification for Industrial Safety Helmets

British Standards

BS EN 352: Hearing protectors. Safety requirements and testing 352-1: 1993; Ear muffs

352-2 : 1993: Ear plugs

352-3 : 1997: Earmuffs attached to an industrial safety helmet.

16.0 Working at height

16.1 General

- 16.1.1 Working at height is the largest single cause of serious accidents in the construction industry and therefore the Contractor shall carry out risk assessments for all work where workers or materials can fall more than two metres.
- 16.1.2 Where work is being carried out above areas where there is public access such as roads footpaths etc. particular care must be taken to ensure that no materials can fall from the working area.
- 16.1.3 Edge protection shall be provided at all leading edges or openings where workers or materials can fall more than two metres. Edge protection shall meet the minimum standard of;
- a) a main guardrail at least 1 metre above the edge
 - b) a toe board at least 200 mm high; and
 - c) an intermediate guard rail or other barrier so that there is no gap more than 470 mm.

16.2 Use of Scaffolds

- 16.2.1 All scaffolds should be erected and dismantled by workmen who are thoroughly experienced in the erection and dismantling of scaffolding.
- 16.2.2 All scaffolds should be inspected by a competent person at least every three days after erection and the results of inspections recorded and the records shall be kept available for checking by the Authority's Representative.
- 16.2.3 Tags shall be fitted to all scaffolds to show whether they are safe for use or not. All Safe for Use tags shall be signed by a senior site engineer from the contractor.
- 16.2.4 All scaffolds shall be constructed of sound materials free from patent defect.
- 16.2.5 The following measures shall be taken;

S-V Tunnel

- (a) the scaffold shall be constructed for the correct use (Light or Heavy Duty)
- (b) securely fixed to existing structures or adequately buttressed;
- (c) the use of barrels, boxes, loose tiles or other unsuitable material shall not be used as supports for working platforms;
- (d) all working platforms shall be fully boarded;
- (e) all working platforms shall have guard rails at one metre height and shall also have an intermediate rail at half height;
- (f) all working platforms shall be provided with toe boards;
- (g) all working platforms shall be kept free of unnecessary obstruction or rubbish
- (h) secure ladder access shall be provided;

16.3 Use of Ladders

- 16.3.1 All ladders shall be of sound construction and shall be free from patent defect.
- 16.3.2 Ladders should be checked weekly and defective ladders shall be promptly and properly repaired or replaced.
- 16.3.3 Ladders shall not be used as working platforms but may be used for work of short duration of up to thirty minutes.
- 16.3.4 Metal ladders shall not be used near or adjacent to overhead power lines unless they have been certified dead under a permit to work system.
- 16.3.5 Ladders shall;
 - (a) **be secured at the top or footed at the bottom to prevent slippage;**
 - (b) not be used if any rung is missing;
 - (c) not be used for any other purpose than to provide access;
 - (d) be set at an angle of seventy five degrees unless designed for vertical access;
 - (e) all vertical ladders shall be fitted with hoops to prevent falls;

16.4 Safety Harnesses / Fall Arresters

Where it is not possible to provide a safe working platform then the use of safety harnesses may be considered. If safety harnesses are used they should be of the full body type and secure anchorage points shall be provided and used. Workers must be instructed in the proper use of harnesses.

16.5 References

Indian Standards;

- IS 3696 (Part 1) : 1987 Safety Code for Scaffolds and Ladders, Part 1, Scaffolds IS 3696 (Part 2) : 1991 Safety Code for Scaffolds and Ladders, Part 2, Ladders
- IS 13416 (Part 1):1992 Recommendations for preventive measures against hazards in the workplace, Part 1, Falling material hazards protection
- IS 13416 (Part 2):1992 Recommendations for preventive measures against hazards in the workplace, Part 2, Fall protection

British Standards

- BS EN 354: 1993: Personal protective equipment against falls from a height. Lanyards
- BS EN 355: 1993: Personal protective equipment against falls from a height. Energy absorbers
- BS EN 358: 1993: Personal equipment for work positioning and prevention of falls from a

height. Work positioning systems

BS EN 360:	1993: Personal protective equipment against falls from a height. Retractable type fall arresters
BS EN 361:	1993: Personal protective equipment against falls from a height. Full body harnesses
BS EN 362:	1993: Personal protective equipment against falls from a height. Connectors
BS EN 363:	1993: Personal protective equipment against falls from a height. Fall arrest systems
BS EN 364:	1993: Personal protective equipment against falls from a height. Test methods
BS EN 365:	1993: Personal protective equipment against falls from a height. General requirements for instructions for use and for marking
BS EN 795:	1997: Protection against falls from a height. Anchor devices. Requirement and testing

17.0 Excavations

17.1 General

- 17.1.1 Excavation is one of the important phases of any construction activity. Due to insufficient attention to the safety aspects it frequently becomes the cause of many accidents. Contractors are therefore required to plan and execute all excavations in a safe manner.
- 17.1.2 The contractor shall ensure that all excavations are supervised by workers with thorough knowledge and experience of excavation work.
- 17.1.3 The integrity of the excavation and the support system shall be inspected prior to the commencement of any works on a daily basis with the results of the inspections being formally recorded. All such records shall be kept available for inspection by the Authority's Representative.
- 17.1.4 Where there is the possibility of any ingress of water then pumping sumps shall be established with pumps being readily available for use and additional ladders placed for use in the event of an emergency evacuation.

17.2 Planning

- 17.2.1 The correct planning of excavations is essential for safety and before digging any excavations Contractors should plan against the following;
 - (a) **collapse of the sides;**
 - (b) **materials falling onto people working in the excavation;**
 - (c) **people and vehicles falling into the excavation;**
 - (d) **people being struck by plant;**
 - (e) **undermining nearby structures;**
 - (f) **contact with underground services;.**
 - (g) **fumes; and**
 - (h) **Make sure the necessary equipment needed such as trench sheets, props, etc, are available on site before work starts.**

17.3 General Precautions

- 17.3.1 The following precautions should be observed;
 - (a) **Prevent the sides and the ends from collapsing by battering them to a safe angle or supporting them with timber, sheeting or proprietary support systems.**

- (b) Do not go into unsupported excavations.
- (c) Never work ahead of the support.
- (d) Remember that even work in shallow trenches can be dangerous. You may need to provide support if the work involves bending or kneeling in the trench.
- (e) Prevention of materials falling into excavations
- (f) Do not store spoil or other materials within one metre of the sides of excavations. The spoil may fall into the excavation and the extra loading will make the sides more prone to collapse.
- (g) Make sure the edges of the excavation are protected against falling materials. Provide toe boards where necessary.
- (h) Wear a hard hat when working in excavations.
- (i) Take steps to prevent people falling into excavations. If the excavation is 2 m or more deep, provide substantial barriers, e.g. guard rails and toe boards.
- (j) Keep vehicles away from excavations wherever possible. Use brightly painted baulks or barriers where necessary.
- (k) Where vehicles have to tip materials into excavations, use stop blocks to prevent them from over-running. Remember that the sides of the excavation may need extra support.

17.4 Undermining nearby structures

17.4.1 The following precautions should be taken to prevent the undermining of nearby structures;

- (a) Make sure excavations do not affect the footings of scaffolds or the foundations of nearby structures. Walls may have very shallow foundations, which can be undermined by even small trenches.
- (b) Decide if the structure needs temporary support before digging starts. Surveys of the foundations and the advice of a structural engineer may be needed.

17.5 Avoiding underground services

17.5.1 The following precautions should be taken to avoid underground services;

- (a) Look around for obvious signs of underground services, e.g. valve covers or patching of the road surface.
- (b) Use locators to trace any services. Mark the ground accordingly.
- (c) Make sure that the person supervising excavation work has service plans and knows how to use them. Everyone carrying out the work should know about safe digging practices and emergency procedures.
- (d) Operate a “Permit to Dig” system.

17.6 References Indian Standards

IS 3764 : 1992 Excavation Work – Code of Safety

IS 13430 : 1992 Safety during additional construction to existing buildings – Code of Practice. IS 2314 : 1986 Steel Sheet Piling sections

IS 5121 : 1969 Safety Code for Piling and Other Deep Foundations

18.0 Lifting operations

18.1 Lifting Appliances:

18.1.1 The Contractor shall ensure that all lifting appliances, including synchronised mobile jacks, pit jacks,

mobile cranes, tower cranes, gantry cranes, launching beams and lorry mounted cranes, prior to being allowed to work on site shall have available for inspection by the Authority's Representative a current Certificate of Inspection issued by a Competent Person approved by NHIDCL.

- 18.1.2 All lifting appliances with a lifting capacity of more than one tonne shall, where practicable, be fitted with Automatic Safe Load Indicators and Audible Warning Devices which shall be kept in an operable condition at all times the lifting appliance is in use. Checks should be made to ensure that the Automatic Safe Load Indicator is properly calibrated and is functioning properly.
- 18.1.3 All lifting appliances shall be maintained in accordance with the manufacturer's instructions and shall be subject to a regular preventative maintenance programme.
- 18.1.4 All lifting appliances shall be inspected every three months by a third party competent person approved by NHIDCL. Certificates of Inspection shall be available with the lifting appliance and a copy shall also be sent to the Employers Representative.
- 18.1.5 The operators of lifting appliances shall conduct daily inspections of their respective lifting appliances with the results of the inspections being recorded and kept available for inspection by the Authority.
- 18.1.6 The Contractor shall ensure that only thoroughly trained and experienced persons aged twenty-one years and over are allowed to operate lifting appliances.

18.2 Lifting Gear:

- 18.2.1 Lifting Gear includes chain slings, rope slings, or similar gear and a ring, link, hook, plate clamp, shackle, swivel or eye bolt.
- 18.2.2 The Contractor shall ensure that all lifting gear shall be in good condition and shall be tested and certified every six months, with the Safe Working Load being stamped or clearly displayed upon it. Records of test shall be kept available for inspection by the Authority's Representative.
- 18.2.3 All lifting gear shall be visually inspected before any use and if any defects are found then it shall be removed from site or dismantled / disabled in order to ensure that it is not used in a defective state.
- 18.2.4 All lifting gear shall be properly stored and not left lying on the ground where it could be damaged or used in an unsafe manner.

