National Highways Authority of India

(Ministry of Road Transport & Highways)
Government of India

REHABILITATION, STREGTHENING AND FOUR LANING OF CHENANI TO NASHRI SECTION OF NH-1A FROM KM 89.00 TO 130.00 (NEW ALIGNMENT) INCLUDING 9 KM LONG TUNNEL (2 LANE) WITH PARALLEL ESCAPE TUNNEL IN THE STATE OF JAMMU & KASHMIR

(Package No. : NHDP-Phase-II/BOT/V/J&K)

CONCESSION AGREEMENT

between

National Highways Authority of India

G - 5&6, Sector – 10, Dwarka, New Delhi – 110 075

and

Chenani Nashri Tunnelway Limited

The IL & FS Financial Center, Plot C-22, G Block, Bandra Kurla Complex,
Bandra (E), Mumbai 400 051

VOLUME - II

(SCHEDULES)

June, 2010

CONTENTS (VOLUME – II: SCHEDULES)

Chenani Nashri Tunnelway Limited

SCHEDULE-A
(See Clause 10.1)

SITE OF PROJECT HIGHWAY

1.0 THE SITE

1.1 Site of the Project Highway shall include the land, buildings, structures and road works as described in **Annex-I** of this **Schedule-A**.

1.2 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 Concessionaire and such inventory shall form part of the memorandum referred to in Clause 10.3.1 of the Agreement.

1.3 Additional land required for Toll Plazas, Traffic Aid Posts, Medical Aid Posts and vehicle rescue posts or for construction of works specified in Change of Scope Order shall be acquired in accordance with the provisions of this Agreement. Upon acquisition, such land shall form part of the Site and vest in the Authority.

CHENANI NASHRI TUNNELWAY LIMITED

Annex - I

(Schedule-A)

Site for Project Highway

1.1 The Site

The project highway aims at construction of 9.0 km long two lane bidirectional tunnel with parallel 9.0 km long escape tunnel on new alignment in between Chenanni Km 89.000 and Nashri, Km 130.000 along the existing NH-1A in the State of J&K defined as **"Project Highway"**.

1.2 Description of the Project Highway

An index map and location plan of the Project Highway is given at **Appendix A-I.**

1.3 Latitudes & Longitudes

The approximate longitude and latitude of the region is 32°-53' North and longitude 75°-1.

1.3.1 Seismicity

The western Himalayas lie within seismic zones IV & V, of the seismic zoning map of India. Earthquakes of sizeable magnitude are not uncommon to the area. In the last 50 years, several major earthquakes with a magnitude in excess of 6 on the Richter Scale, have occurred in North-West Himalayas. The last significant seismic activity struck the area in October 2005, and with a magnitude of 7.6, it was with catastrophic results throughout the entire region.

1.4 Geology

The tunnel has to negotiate bed rock comprising rocks belonging to Murree formation (Fig.2) represented by sequence of Argillceous and Arenaceous rocks, comprising alternating sequence of sandstones, claystones, siltstones and clay shales with bands of pseudo conglomerate and calcareous concretions of smaller size set in a clay or silty matrix. The sandstones are fine to coarse grained, fairly massive to moderately blocky frequently showing opening with fillings. Hard to medium strength, sometimes showing weathering affect in patches. Sandstones are partly calcereous and ferrugenous with prominent bedding laminations.

Siltstones are fine grained with well developed bedding laminations, frequently micaceous with mottled appearing. They are charged with films and veins of calcite. Their strength is hard to fair; they sometimes contain calcareous and ferruginous material. Claystones are fine grained, soft to fairly hard, closely folded and sometimes highly fribly and crambled. Clay shales are well compacted, including silty and sandy lenses with occasional calcareous modules. They are fissured, weathered, expendable, and they are prone to swelling. They are highly frible and crumbled. Plastic gougy seams were developed in clay shale bands due to the folding.

The rock is highly disturbed having a general dip of approximately 30° at the higher levels and 70° at the lower levels on either side in folded strata with NNW-SSE strike. There are three sets of joints: bedding joints, cross joints and micro joints dipping 20° to 80°. Steeply dipping joints predominate over gently dipping joints. The tunnel alignment passes through Kud Syncline and is bounded by Murree thrust in the north and by main boundary fault in the south. The rock mass is locally folded plunging towards east. Rock mass faulting results in its highly jointed and fractured nature.

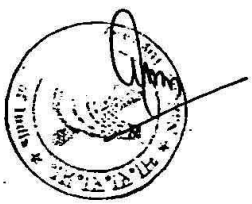
There are two perennial Nalas close to the tunnel portals (south and north), therefore water ingress is expected during the tunnelling. Also presence of water pockets in the tunnel profile is expected due to structural conditions of the rock mass. Presence of soft bands interlaying

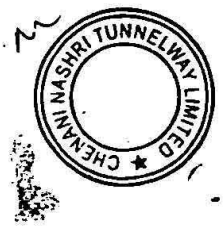
Annex – II

(Schedule-A)

SITE OF THE SIX-LANING

There is no site for six laning on this project.





competent hard bands is typical feature of Murree Formation.