18.3 Lifting Operations:

- 18.3.1 The Contractor shall ensure that during the course of any lifting operations the following minimum requirements shall be followed:

- (a) All lifting operations shall be under the control of a competent "Lifting Supervisor" appointed by the contractor.**
- (b) Only thoroughly trained and experienced crane drivers shall be allowed to operate cranes.**
- (c) Only thoroughly trained and experienced slingers and riggers shall be allowed to sling loads and give directions to crane operators.**
- (d) A standard code of hand signals shall be adopted for controlling the movements of the crane and both the driver and the signaller shall be thoroughly familiar with the signals.**
- (e) The driver of the crane shall respond to signals from only the appointed signaller but shall obey the stop signal at any time no matter who gives it.**
- (f) Before commencing any lifting operations the ground conditions on which the crane is to stand shall be investigated in order to ensure that the load bearing capabilities are adequate.**
- (g) The weight of the load must be known to the crane driver and the slinger/rigger before lifting commences.**

- (h) No loads are to be slewed over public areas without stopping pedestrians and vehicles first.
- (i) No unauthorised persons are allowed into the lifting zone.
- (j) No person is allowed to ride the hook of the crane or the loads being lifted.
- (k) Any areas where a minimum clearance of six hundred millimetres from the rear of the slewing kentledge of the crane cannot be achieved and where persons could be trapped against obstacles then a fence shall be erected to prevent access.
- (l) All crane hooks shall be fitted with an operable safety catch.
- (m) Wherever practicable all loads shall have tag-lines attached in order to ensure that the load can be controlled at all times.
- (n) Provision shall be made to ensure that the lifting slings or chains can be safely removed from the loads once they have been landed.
- (o) All lifted loads and stacked materials shall be left in a secure and stable condition at all times.
- (p) Whenever working close to isolated overhead power-lines the lifting appliances shall be grounded to earth as a secondary precaution against accidental energisation.
- (q) No close working to any live overhead power-lines is permitted without the operation of a strict Permit to Work system being in place.

18.3 References Indian Standards

IS 807 : 1976 Code of Practice for the design, manufacture and testing of cranes
IS 7293 : 1974 Safety Code for working with Construction Machinery;

IS 13583 : 1993 Code of Practice for training of Crane Drivers Part 1 General

British Standards

BS 7121: Code of practice for safe use of cranes

BS 7262: 1990: Specification for automatic safe load indicators

19.0 Work in Confined Spaces

19.1 General

19.1.1 The term 'confined space' has two defining features. Firstly, it is a place which is substantially (though not always entirely) enclosed and, secondly, there will be a reasonably foreseeable risk of serious injury from hazardous substances or conditions within the space or nearby.

19.1.2 Some confined spaces are fairly easy to identify, for example, closed tanks and sewers. Others are less obvious but may be equally dangerous, for example closed and unventilated or inadequately ventilated rooms and silos, ducts, culverts, tunnels, boreholes, bored piles, manholes, shafts, excavations, sumps, inspection pits, cofferdams, and building voids.

19.2 The hazards

19.2.1 The most likely hazards are as follows:

- (a) **Flammable Substances and Oxygen Enrichment;**
- (b) **Toxic Gas, Fume or Vapour;**
- (c) **Oxygen deficiency;**
- (d) **The Ingress or Presence of Liquids;**
- (e) **Presence of Excessive Heat,**

(f) Excessive Humidity.

19.2 Entry Procedures

19.2.1 Contractors will ensure that no work will be undertaken in Confined Spaces unless a Permit to Work, see Section 12.3, has been prepared and issued.

19.2.2 Only persons who have been thoroughly trained, experienced and are physically fit shall be allowed to work in Confined Spaces.

19.2.3 Persons with any of the following medical conditions shall not be allowed to work in confined spaces:

- (a) a history of fits, blackouts or fainting attacks,**
- (b) a history of heart disease or disorder,**
- (c) high blood pressure,**
- (d) asthma bronchitis, or shortness of breath on exertion,**
- (e) deafness**
- (f) meniers disease or disease involving giddiness or loss of balance,**
- (g) claustrophobia or nervous or mental disorder,**
- (h) back pain or joint trouble that would limit mobility in confined spaces,**
- (i) deformity or disease of the lower limbs limiting movement.**
- (j) Chronic skin disease,**
- (k) Serious defects in eye sight or lack of sense of smell**

19.2.4 No smoking shall be allowed in or within 2 metres of the opening to any confined space and suitable warning signs shall be positioned.

19.2.5 Before any confined space work commences the following equipment shall be available for use:

- (a) Multi Gas Monitor; or other suitable gas monitoring equipment.**
- (b) Sufficient sets of Self Contained Breathing Apparatus to enable rescue to be carried out;**
- (c) Full Body Type Harness for each worker;**
- (d) Tripod and Lifeline Hoist Rope; for work in situations where a vertical exit from the confined space is required.**
- (e) Flame-proof lighting. (Hand lamps not more than 24 volts.);**
- (f) Resuscitation Equipment;**
- (g) Ventilation Equipment.**

The persons involved in the confined space working operations shall need to be thoroughly trained and certified as being competent in the use of the above detailed item of equipment.

19.3 References Indian Standards

IS 11972 : 1987 Code of Practice for safety precautions to be taken when entering a sewerage system

20.0 Site Electricity

20.1 General

20.1.1 The Contractor shall nominate a representative whose name and qualifications shall be submitted in writing to the Authority's Representative for review not later than 4 weeks before the appointment and who shall be solely responsible for ensuring the safety of all temporary electrical equipment on Site. The Contractor shall not install or operate any temporary Site electrical systems until this representative

S-V Tunnel

is appointed and has commenced duties.

- 20.1.2 The name and contact telephone number of the representative having been reviewed without objection by the Authority's Representative shall be displayed at the main distribution board for the temporary electrical supply so that he can be contacted in case of an emergency.
- 20.1.3 The Contractor shall submit schematic diagrams and the details of the equipment for all temporary electrical installations, and these diagrams together with the temporary electrical equipment shall be submitted to the Authority's Representative for review.
- 20.1.4 All electrical installation work on Site shall be carried out in accordance with the requirements laid down in the Specification. All work shall be supervised or executed by qualified and suitably categorised electricians.
- 20.1.5 All Temporary Electrical Site installations and distribution systems shall as a minimum meet IP44 standards and be in accordance with:-

- (a) Indian Electrical Regulations;**
- (b) The Power Companies' Supply Rules;**
- (c) BS 7671 Requirements for electrical installation, the IEE Wiring Regulations (16th Edition);**
- (d) BS 7375 Distribution of Electricity on Construction and Building Sites;**
- (e) BS 4363 Distribution Assemblies for Electricity Supplies for Construction and Building Sites; and**
- (f) BS 6164 Safety in Tunnelling in the Construction Industry.**

20.2 Design Considerations

- 20.2.1 Distribution equipment utilised within the temporary electrical distribution system shall incorporate the following features:-
 - (a) flexibility in application for repeated use;**
 - (b) suitability for transport and storage;**
 - (c) robust construction to resist moisture and damage; and**
 - (d) safety in use.**
- 20.2.2 All cabling shall be run at high level whenever possible and firmly secured to ensure it does not present a hazard or obstruction to people and equipment.
- 20.2.3 The installation on Site shall allow convenient access to authorised and competent operatives to work on the apparatus contained within.

20.3 Distribution of supply

- 20.3.1 The Site mains voltage shall be as the Electricity Utility supplies, 415V 3-phase 4-wire system.
 - (a) Single-phase voltage shall be as the Electricity Utility supplies, 240V supply.**
 - (b) Reduced voltages shall conform to BS 7375.**
- 20.3.2 The following voltages shall be adhered to for typical applications throughout the distribution systems:
 - (a) fixed plant - 415V 3 phase;**
 - (b) movable plant fed by trailing cable - 415V 3 phase;**
 - (c) installations in Site buildings - 240V 1 phase;**
 - (d) fixed flood lighting - 240V 1 phase;**

S-V Tunnel

- (e) portable and hand held tools - 110V 1 phase;**
- (f) Site lighting (other than flood lighting) - 110V 1 phase; and**
- (g) portable hand-lamps (general use) - 110V 1 phase.**

20.3.3 When the low voltage supply is energised via the Employer's transformer, any power utilised from that source shall be either 415V 3 phase or / 240V. 1 phase as appropriate. The Contractor shall carry out any conversion that may be necessary to enable him to use power from that source.

20.3.4 Protection shall be provided for all main and sub-circuits against excess current, residual current and earth faults. The protective devices shall be capable of interrupting (without damage to any equipment or the mains or sub-circuits) any short circuit current that may occur.

20.3.5 Earthing and bonding shall be provided for all electrical installations and equipment to prevent the possibility of dangerous voltage rises and to ensure that faults are rapidly cleared by installed circuit protection.

20.3.6 Only plugs and fittings of the weatherproof type shall be used and they should be colour coded in accordance with the Internationally recognised standards for example as detailed as follows:

- (a) 110 volts Yellow.**
- (b) 240 volts Blue.**
- (c) 415 volts Red.**

20.4 Cables

20.4.1 Cables shall be selected after full consideration of the conditions to which they will be exposed and the duties for which they are required. For supply cables up to 3.3kV the cable armouring shall be used as the earth return in conditions where the cable is continuously extended and not subject to continuous movement after installation.

20.4.2 For supplies to mobile or transportable equipment where operation of the equipment subjects the cable to flexing, the cable shall conform to one of the following specifications appropriate to the duties imposed on it:

- (a) BS 6708 flexible cables for use at mines and quarries;
- (b) BS 6007 rubber insulated cables for electric power and lighting; and
- (c) BS 6500 insulated flexible cords and cables.

20.5 Maintenance

20.5.1 Strict maintenance and weekly checks of control apparatus and wiring distribution systems shall be carried out by an electrician (duly qualified to carry out the said checks) to ensure safe and efficient operation of the systems. The Contractor shall submit for review by the Authority's Representative details of his maintenance schedule and maintenance works record.

20.5.2 All portable electrical appliances shall be permanently numbered (scarf tag labels or similar) and a record kept of the date of issue, date of the last inspection carried out and the recommended inspection period.

20.6 References

- (a) Indian Electrical Regulations;
- (b) BS EN 60529 Degrees of protection provided by enclosures (IP Code)
- (c) The Power Companies' Supply Rules;
- (d) BS 7671 Requirements for electrical installation the IEE Wiring Regulations (16th Edition);
- (e) BS 7375 Distribution of Electricity on Construction and Building Sites;

S-V Tunnel

- (f) BS 4363 Distribution Assemblies for Electricity Supplies for Construction and Building Sites; and
- (g) BS 6164 Safety in Tunnelling in the Construction Industry.

21.0 Welding and cutting

21.1 General

21.1.1 Contractors shall ensure that all welding, cutting and gouging is carried out so that the risks are kept at a minimum. There will be some circumstances when Permits to Work will need to be issued, such as

- (a) **working in tunnels;**
- (b) welding over areas where others are working;
- (c) working in areas with increased fire risks or hazardous environments;

21.1.2 All equipment must be in good condition, properly installed and routinely inspected by a competent person, and records must be kept available for inspection by the Authority's Representative.

21.1.3 Flexible hoses, cables and connections must be free from damage or risk of damage in service. Cables and hoses shall have adequate carrying capacity.

21.1.4 Welders shall wear the correct personal protective equipment which includes the following;

- (a) **face and eye protection with correct grade of shield;**
- (b) **gauntlet gloves;**
- (c) **safety footwear**
- (d) **welders apron or fire retardant overalls;**
- (e) **The atmosphere in the vicinity of work must be known to be safe to breathe and free from flammable gases.**

21.1.5 Adequate ventilation and fume extraction must be provided and used as required by the risk assessment and especially in enclosed areas and pits.

21.1.6 Surfaces to be heated by the process must be cleaned of contaminants that may be degraded by heat or give off noxious fumes (e.g. paints, plastics, zinc coating).

21.1.7 Naked flames or high temperature surfaces must not be allowed in the vicinity of volatile solvents.

21.1.8 All moveable flammable materials must be removed from the vicinity of work and fireproof covers placed over all flammable materials that cannot be removed.

21.1.9 During all welding the work piece and any access equipment must be safely secured.

21.2 Oxy-fuel Gas Processes

21.2.1 Handle cylinders carefully, keep outside enclosed areas and secure in an upright position. Keep oxygen cylinders away from fuel gas cylinders where possible.

21.2.2 Flash back arresters shall be fitted to both the fuel gas and oxygen cylinders;

21.2.3 Non return valves shall be fitted to the torch or cutting torch;

21.2.4 Ensure screwed fittings and hoses are correct and keep screwed and sealed surfaces free of contaminants, such as oil and grease.

21.2.5 Close cylinder valves when flame is extinguished.

21.2.6 Ensure any vessel, drum or tank that has contained flammable or toxic substances has been properly cleaned and inspected before subjecting it to hot work.

21.2.7 Checks for gas leaks should be carried out using soapy water.

S-V Tunnel

21.2.8 Remove all torches from enclosed areas when not in use.

21.2.9 Suitable fire extinguisher to be available at all places where hot work is being carried out.

21.2.10 Use firewatchers if there is a possibility of ignition unobserved by the operator (e.g. on the other side of bulkheads).

21.3 Arc Cutting, Gouging and Welding Processes

21.3.1 Connect the welding current return cable to the workpiece close to the arc point or to a well electrically conductive support structure in good contact with the workpiece. Also, connect the workpiece or the support structure to a separate earth terminal.

21.3.2 Take precautions against the risk of increased fume hazards when welding with chrome containing fluxed consumables or high current metal inert gas (MIG) or tungsten inert gas (TIG) processes.

21.3.3 Avoid being in contact with water or wet floors when welding. Use duckboards or rubber protection.

21.3.4 Provide screens to limit exposure of others to glare from arcs.

21.3.5 Use the correct eye and face protection with the correct filter glass.

21.3.6 Use a low voltage open circuit relay device if welding with alternating current in constricted or damp places.

21.4 References Indian Standards.

IS 818 : 1961	Code of Practice for safety and health requirements in electric, gas welding and cutting operations.
IS 1179 : 1967	Specification for equipment for eye and face protection during welding
IS 5983 : 1967	Specification for protective filters for welding, cutting and similar operations.
IS 13416 (Part 5) : 1994	Preventative measures against hazards at workplaces – Recommendations Part 5 Fire Protection

British Standards

BS EN 166:	1996: Personal eye-protection. Specifications
BS EN 169:	1992: Specification for filters for personal eye protection equipment used in welding and similar operations
BS EN 175:	1997: Personal protection. Equipment for eye and face protection during welding and allied processes

22.0 Compressed Gases

22.1 Storage

22.1.1 The Contractor shall ensure that all compressed gases, such as oxygen and fuel gases, are stored in a safe manner in keeping with the following requirements.

22.1.2 When not in use compressed gas cylinders should preferably be stored in the open air in a well ventilated area at ground level on a firm level surface at least 3m away from any cellars, drains, excavations or other hollows where vapour may collect. There should be good access to the area, which should be kept clean and clear of combustible material, including wood, packing materials and vegetation. If any protection is provided to prevent cylinders being exposed to the weather, it should be of non-combustible material and should not inhibit ventilation. The area should not be close to any source of heat.

22.1.3 If storage in the open air is not reasonably practicable, compressed cylinders must be stored in adequately ventilated storerooms. The storeroom must be constructed of non- combustible material

S-V Tunnel

- 22.1.4 Liquefied Petroleum Gas (LPG) cylinders should be stored separately from oxygen cylinders, other flammable liquids, oxidising materials such as sodium chlorate, and toxic or corrosive substances. Such materials should be kept at least 3 metres away from LPG cylinders.
- 22.1.5 It is important that the valves of so-called 'empty' cylinders are kept closed as well as those of full cylinders and that plugs, shrouds and caps are kept in place on all cylinders. This is necessary not only to prevent the escape of any residual compressed gas into the atmosphere but also to ensure that air is not sucked into the cylinder to form an explosive mixture inside it. All cylinders should be stored with their valves uppermost. Storage of LPG cylinders on their sides is particularly hazardous as in the event of a leaking or inadequately closed valve there is the possibility of leakage of liquid and a consequential release into the atmosphere of far greater quantities of flammable vapour.
- 22.1.6 The storage area should be enclosed by a fence approximately 2 metres in height. The fence should be made of non-combustible material and should not inhibit natural ventilation, particularly at low level - a wire mesh fence is particularly suitable for this purpose. The fence should have at least two means of exit, which should not be adjacent to each other. The gates should open outwards and not be self-locking. Both exits should be unlocked when persons are within the storage compound. At all times when the site is unattended the storage area should be secured.
- 22.1.7 On sites where only small quantities of compressed gas are stored (i.e. less than 300 kg) and it is practicable neither to provide an open air storage compound as described in para 21.1.6 nor a properly constructed storage building cylinders may be kept in a lockable wire cage in a safe place in the open air. Only one exit will be necessary providing there is no risk of a person being trapped in the enclosure. The cage should be clearly marked "Highly Flammable and notices prohibiting smoking and naked lights should be displayed.
- 22.1.8 Suitable portable first aid fire extinguishers shall be positioned in close proximity to the storage area for use in an emergency.

22.2 Handling Compressed Gas cylinders

- 22.2.1 Cylinders should be handled with care and wherever practicable moved on specially designed trolleys. The valve on a cylinder should not be used for lifting or to lever the cylinder into position. Damage to the valve can result in highly dangerous situations following the escape of gas. For the same reason throwing or dropping cylinders should be prohibited as in such circumstances damage to the valve is even more likely.
- 22.2.2 Before connecting any cylinder or container of compressed gas to equipment it is essential that all fires, flames or other sources of ignition in the vicinity, including cigarettes and pilot lights, are extinguished. Where practicable cylinders should be changed in the open air. The cylinder should be examined and any damaged or faulty cylinder should NOT be used. No attempt should be made to rectify any fault or damage. The cylinder should be put in a safe place away from other cylinders or combustible materials until returned to the supplier.
- 22.2.3 If a cylinder is found to be leaking and the leak cannot be stopped, the cylinder should be carefully removed to a well-ventilated open space free from sources of ignition. It should be left with the leak, usually at the valve, uppermost, marked faulty and notices displayed prohibiting smoking or other naked lights. General access should be prevented by barriers or otherwise. The supplier of the cylinder should be informed immediately. Under no circumstances should users attempt to dismantle or repair defective cylinders.

22.3 Regulators

- 22.3.1 Regulators should be suitable for the gas and pressure in use. Checks for leaks at the regulator nuts should be made only by using soapy water. In the event of a defect or of any damage to a regulator, no attempt should be made to repair it. Such repairs should only be carried out by specialists.

22.4 Hoses

S-V Tunnel

- 22.4.1 Flexible tubing should only be used for final connections to appliances. Flexible hoses should comply with BS 3212, BS 5120 or other nationally recognised standard. They should be additionally protected or of steel braid reinforced construction wherever they might be subject to damage by abrasion and so sited that they are not exposed to excessive heat. The length of hoses should be kept as short as practicable

22.5 Training and Instruction

- 22.5.1 Many accidents involving compressed gas are due to ignorance of simple basic precautions. It is essential that all persons using compressed gas are suitably instructed about the hazards and the precautions to be taken in its use

22.6 References

Indian Standards: IS 2190 : 1979 Code of Practice for the selection installation and maintenance of portable first aid fire extinguishers.

23.0 Machinery

23.1 Machinery Fencing

- 23.1.1 The Contractor shall ensure that all gears, revolving shafts, flywheels, couplings and other dangerous parts of machinery shall be effectively guarded unless they are so constructed, installed or placed as to be safe as if they were guarded.
- 23.1.2 Fencing of dangerous parts of machinery shall not be removed while the machinery is in use or in motion. If the fencing is required to be removed for maintenance purposes it shall be replaced before the machine is taken into use.

23.2 Maintenance

- 23.2.1 The Contractor shall ensure that all machinery used on site is in safe condition and is properly maintained and repaired by duly authorised, thoroughly trained and experienced persons.
- 23.2.2 No repair to machinery shall be carried out whilst it is in motion unless it is unavoidable.
- 23.2.3 Maintenance records shall be kept available for inspection by the Authority's Representative.

23.3 Air Receivers

- 23.3.1 All Air receivers shall be fitted with a pressure relief valve and shall have the safe working pressure clearly marked upon them.
- 23.3.2 Every air receiver shall be subject to an annual test, which shall be carried out by a duly authorised person. The results of all tests shall be recorded and the records shall be kept available for inspection by the Authority's Representative.
- 23.3.3 The connection couplers on compressed airlines shall be securely fixed together and have safety chains or be wired at the joints in order to ensure that the joints do not come apart when charged with compressed air.

23.4 Woodworking Machines

- 23.4.1 All woodworking machines shall be fitted with the following guards and devices;

- (a) **Top Guard;**
- (b) Riving Knife;
- (c) Guards to protect all drive belts etc.;
- (d) An emergency stop switch easily accessible by the operator;
- (e) A push stick;

S-V Tunnel

23.4.2 Woodworking machines shall be operated only by thoroughly trained and experienced operators.

23.5 Abrasive Wheels

23.5.1 All Abrasive wheel machines shall be fitted with appropriate guards which shall be kept in place at all times the machine is in use.

23.5.2 All abrasive wheel machines shall have the spindle speed clearly marked upon them in revolutions per minute.

23.5.3 Only thoroughly trained and experienced persons are allowed to change the wheels on the machines. Wheels must be inspected and ring tested before mounting to ensure that wheels are free from cracks or defects.

23.5.4 Safety Goggles or Face shields must be worn when grinding or cutting with abrasive wheels.

23.6 References Indian Standards

IS 7293 : 1974 Safety Code for Working with Construction Machinery

24.0 Heavy plant operations

24.1 General

24.1.1 The contractor shall ensure that only safe and well-maintained plant and equipment shall be allowed to operate on any of the sites.

24.1.2 All operators of heavy plant such as, earth movers, piling rigs, etc. shall be medically fit, over eighteen years of age and be thoroughly trained and experienced to operate the equipment.

24.1.3 No unauthorised person shall be permitted to ride on plant.

24.1.4 The operators shall conduct daily inspections of their respective items of plant with the results of these inspections being recorded and the records kept available for inspection by the Authority's Representative.

24.1.5 All mobile heavy plant shall be equipped with at least one 5kg Dry Powder Fire Extinguisher, carried at a suitable position so as to ensure its easy availability.

24.1.6 Whenever heavy plant is operating in congested areas, thoroughly trained and experienced banksmen shall be deployed to control the plant and personnel movement and interface.

24.1.7 Any waste engine oil and filters following any on site servicing and maintenance shall be removed from the sites and disposed of in an environmentally conscious manner at authorised disposal locations.

24.1.8 All drums of fuel oil shall be stored on drip trays or the fuel shall be kept in bunded bulk storage fuel tanks, with quantities stored being kept to a minimum.

24.1.9 The storage areas shall have dry powder fire extinguishers positioned in close proximity to their location for use in an emergency.

24.2 References Indian Standards

IS 7293 : 1974 Safety Code for Working with Construction Machinery

IS 2190 : 1979 Code of Practice for the selection, installation and maintenance of portable first aid fire extinguishers.

25.0 Tunneling operations

25.1 Procedures

25.1.1 The Contractor shall develop safety procedures and methods of working to be adopted during the course of tunnelling operations. These procedures shall include but not be limited to;

S-V Tunnel

- (a) Shafts and Tunnels Entry Procedure. (Including visitors.)**
- (b) Blasting operations.**
- (c) Atmosphere Monitoring.(Oxygen Levels, Explosive Gases, Carbon Monoxide, Hydrogen Sulphide, Oxides of Nitrogen, temperature , humidity, dust etc.) See also Section 15.4 of this Manual.**
- (d) Portal Gantry Crane Operating Procedures.**
- (e) Emergency Preparedness Plan for the Shaft and Tunnels. (Including liaison with the Emergency Services.)**
- (f) Work Train Operating Procedure.**
- (g) Tunnel Boring Machine Cutter Head Chamber Entry procedure.**

A detailed method statement as outlined in Section 12.2 METHOD STATEMENTS must be produced by the Contractor, and approved by the Authority's Representative before the commencement of any tunnelling operations.

25.2 Sanitation and Drinking Water

- 25.2.1 Unless the worksite is within 500 metres of the portal of the tunnel, sanitation facilities shall be provided. Suitable toilets shall be provided on the scale of one unit for every 50 men on the shift. Toilets shall be effectively and regularly cleaned and disinfectants provided.
- 25.2.2 At least 5 litres of clean drinking water shall be provided per person employed on the shift. The water shall be sited near the portal and also inside tunnels over 500 metres in length. The water shall be contained in a clean container with a tight fitting lid.
- 25.2.3 Washing and cleaning facilities shall be provided for all workers near the portal.

25.3 Lighting

- 25.3.1 The Contractor shall provide adequate lighting at the face and at any other point where work is in progress. A minimum of 50 lux shall be provided at the face, walkways and similar work areas. When mucking is done by tipping wagons running on trolley tracks a minimum of 30 lux shall be maintained. In all other areas the level of lighting shall not be less than 10 lux.
- 25.3.2 Emergency lighting shall be installed at the working faces and at 100m intervals along the tunnel to help escape workmen in case of accidents.

25.4 Ventilation

- 25.4.1 The Contractor shall make provision for adequate ventilation of all shafts and tunnels. The ventilation shall be sufficient to ensure proper dispersal of any dust or fume.(see also Section 15.4)

25.4 Protection Against Fire

- 25.4.1 As far as practicable, combustible materials shall not be used in the construction of any room or recess containing electrical apparatus.
- 25.4.2 No flammable material shall be stored in any part of the tunnel unless it is contained in suitable flameproof containers.
- 25.4.3 An adequate supply of suitable first aid fire fighting equipment shall be kept at convenient locations throughout the tunnel. This equipment shall be tested at least once a month and records kept available for inspection by the Authority's Representative.

25.6 Warning Signals

- 25.6.1 The contractor shall install a suitable system of warning signals for the movement of plant and materials within shafts and tunnels.

S-V Tunnel

- 25.6.2 The system shall be checked daily immediately prior to the commencement of tunnelling work under the supervision of a responsible person.
- 25.6.3 The Contractor shall make detailed emergency warning signals for cases of fire, tunnel collapse etc.

25.7 References Indian Standards

IS 4756 : 1978 Safety Code for Tunnelling Work.

IS 2190 : 1979 Code of Practice for the selection, installation and maintenance of portable first aid fire extinguishers.

British Standard

BS 6164 : 2001 Code of Practice for safety in tunnelling in the construction industry

26.0 Blasting operations

26.1 Authorization for Blasting

- 26.1.1 The Contractor shall ensure that all blasting operations will only be permitted following consultations with the relevant authorities and subsequent issuing of the permission to blast permits. The Authority's Representative must also give his consent in writing before any blasting operations take place.
- 26.1.2 All blasting shall be conducted under the direct supervision of a Licensed Shotfirer.

26.2 Risk Assessment and Method Statements

- 26.2.1 The Contractor shall produce a detailed hazard and risk assessment and an in depth method statement for amongst others the following elements:

- (a) **Type of explosives to be used.**
- (b) **Anticipated effects of vibration on nearby structures.**
- (c) **Blasting patterns.**
- (d) **Delivery of the explosives.**
- (e) **Transportation and storage of explosives on site.**
- (f) **Drilling and charging of holes.**
- (g) **Warning sirens.**
- (h) **Measurement of Vibration**
- (i) **Provision of sentries.**
- (j) **Use of blast screens.**
- (k) **ALL CLEAR.**
- (l) **Ventilation following blasting.**
- (m) **Atmosphere monitoring.**
- (n) **Procedure for miss-fires.**

26.3 References Indian Standards

IS 4081 : 1986 Safety Code for Blasting and related Drilling Operations

British Standards

BS 5607 : 1988 Code of Practice for the safe use of explosives in the construction industry.

27.0 Demolition

27.1 General

S-V Tunnel

- 27.1.1 The Contractor shall ensure that all demolition works shall be carried out in a controlled manner under the management of experienced and competent supervision.
- 27.1.2 Prior to any demolition commencing, a survey shall be conducted to identify if there are any hazardous materials present, for example the presence of materials such as asbestos and lead.
- 27.1.3 If any hazardous materials are found, then consideration shall be given as to whether they shall need to be removed by a Specialist Agency or Sub-contractor prior to the main demolition works commencing.
- 27.1.4 Before the demolition commences all relevant notifications will need to be given to the local authorities and media.
- 27.1.5 Measures for protection to the public shall be required to be put into place in order to give protection from any possible falling debris and dust generation.
- 27.1.6 All power supplies and services shall be disconnected before any demolition work commences.

27.2 References Indian Standards

- IS 4130: 1991 Demolition of Buildings – Code of Safety
- IS 13416 (Part 3):1994 Recommendations for preventive measures against hazards in the workplace,
Part 3, Disposal of Debris

28.0 Falsework / Formwork

28.1 General

- 28.1.1 The contractor shall ensure that all falsework / formwork has been properly designed and is suitable for the purpose.
- 28.1.2 All designed falsework / formwork shall be erected in strict accordance to the design.
- 28.1.3 Prior to the loading and subsequent striking of falsework / formwork, permission shall be obtained from the Contractor's Designer and Engineer who shall both inspect and sign off on the structure in person.
- 28.1.4 Adequate provision shall be made on the working platforms for the concrete placement operations, these shall include locations for vibrators and the unobstructed movement of personnel controlling the rubber hose during the concrete pumping operations or the concrete skip during any skipping operations.
- 28.1.5 The Contractor should use the following checklist to check that falsework / formwork is being used safely;
 - (a) have the design and the supports for shuttering and falsework / formwork been checked?**
 - (b) is it being erected safely from steps or proper platforms?**
 - (c) are the props plumb and properly set out?**
 - (d) are the bases and ground conditions adequate for the loads?**
 - (e) are the correct pins used in the props?**
 - (f) are the timbers in good condition?**
 - (g) is it inspected by a competent person against the agreed design before permission is given to pour concrete?**

29.0 Piling and diaphragm Walls

29.1 General

- 29.1.1 The contractor shall prepare safe systems of work and method statements for all work concerned with piling and diaphragm walls. He shall take the following points into consideration.
- 29.1.2 Any excavated piles or panels shall not be left unattended, unless they are adequately fenced around to

S-V Tunnel

prevent accidental entry into the immediate vicinity of the pile or panel.

- 29.1.3 Because of the use of heavy plant and equipment in generally congested work areas then trained banksmen shall be deployed to control the movement of the plant and personnel interface.
- 29.1.4 All lifting operations shall be conducted in accordance with the requirements as detailed in Section 18 Lifting Operations.
- 29.1.5 Calcium Oxide shall not be used for stabilising the excavated spoil as it is an acute irritant, unless an agreed method statement has been produced.
- 29.1.6 A method statement shall be produced by the Contractor, which details the process for grab retrieval in the event of a grab becoming detached during the course of a pile or panel excavation.
- 29.1.7 A method statement shall be produced by the Contractor, which details the process for stop end recovery.
- 29.1.8 Wheel washing facilities shall be available on the sites for washing down the spoil removal trucks and the concrete delivery vehicles.
- 29.1.9 Bentonite and polymer storage tanks shall be bunded around to retain any unintentional and uncontrolled spillage.
- 29.1.10 The contractor shall submit to the Authority's Representative, for approval, proposals for the treatment of Bentonite slurry and its subsequent disposal.
- 29.1.11 No Bentonite spillage shall be allowed on any roads.
- 29.1.12 Regular site cleaning shall be carried out at all work-sites.
- 29.1.13 The Contractor as part of his Emergency Plans shall develop procedures for the collapse of piles and diaphragm walls.

29.2 References Indian Standards

IS 5121 : 1969 Safety Code for Piling and other Deep Foundations

IS 8989 : 1978 Safety Code for the Erection of Concrete Framed Structures

30.0 Work adjacent to live railways

General

- 30.1.1 Whenever work is to be conducted in close proximity to the live railways then the following measures shall need to be addressed:
 - (a) **The rules provided for in the Railway's manual shall be followed.**
 - (b) No persons are allowed to encroach onto the railway unless specific authority has been given by the owner.
 - (c) Adequate protection in accordance with the railway owner's requirements shall be followed. (Provision of Block Inspectors, Flagmen and Lookouts.)
 - (d) All persons shall wear high visibility clothing at all times.
 - (e) Any induction training requirements of the railway owner shall be strictly observed

31.0 Work adjacent to live roadways

30.1 General

- 31.1.1 Whenever working adjacent to any live roadways then the following aspects shall be considered.

- (a) **Close liaison with the Police and Local Authorities.**
- (b) **Production of an agreed traffic management scheme in accordance with the local traffic**

laws. (Barriers, signs, lights and road markings.) this shall include adequate provision for pedestrians.

- (c) The provision and wearing of high visibility clothing by all personnel engaged in the activities.
- (d) Traffic Marshals shall be appointed and deployed to ensure that all road movement is carried out safely.

32.0 Personal protective equipment

31 General

31.1.1 The Contractor shall at all times keep and maintain an adequate supply of suitable personnel protective equipment which shall be readily available for use at all times on the sites, and would include amongst others the following items:

- (a) Safety Helmets.
- (b) Hearing Protection.
- (c) Respiratory Protection.
- (d) Eye Protection.
- (e) Protective Gloves.
- (f) Safety Footwear.
- (g) High Visibility Clothing to BS EN 471 Class 3 standard

31.1.2 All sites shall be designated as HARD HAT and SAFETY BOOTS SITES and as such an adequate supply of safety helmets and safety boots shall be kept available for use by all staff, workers and authorised visitors to the sites.

31.1.2 The Contractor shall remove from the site any worker who consistently refuses to wear the appropriate personal protective equipment.

31.1 References Indian Standards

IS 2925 : 1984	Specification for Industrial Safety Helmets.
IS 1179 : 1967	Specification for equipment for eye and face protection during welding. IS 6994 Standard for Industrial Gloves

British Standards

BS EN 166:	1996: Personal eye-protection. Specifications
BS EN 169:	1992: Specification for filters for personal eye protection equipment used in welding and similar operations
BS EN 175:	1997: Personal protection. Equipment for eye and face protection during welding and allied processes
BS EN 352:	Hearing protectors. Safety requirements and testing 352-1: 1993: Ear muffs
352-2 : 1993:	Ear plugs
352-3 : 1997:	Earmuffs attached to an industrial safety helmet
BS EN 345:	Safety footwear for professional use
BS EN 471	High visibility clothing

33.0 First aid

32.1 First Aid Bases

S-V Tunnel

32.1.1 The Contractor shall establish a First Aid Base, at each of his principal work areas. If during the life of the contract the Contractor's principal work area moves from one location to another, the Contractor shall be required to move his First Aid Base.

32.1.2 If the Contractor operates more than one principal work area he will be required to have a First Aid Base at each of his principal work areas.

32.1.3 The First Aid Base shall consist of as a minimum;

- (a) **A treatment room fitted with two treatment couches,**
- (b) **A hand wash basin with running water;**
- (c) **Lockable cupboards to contain sufficient medical supplies;**
- (d) **Bed.**
- (e) **Six Chairs with footrests**
- (f) **Desk and chair.**
- (g) **Six Stretchers (Which can be lifted and lowered by a crane.)**
- (h) **Pillows and blankets.**
- (i) **Refuse containers.**
- (j) **Medical dressings. (Bandages, plasters, antiseptic wipes.)**
- (k) **Eye irrigation sterile solution.**
- (l) **Paper towels.**
- (m) **Disposable gloves.**

32.1.4 The first-aid unit shall be provided with air conditioning and shall be kept in a clean and tidy state at all times.

32.2 Medical Staff

32.2.1 A qualified Doctor, Nurse and assistant Nurse shall be in attendance at the first aid base during all times when work is being undertaken on the site.

32.3 Ambulance

32.3.1 A fully equipped ambulance and driver shall be provided at the first aid base during all working hours. The ambulance shall be equipped with emergency life support equipment suitable for application in construction site accidents.

32.4 First Aid Boxes

32.4.1 Portable first aid boxes will be maintained fully equipped at each local site offices and work locations where 20 or more persons work at a time.

32.4.2 In each site office and location one employee, suitably trained in first aid, should be available at all working hours for the purpose of attending to emergencies.

33.0 Fire precautions

33.1 General

33.1.1 The Contractor shall be responsible for supplying and maintaining adequate fire precaution facilities on all his sites. The following minimum standards should be adhered to.

33.1.2 The Contractor shall ensure that specially trained personnel are available to deal with fires due to electrical causes, gas explosions etc.

33.1.3 A good standard of housekeeping shall be maintained at all times on the sites.

S-V Tunnel

- 33.1.4 No accumulations of rubbish shall be allowed to gather.
- 33.1.5 Combustible scrap and other construction debris should be disposed off site on a regular basis. If scrap is to be burnt on site, the burning site should be specified and located at a distance no less than 12 metres from any construction work or any other combustible material.
- 33.1.6 Signage shall be erected at prominent positions showing the correct use of portable first aid fire extinguishers.
- 33.1.7 Emergency plans and Fire Evacuation plans shall be prepared and issued . Mock drills should be held on a regular basis to ensure the effectiveness of the arrangements.

33.2 Fire Fighting Equipment

- 33.2.1 At various locations around the site clearly visible fire points shall be established for use in an emergency and each fire point should have available as a minimum the following type of equipment:

- (a) **Dry Powder Extinguisher.**

- (b) **Water Type Extinguisher.**

- (c) **Bucket of Sand.**

- 33.2.2 Recharging of fire extinguishers and their proper maintenance should be ensured and as a minimum should meet Indian National Standards
- 33.2.3 Water supply for fire fighting purposes should be provided at the construction site. This may be in the form of static water tank of adequate capacity or a hydrant line with adequate water pressure at outlet points.
- 33.2.4 Sufficient number of fire hoses with branch pipes should be provided at site so that the fire can be controlled until the arrival the arrival of the Fire Brigade.
- 33.2.5 The contractor shall need to give consideration to the provision of adequate fire fighting arrangements within the underground and tunnelling operations including the provision of Fire Service compatible hose connections and emergency lighting
- 33.2.6 The Telephone Number of the local fire brigade should be prominently displayed near each telephone on site.
- 33.2.7 Supervisors and workmen at the site should be trained in the use of fire fighting equipment provided at the site.

33.3 Storage of Flammable Liquids

- 33.3.1 All flammable liquids shall be kept in a secure fire resistant store protected from electrical sparks welding sparks open flames and smoking.
- 33.3.2 Only such amounts of flammable liquids should be issued as are required for immediate use. Cans for carrying flammable liquids should be leakproof and properly stoppered and clearly marked “FLAMMABLE LIQUID”.
- 33.3.3 Rags soaked in paints, kerosene and other flammable liquids should be disposed of daily under supervision. Large quantities of such rags should not be allowed to accumulate.
- 33.3.4 All Diesel fuel storage tanks shall be bunded around in order to control any spillage or leakage that may occur.
- 33.3.5 “NO SMOKING” signs shall be prominently displayed at all areas where flammable materials are stored.

33.4 References Indian Standards

IS 13416 (Part 5) : 1994 Preventative measures against hazards at workplaces –
Recommendations Part 5 Fire Protection

S-V Tunnel

IS 1646 : 1982	Code of Practice for fire safety of buildings (general) : Electrical Installations
IS 2190 : 1979	Code of practice for selection installation and maintenance of portable first aid fire extinguishers
IS 12349 : 1988	Fire Protection – Safety Signs Also Part IV of National Building Code of India : 1983

34.0 Site perimeter HOARDING

34.1 General

- 34.1.1 The Contractor is required to keep the site as safe and secure as possible at all times, this includes the erection of site perimeter Hoarding for tunnel site which shall also deter trespassers both adult and children alike.
- 34.1.2 The Contractor shall provide a solid two metre high securely erected fence be installed around the perimeter of the tunnel site, with agreed and guarded access and egress points for both personnel and vehicles.
- 34.1.3 The Site Perimeter Fencing shall be constructed.
- 34.1.4 At each entrance to the site the Contractor shall erect a large billboard warning all persons who enter the site that they are required to wear the appropriate Personal Protective Clothing and that no unauthorised access is allowed.
- 34.1.5 Wherever the fence runs adjacent to the highway with no buffer-zones then the fence shall have traffic warning lights duly affixed to it.
- 34.1.6 Wherever the fence borders on pedestrian footpaths lighting shall be provided to illuminate the pedestrian routes. The positioning of the fence-line shall not reduce the width of the pedestrian footpath to less than 900 mm in order to be able to accommodate disabled persons in wheelchairs.
- 34.1.7 Site perimeter fencing shall be washed at least once a month and repainted at least annually.
- 34.1.8 The site fencing shall need to be inspected on a regular basis in order to ensure that the integrity of the fencing is maintained at all times as far as is practicable.

34.2 References Indian Standards

IS 13430 : 1992 Safety During Additional Construction and Alteration to Existing Buildings - Code of Practice

IS 9457 Standard for colours of safety signs

35.0 Traffic management

35.1 General

- 35.1.1 The contractor shall ensure that all traffic management schemes shall be in accordance with the agreed schemes following consultation with the Local Traffic Police and the Metropolitan and other Authorities in charge of the area.
- 35.1.2 Adequate and clear warning signs shall be displayed at appropriate distances before the commencement of the site workings. In addition prior warning shall be given concerning the location of the approaching site entry and exit points.
- 35.1.3 All traffic signs, barriers, cones and lighting shall be kept maintained and clean at all times.
- 35.1.4 Site vehicles exiting the site shall observe caution at all times, if the vehicles are exiting directly onto the live carriageway then they shall be directed by an identifiable Traffic Controller.
- 35.1.5 Regular inspections of the traffic management schemes shall be conducted by the Contractors in both the daytime and night time hours with the results of these inspections being recorded. These records

S-V Tunnel

shall be kept available for inspection by the Authority's Representative.

35.2 Vehicle Control

35.2.1 Traffic Controllers shall be available for directing vehicles that are exiting the sites directly onto the live carriageways. Any vehicles entering the sites that are required to execute reversing manoeuvres shall do so under the strict control of a trained and designated banksman.

35.3 Spoil Removal

35.3.1 Only well maintained and licensed vehicles shall be allowed to be used for the removal of excavated spoil from the sites.

35.3.2 All drivers shall be medically fit and in possession of a valid and current driving licence.

35.3.3 No vehicles, which are overloaded, shall be allowed to leave the site.

35.3.4 Any vehicles leaving the sites carrying loads which are liable to produce airborne contaminants shall prior to leaving the site securely sheet the load over in order to effectively contain any dispersment during transportation on the public highway.

35.3.5 Vehicles exiting the site directly onto the live carriageway shall do so under the control of the clearly identified Traffic Controller.

35.3.6 Any vehicles that are required to reverse whilst on the site shall do so under the control of a trained banksman.

35.3.7 Any vehicles prior to leaving the site shall have their wheels washed and any loose material removed.

35.3.8 Any spoil that is removed from the work-sites shall be disposed of only at authorised dumping sites.

35.4 References Indian standards

IS 4130: 1991 Demolition of Buildings – Code of Safety

IS 13416 (Part 3):1994 Recommendations for preventive measures against hazards in the workplace, Part 3, Disposal of Debris

36.0 Visitors to site

36.1 General

36.1.1 All visitors to site shall report to the Contractors site offices where they shall be issued with appropriate Personal Protective Equipment if they are to go out onto the site work areas. Any visitors going out to the site work areas shall be accompanied at all times by a member of the site personnel.

LIST OF SCHEDULES

The following Schedules are given to assist the Contractor's understanding of the Hierarchy of Safety adopted by NHIDCL and to give additional advice in support of this Manual.

Schedule 1 Examples of Conditions of Contract Agreement relating to Safety and Industrial Health

Schedule 2 List of Relevant Indian and British Standards

Schedule 3 Sample Safety Forms:

Schedule 4 Example of Toolbox Talks

Schedule 5 Hierarchy of Safety and Industrial Health for NHIDCL Contracts

SCHEDULE 1**SAMPLE SAFETY FORMS**

The purpose of this schedule is to provide a set of standardised forms for the Contractor to use when reporting information to the Authority's Representative. The Contractor is free to adapt the forms for his own use, however when the form is being used to transmit information to the Authority's Representative it must contain, as a minimum, the information shown on the following forms.

List of Forms:

SAF 001	Accident / Incident / Dangerous Occurrence Report Form
SAF 002	Accident Report - Injury Analysis Form
SAF 003	Accident Statistics – Monthly Report Form
SAF 004	Contractor's Monthly Safety Report
SAF 010	Permit to Work – Confined Spaces
SAF 011	Permit to Work – Electrical
SAF 012	Permit to Work – Hot Work
SAF 020	Risk Assessment Work Sheet
SAF 021	Hazardous Substance Assessment Sheet
SAF 030	Site Safety and Emergency Standby List
SAF 031	Safety Training Attendance Record
SAF 032	Weekly Fire Fighting Equipment Check List
SAF 033	Scaffold Inspection Checklist
SAF 040	Contractor's Application for Approval of Safety Manager

NATIONAL HIGHWAYS & INFRASTRUCTURE DEVELOPMENT CORPORATION LIMITED	SAMPLE SAFETY FORM REFERENCE:	SAF-001
ACCIDENT/DANGEROUS OCCURRENCE REPORT FORM		Accident No.
Name of Contractor		Contract No.
Instructions: 1. A copy of this form shall be completed for every Accident and Dangerous Occurrence. 2. It must be signed by a seniors item an agementre presentative. 3. A copy shall be sent to the Authority's Representative within 24 hours of the Accident.		
Part A: Details of Injured Person Name: _____ Date of Birth: _____ Male ☐ Female ☐ Address: _____ _____ Job Title: _____ Name of Employer: _____		
Part B: Details of The Accident Date: _____ Time: _____ Location: _____ Describe the task the injured person was doing at the time of the accident: Describe in detail show the accident happened (Attach, sketch, plan photographs etc.): Was any plant or machinery involved yes/no :if yes give details: Name of any Witnesses:		
Part C: Details of the Inquiry What was the Injury ? (eg. Fracture, Lacerations) What part of the body was injured? Was the injury: Fatal ☐ Major Injury ☐ Minor Injury ☐ Was the injured person sent to; First Aid ☐ Doctor ☐ Hospital ☐ Home ☐		
Part D: Certification I have checked the above information and can confirm that it is a true record of the accident Signed _____ Safety Officer Date _____ Signed _____ Project Manager Date _____		

S-V Tunnel

NATIONAL HIGHWAYS & INFRASTRUCTURE DEVELOPMENT CORPORATION LIMITED		SAMPLE SAFETY FORM REFERENCE:		SAF002																																																							
ACCIDENT REPORT - INJURY ANALYSIS FORM				ACCIDENT No.....																																																							
NAME OF CONTRACTOR			CONTRACT NO																																																								
Name of Injured Employee		Date of Birth		Male	Female																																																						
Address:																																																											
Job Title:																																																											
Name of Employer:																																																											
Date of Accident:																																																											
Time:																																																											
Location:																																																											
Cause of Accident																																																											
<table style="width: 100%; border: none;"> <tr> <td>☐ 01 Machinery</td> <td>☐ 05 Falling objects</td> <td>☐ 08 Hot or corrosive substances</td> <td>☐ 11 Handling goods or</td> </tr> <tr> <td>☐ 02 Electricity</td> <td>☐ 06 Stepping on or striking</td> <td>☐ 09 Gassing poisoning & other equipment</td> <td></td> </tr> <tr> <td>☐ 03 Hand Tool</td> <td>☐ against objects</td> <td>☐ toxic substances</td> <td>☐ 12 Transport</td> </tr> <tr> <td>☐ 04 Foreign Body in eye</td> <td>☐ 07 Falls of person</td> <td>☐ 10 Explosions or fires</td> <td>☐ 13</td> </tr> <tr> <td>☐ Miscellaneous</td> <td>☐</td> <td>☐</td> <td></td> </tr> </table>						☐ 01 Machinery	☐ 05 Falling objects	☐ 08 Hot or corrosive substances	☐ 11 Handling goods or	☐ 02 Electricity	☐ 06 Stepping on or striking	☐ 09 Gassing poisoning & other equipment		☐ 03 Hand Tool	☐ against objects	☐ toxic substances	☐ 12 Transport	☐ 04 Foreign Body in eye	☐ 07 Falls of person	☐ 10 Explosions or fires	☐ 13	☐ Miscellaneous	☐	☐																																			
☐ 01 Machinery	☐ 05 Falling objects	☐ 08 Hot or corrosive substances	☐ 11 Handling goods or																																																								
☐ 02 Electricity	☐ 06 Stepping on or striking	☐ 09 Gassing poisoning & other equipment																																																									
☐ 03 Hand Tool	☐ against objects	☐ toxic substances	☐ 12 Transport																																																								
☐ 04 Foreign Body in eye	☐ 07 Falls of person	☐ 10 Explosions or fires	☐ 13																																																								
☐ Miscellaneous	☐	☐																																																									
Severity of Injury																																																											
<table style="width: 100%; border: none;"> <tr> <td>☐ 01 First Aid</td> <td>☐ 02 Medical Aid</td> <td>☐ 03 Three days or less</td> <td>☐ 04 Over or three days</td> <td>☐ 05 Discharged</td> </tr> <tr> <td>☐ 06 Detained</td> <td>☐ 07 Fatal</td> <td>☐ 08 Days Lost</td> <td></td> <td></td> </tr> </table>						☐ 01 First Aid	☐ 02 Medical Aid	☐ 03 Three days or less	☐ 04 Over or three days	☐ 05 Discharged	☐ 06 Detained	☐ 07 Fatal	☐ 08 Days Lost																																														
☐ 01 First Aid	☐ 02 Medical Aid	☐ 03 Three days or less	☐ 04 Over or three days	☐ 05 Discharged																																																							
☐ 06 Detained	☐ 07 Fatal	☐ 08 Days Lost																																																									
Nature of Injury																																																											
ENTER IN ORDER OF SERIOUSNESS																																																											
<table style="width: 100%; border: none;"> <tr> <td>☐ 01 Amputation</td> <td>☐ 05 Crush/Compression</td> <td>☐ 09 Foreign Body (eye)</td> <td>☐ 13 Sprain/Strain</td> </tr> <tr> <td>☐ 02 Cut</td> <td>☐ 06 Contusion/Bruise</td> <td>☐ 10 Foreign Body (other)</td> <td>☐ 14 Inhalation/Ingestion</td> </tr> <tr> <td>☐ 03 Location</td> <td>☐ 07 Fracture</td> <td>☐ 11 Puncture</td> <td>☐ 15 Concussion</td> </tr> <tr> <td>☐ 04 Abrasion</td> <td>☐ 08 Dislocation</td> <td>☐ 12 Scald/Burn</td> <td>☐ 16 Others</td> </tr> </table>						☐ 01 Amputation	☐ 05 Crush/Compression	☐ 09 Foreign Body (eye)	☐ 13 Sprain/Strain	☐ 02 Cut	☐ 06 Contusion/Bruise	☐ 10 Foreign Body (other)	☐ 14 Inhalation/Ingestion	☐ 03 Location	☐ 07 Fracture	☐ 11 Puncture	☐ 15 Concussion	☐ 04 Abrasion	☐ 08 Dislocation	☐ 12 Scald/Burn	☐ 16 Others																																						
☐ 01 Amputation	☐ 05 Crush/Compression	☐ 09 Foreign Body (eye)	☐ 13 Sprain/Strain																																																								
☐ 02 Cut	☐ 06 Contusion/Bruise	☐ 10 Foreign Body (other)	☐ 14 Inhalation/Ingestion																																																								
☐ 03 Location	☐ 07 Fracture	☐ 11 Puncture	☐ 15 Concussion																																																								
☐ 04 Abrasion	☐ 08 Dislocation	☐ 12 Scald/Burn	☐ 16 Others																																																								
Part of Body Injured																																																											
ENTER IN ORDER OF SERIOUSNESS																																																											
HEAD AND SHOULDER		TRUNK		UPPER EXTREMITIES																																																							
LOWER EXTREMITIES																																																											
<table style="width: 100%; border: none;"> <tr> <td>☐ 01 Skull</td> <td>☐ 11 Back</td> <td>☐ 18 Shoulder</td> <td>☐ 26 Hip/Buttock</td> <td></td> <td></td> </tr> <tr> <td>☐ 02 Scalp & Forehead</td> <td>☐ 12 Chest</td> <td>☐</td> <td>☐ 19 Upper arm</td> <td>☐ 27 Thigh</td> <td></td> </tr> <tr> <td>☐ 03 Eye</td> <td>☐ 13 Abdomen</td> <td>☐ 20 Elbow</td> <td>☐ 28 Knee</td> <td></td> <td></td> </tr> <tr> <td>☐ 04 Ear</td> <td>☐ 14 Groin</td> <td>☐ 21 Forearm</td> <td>☐ 29 Shank</td> <td></td> <td></td> </tr> <tr> <td>☐ 05 Nose</td> <td>☐ 15 Respiratory System</td> <td>☐ 22 Wrist</td> <td>☐ 30 Ankle</td> <td></td> <td></td> </tr> <tr> <td>☐ 06 Mouth, teeth, jaw</td> <td>☐ 16 Digestive</td> <td>☐ 23 Hand</td> <td>☐ 31 Heel/sole/instep</td> <td>☐ System & Figures</td> <td></td> </tr> <tr> <td>☐ 07 Face & Cheek</td> <td>☐ 17 Others</td> <td>☐ 24 Thumb</td> <td>☐ 32 Toes</td> <td></td> <td></td> </tr> <tr> <td>☐ 08 Neck & Shoulder</td> <td>☐ 25 Others</td> <td>☐ 33 Others</td> <td></td> <td></td> <td></td> </tr> <tr> <td>☐ 09 Brain</td> <td>☐ 10 Others</td> <td></td> <td></td> <td></td> <td></td> </tr> </table>						☐ 01 Skull	☐ 11 Back	☐ 18 Shoulder	☐ 26 Hip/Buttock			☐ 02 Scalp & Forehead	☐ 12 Chest	☐	☐ 19 Upper arm	☐ 27 Thigh		☐ 03 Eye	☐ 13 Abdomen	☐ 20 Elbow	☐ 28 Knee			☐ 04 Ear	☐ 14 Groin	☐ 21 Forearm	☐ 29 Shank			☐ 05 Nose	☐ 15 Respiratory System	☐ 22 Wrist	☐ 30 Ankle			☐ 06 Mouth, teeth, jaw	☐ 16 Digestive	☐ 23 Hand	☐ 31 Heel/sole/instep	☐ System & Figures		☐ 07 Face & Cheek	☐ 17 Others	☐ 24 Thumb	☐ 32 Toes			☐ 08 Neck & Shoulder	☐ 25 Others	☐ 33 Others				☐ 09 Brain	☐ 10 Others				
☐ 01 Skull	☐ 11 Back	☐ 18 Shoulder	☐ 26 Hip/Buttock																																																								
☐ 02 Scalp & Forehead	☐ 12 Chest	☐	☐ 19 Upper arm	☐ 27 Thigh																																																							
☐ 03 Eye	☐ 13 Abdomen	☐ 20 Elbow	☐ 28 Knee																																																								
☐ 04 Ear	☐ 14 Groin	☐ 21 Forearm	☐ 29 Shank																																																								
☐ 05 Nose	☐ 15 Respiratory System	☐ 22 Wrist	☐ 30 Ankle																																																								
☐ 06 Mouth, teeth, jaw	☐ 16 Digestive	☐ 23 Hand	☐ 31 Heel/sole/instep	☐ System & Figures																																																							
☐ 07 Face & Cheek	☐ 17 Others	☐ 24 Thumb	☐ 32 Toes																																																								
☐ 08 Neck & Shoulder	☐ 25 Others	☐ 33 Others																																																									
☐ 09 Brain	☐ 10 Others																																																										

Unsafe Conditions

☐ 01RoughSlippery

☐ 02Designeffect

☐ 03 Wornfrayed

☐ 04Noprotectivegear

☐ 05Defectiveprotectivegear

☐ 06Improperdress

☐ 07Improperguard

☐ 08Improperventilation

☐ 09Improperillumination

☐ 10Improperprocedureofjobtrafficorprocessoperationetc.

☐ 11Inadequateprocedure

☐ 12Inadequate aislespacejobmethods

existsetc.,

☐ 13Unsafeplanning&/orlayout.

☐ 17Nounsafeconditions

☐ 14

Unsafeprocessor

☐ 15Overloading

☐ 16PoorHouseKeeping

Personal Factor

☐ 01 Attitude

☐ 02 Knowledgeorskill

☐ 03PhysicalDefects

☐ 04UnsafeActbyanother person

☐ 05Nounsafepersonalfactor

Unsafe Act

☐ 01 Operatingwithoutauthority

☐ 02 Failuretosecureorwarn/handsinsteadofposturepersonalprotectiveequipment

☐ 03 Makingsafetydevicesequipment/orequipment

☐ 04 Workingonmovingorunsafely

☐ 05 Usingunsafeequipment

☐ 06Takingunsafepositionor

☐ 07Operatingor workingat

☐ 08Unsafeloading,placing,

☐ 09Failuretousesafeattire or

☐ 10Horseplay

☐ 11NounsafeactdangerousEquipmentmixing

How would a similar accident be avoided?

What has been done to prevent similar accidents?Comments:

Safety Officer

Sign:

Name:

Date:

//

Project Manager

Sign:

Name:

Date:

/ /

NATIONAL HIGHWAYS & INFRASTRUCTURE DEVELOPMENT CORPORATION LIMITED		SAMPLE SAFETY FORM REFERENCE:	SAF- 003
CONTRACTORS MONTHLY ACCIDENT STATISTICS REPORT			
NAME OF CONTRACTOR		CONTRACT NO	
REPORT FOR MONTH ENDING:			
COMMENCEMENT DATE:		SCHEDULED COMPLETION DATE:	
	ACCIDENT STATISTICS SUMMARY	FOR MONTH	CUMULATIVE
1.	Number of Manhours Worked		
2.	Number of Mandays Worked		
3.	Number of Reportable Fatal Accidents		
4.	Number of Reportable Non-Fatal Accidents		
5.	Number of Dangerous Occurrences		
6.	Number of Manhours Lost		
7.	Number of Mandays Lost		
8.	Number of Reportable Accidents per 100,000 Manhours Worked $= \frac{[(3) + (4)]}{(1)} \times 100,000 = \text{Accident Frequency Rate}$		
9.	Average Number of Worker Daily		
REMARKS:			
Signed: _____ Safety Officer: _____ Date: / / Signed: _____ Project Manager: _____ Date: / /			
NOTE: This form must be completed and returned to the Authority's Representative within 5 days after the end of each month.			

NATIONAL HIGHWAYS & INFRASTRUCTURE DEVELOPMENT CORPORATION LIMITED	SAMPLE SAFETY FORM REFERENCE:	SAF - 004
CONTRACTORS MONTHLY SAFETY REPORT		
NAME OF CONTRACTOR	CONTRACT NO.	
This report which shall be submitted to the Authority's Representative within five days of the end of each month consists of two sections; Part A. and Part B. PART A Accident Statistics Accident Statistics which shall be presented in the format shown on the Accident Statistics Monthly Report Form (SAF 003) Highlights of serious accidents which have occurred during the Month. Details of any Fires which have occurred during the Month. PART B Safety Activities Safety Committee. An extract of the salient points of the last month's meeting and any action taken. Details of Tool Box Talks held during the month to include: numbers up to date, total number of workers attending each talk, the safety topics covered, 3. Details of any other training provided either on site or by attendance to outside courses such as First-Aid, Crane Operator, Singer/Rigger's Etc. Safety promotion undertaken during the month, poster campaigns, competitions, etc. Details of Safety Inspections carried out during the month. This information should show internal inspections and inspections by any outside bodies. Details of Emergency Evacuation drills or exercises carried out during the month including the involvement, if any, of outside bodies. Any other relevant information.		

NATIONAL HIGHWAYS & INFRASTRUCTURE DEVELOPMENT CORPORATION LIMITED	SAMPLE SAFETY FORM REFERENCE :	SAF - 010
PERMIT TO WORK – CONFINED SPACES		
NAME OF CONTRACTOR		CONTRACT NO
PERMIT NO. CF		DATE / /
PART 1. ISSUE		
Issue to (Name of Person) _____ Section _____ Details of		
Confined Space		
Location _____		
Work to be carried out _____		
Results of Confined Space Testing:		
Oxygen Content _____	Explosive Gas _____	LEL _____
Toxic Gas 1: _____ Toxic Gas 2: _____		
Date and Time Tests Conducted _____ Type and		
Model of Equipment used _____		
Precautions Required _____		
I hereby declare that the above Confined Space is safe to enter without the use of breathing apparatus, provided the conditions of this permit and the requirements of the Company Safety Rules and observed.		
THIS PERMIT ONLY VALID FOR THE PERIOD SPECIFIED, WHICH MUST NOT EXCEED 24 HOURS		
Date: _____	Time of Issue: _____	Date: _____
Time of Expiry Signed _____		Being the
Authorised Person (Confined Spaces)		
PART 2. RECEIPT		
I hereby declare that work by myself, or by any person under my control in the above Confined Space shall be carried out in accordance with the conditions of this permit and the requirements of the company Safety Rules. All persons permitted to enter the Confined Space have been or will be informed of when the safe period for entry will expire.		
Signed _____	Time _____	Date _____
Being the		Competent Person (Confined Spaces)

PART 3. CLEARANCE CERTIFICATE	
I declare that all persons under my charge have been withdrawn and warned that it is no longer safe to work in the Confined Space deatiled above, and that all gear, tools and other equipment have been removed.	
Signed	Time_____Date_____
Being the Competent Person (Confined Spaces)	
PART 4. CANCELLATION	
I acknowledge receipt of the clearance of the Permit THIS PERMIT IS NOW CANCELLED	
Signed	_____
Being the Authorized Person (Confined Spaces)	
Time	_____Date_____

NATIONAL HIGHWAYS & INFRASTRUCTURE DEVELOPMENT CORPORATION LIMITED	SAMPLE SAFETY FORM REFERENCE :	SAF – 011
PERMIT TO WORK – ELECTRICAL		
Name of Contractor		Contract No.
PERMIT NO. E: _____ Date _____		
Part 1 : Issue Issue to _____ I hereby declare that it is safe to work on the _____ Following apparatus which is dead, is isolated _____ From all live conductors and is connected to earth _____ The apparatus is efficiently connected to earth _____ At the following points _____ All other apparatus is dangerous The following is the work to be carried out on the _____ Apparatus. _____ Caution Notices are posted at _____ Special Keys required for access to enclosures Special Precautions to be taken _____ This permit is valid only for the specified period which must not exceed 24 hours Signed _____ being an Authorized Person Possessing authority to issue a Permit for the work specified above. Time of issue _____ Date _____ Time of Enquiry _____		
Part 2 : Receipt I hereby declare that I accept responsibility for carrying out the work on the apparatus detailed on this permit, and that no attempt will be made by me, or by the men under my control, to carry out work on any other apparatus. Signed _____ Time _____ Date _____		
Part 3 : Clearance Certificate I hereby declare that the work for which this permit was issued is now suspended/completed and that all men under my charge have been withdrawn, and warned that it is no longer safe to work on the apparatus specified on this permit and that gear, tools and temporary earthing connections are all clear. I acknowledge return of authorised Key Nos _____ Signature of person responsible for issue of permit _____ Time _____ Date _____		

NATIONAL HIGHWAYS & INFRASTRUCTURE DEVELOPMENT CORPORATION LIMITED		SAMPLE SAFETY FORM REFERENCE:	SAF - 012
PERMIT TO WORK – HOT WORK			
NAME OF CONTRACTOR		CONTRACT NO	
PERMIT NO. HW:		Date	
Part 1: Issue			
Issue to (Name of person)		Section	
Details of Hot Work Location			
Work to be carried out			
I hereby declare that the above Hot Work is safe to carry out and that all appropriate fire precautions are in place including the issue of additional 5 kg Dry Powder Extinguisher on site and that all Company Safety Rules have been observed.			
Date:		Time of Issue	Time of Expiry
This permit is valid only for the period specified which must not exceed 24 hours			
Signed		Time	Date
<i>Being the Authorized Person (Hot Work)</i>			
Part 2 : Receipt			
I hereby declare that the work by myself, or by any person under my control or the above Hot Work shall be carried out in accordance with the conditions of this certificate and the requirements of the company Safety rules. All persons permitted to work on this Hot Work have been or will be informed of when the safe period for entry will expire.			
Signed _____		Time _____	Date _____
<i>Being the Competent (Hot Work)</i>			
Part 3: Clearance			
I declare that all Hot Work under my control has now been stopped and the area has been checked out found clear of any risk of fire and that all tools and other equipment have been removed.			
Signed _____		Time _____	Date _____
<i>Being the Competent (Hot Work)</i>			
Part 4 : Cancellation			
I acknowledge receipt of the clearance of this Certificate. This certificate is now cancelled			
Signed _____			
<i>Being the Authorized Person (Hot Work)</i>			
Time		Date	

NATIONAL HIGHWAYS & INFRASTRUCTURE DEVELOPMENT CORPORATION LIMITED				SAMPLE SAFETY FORM REFERENCE:	SAF - 020
NAME OF CONTRACTOR		CONTRACT No.	HAZARD/RISK ASSESSMENT SHEET	DATE:	
OPERATION:			METHOD STATEMENT Ref:	PAGE:	
HAZARDS	RISKS	DEGREE	CONTROL	MONITORING	

S-V Tunnel

NATIONAL HIGHWAYS & INFRASTRUCTURE DEVELOPMENT CORPORATION LIMITED		SAMPLE SAFETY FORM REFERENCE:	SAF - 021
HAZARDOUS SUBSTANCES TO BE USED ON SITE			
NAME OF CONTRACTOR		CONTRACT No.	
To be completed at Commencement and Revised Periodically and Updated as required			
Generally Assessed (For use outside or in well ventilated areas)		Others Specific assessments required	

1	☐	Cement	24	☐	Epoxy Cleaners	47	☐	
2	☐	Lime	25	☐	Butyl Mastic Sealants	48	☐	
3	☐	Plaster	26	☐	Acrylic Sealants	49	☐	
4	☐	Artex	27	☐	Mastic Primers	50	☐	
5	☐	Sand	28	☐	Mastic Solvents	51	☐	
6	☐	Aggregates	29	☐	Elastomeric Sealants	52	☐	
7	☐	Plasticisers	30	☐	Elastomeric Primers	53	☐	
8	☐	Retarders	31	☐	Elastomeric Solvents	54	☐	
9	☐	Rapid Hardeners	32	☐	Hot Mastic Sealants	55	☐	
10	☐	Colouring / Mortar	33	☐	Bitumastics	56	☐	
11	☐	Curing Agents	34	☐	Coated Road Stone	57	☐	
12	☐	Rapid	35	☐	Contact Adhesives	58	☐	
13	☐	Diesel / Gas Oil	36	☐	Contact Solvents	59	☐	
14	☐	Engine Oils	37	☐	Softwoods	60	☐	
15	☐	Hydraulic Oils	38	☐	Hardwoods			
16	☐	Shutter Oils	39	☐	Fibreboards			
17	☐	Greases	40	☐	Paints / Primers			
18	☐	Pipe Lubricants	41	☐	Paint Solvents			
19	☐	Epoxy Mortars	42	☐	Brush Cleaners			
20	☐	Epoxy Adhesives	43	☐	Bleaches			
21	☐	Epoxy Sealants	44	☐	Brick Cleaner			
22	☐	Epoxy Primers	45	☐	Concrete Cleaner			
23	☐	Epoxy Solvents	46	☐	Liquified Petroleum Gas			

Completed by: Sign: Name: Title: Date: / /

NATIONAL HIGHWAYS &INFRASTRUCTURE DEVELOPMENT CORPORATION LIMITED		SAMPLESAFETY FORM REFERENCE :		SAF - 030
SITE SAFETY AND EMERGENCY STAND BY NAME LIST				
Name of Contractor				Contract No.
The following persons have been appointed to be our representatives on site for all site safety emergencies.				
Name of Representative	Position	Office Tel. No.	Home Tel. No.	Mobile No.
Project Manager Name Signature Date				

NATIONAL HIGHWAYS & INFRASTRUCTURE DEVELOPMENT CORPORATION LIMITED		SAMPLE SAFETY FORM REFERENCE:	SAF - 031
SAFETY TRAINING ATTENDANCE RECORD			
NAME OF CONTRACTOR		CONTRACT No.	
Title of Course		Date / / Course Reference No.	
Duration	Name of Trainer (s)		
No.	Name	Section / Sub- Contractor	Signature
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
CONFIRMED AS CORRECT BY:			
SIGNATURE: _____ SAFETY MANAGER DATE / /			
SIGNATURE: _____ PROJECT MANAGER DATE / /			

S-V Tunnel

NATIONAL HIGHWAYS & INFRASTRUCTURE DEVELOPMENT CORPORATION LIMITED				SAMPLE SAFETY FORM REFERENCE:		SAF - 032	
WEEKLY FIRE FIGHTING EQUIPMENT CHECK							
NAME OF CONTRACTOR					CONTRACT NO		
SITE / LOCATION			DATE OF CHECK			/	/
FIRE POINT NUMBER	EXTINGUISHERS IN GOOD ORDER		ACCESS TO EXTINGUISHERS		SIGNAGE		
	YES	NO	CLEAR	OBSTRUCTED	CORRECT	INCORRECT	
COMMENTS:							
CHECK CARRIED OUT BY:							
NAME :		SIGNATURE	POSITION			DATE: / /	

NATIONAL HIGHWAYS & INFRASTRUCTURE DEVELOPMENT CORPORATION LIMITED		SAMPLE SAFETY FORM REFERENCE :	SAF - 033
SCAFFOLD INSPECTION CHECKLIST			
NAME OF CONTRACTOR:		CONTRACT No.	DATE: //
Work commencement – Date ___/___/___			
Location and description of scaffold, etc and other plant or equipment inspected	Date of Inspection	Result of Inspection State whether in good order	Signature of person who made the Inspection
1	2	3	4

SHORT CHECK LIST – ATTACH INSPECTION CHECK THAT YOUR SCAFFOLDING DOES NOT HAVE FAULTS

Week		1	2	3	4	Week		1	2	3	4	Week		1	2	3	4
FOOTING STANDARDS	Soft and uneven					RACING FAÇADE & LEDGER PUTLOGS AND TRANSOMS COUPLINGS	Some missing					TILES BOARDING	Some missing				
	No base						Loose						Loose				
	No sole boards						Wrong Fittings						Bad boards				
	Undermined						Wrongly Spaced						Trap Boards				
	Not plumb						Loose						Incomplete				
	Jointed at same Height						Wrongly Supported						Insufficient				
	Wrong Spacing						Wrong fitting						Supports				
	Damaged						Loose						Wrong Height				
	Not level						Damaged						Loose				
	Joint in same bays						No check couplers						Some Missing				
Loose					Wrong Spacing					Damaged							
Damaged					Wrong couplings					Insufficient Length							
					Weak Support					Not tied							

SIGNATURE _____ NAME _____ DATE / /

S-V Tunnel

NATIONAL HIGHWAYS & INFRASTRUCTURE DEVELOPMENT CORPORATION LIMITED	SAMPLE SAFETY FORM REFERENCE:	SAF - 040
CONTRACTOR'S APPLICATION FOR SAFETY OFFICERTO WORK <i>FOR CONTRACT.....</i>		
NAME OF CONTRACTOR	CONTRACT No.	
GENERAL PARTICULARS Name : _____ (In Block Capitals) Date of Birth		

SCHEDULE 2**EXAMPLES OF TOOL BOX TALKS**

The purpose of the following Toolbox Talks is give guidance on the subject matter to be covered during the talk. The talk should be given to groups of workers no greater than twenty in number by their supervisor. Each talk should last between ten and fifteen minutes. An attendance sheet of each talk should be kept showing who presented the session, the workers who attended, and the duration. Form SAF 031 Safety Training Attendance Record should be used for this purpose.

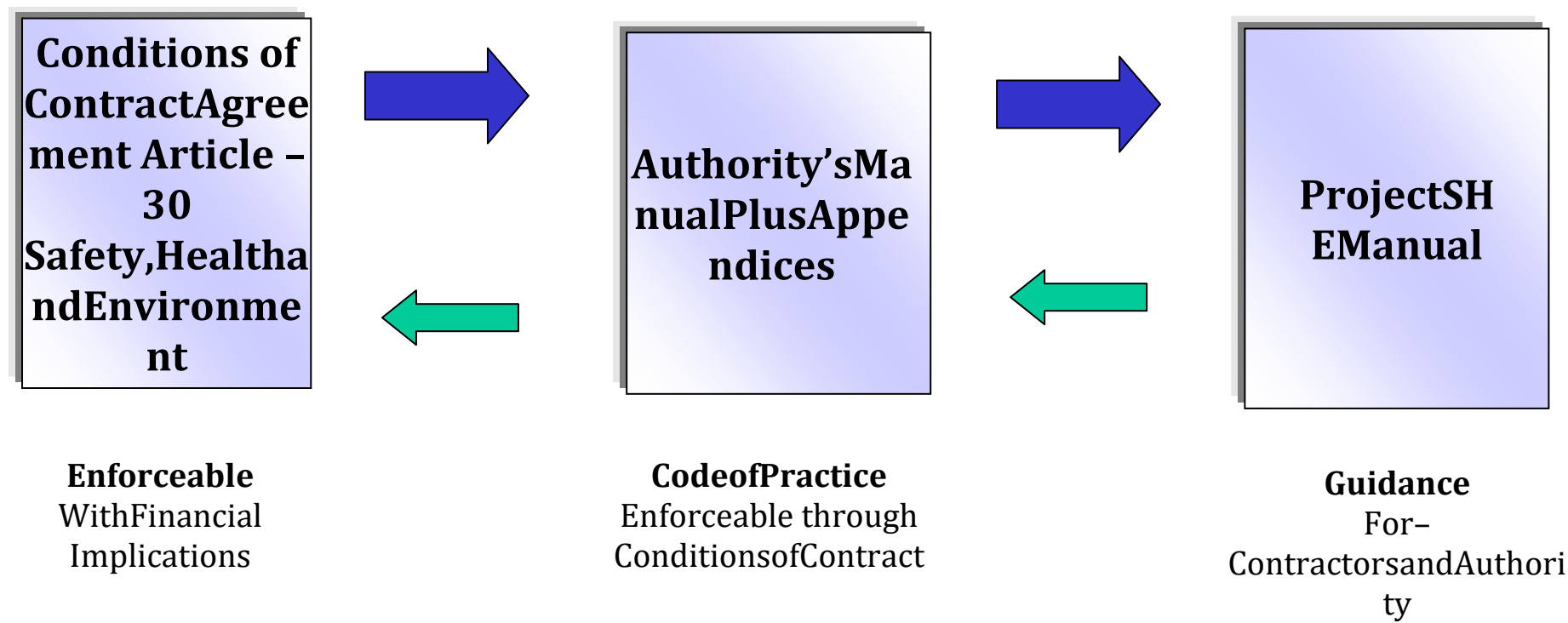
The following list shows the subjects covered:

1. Personal Points – Example inserted
2. Manual Handling
3. Hand Tools
4. Woodworking Machinery
5. Ladders
6. Cartridge Tools
7. Compressed Air
8. Oxygen
9. Compressed gas Cylinders
10. Drilling Machines
11. Pre-permit activation job specific toolbox talk

NATIONAL HIGHWAYS & INFRASTRUCTURE DEVELOPMENT CORPORATION LIMITED	TOOL BOX TALK No 1
PERSONAL POINTS	
• Never take chances. • Carry out the instructions you have been given. • If you do not know or understand - Ask. • If you see on unsafe condition - Rectify it or report it. • If you have an accident make sure you report it and get it properly attended to. • Obey all safety signs and rules. • Do not distract others or “horseplay” around • Only operate plant and equipment that you are authorised to. • Never operate machinery unless all the guards are in place. • Always wear the protective clothing and equipment that you have been provided with. • Keep your work place clean and tidy. • Look after your tools, don’t leave them on the ground where they can be damaged or where people can fall over them.	

SCHEDULE 3

HIERARCHY OF SAFETY HEALTH & ENVIRONMENTAL FOR NHIDCL CONTRACTORS



******* End of the Document *******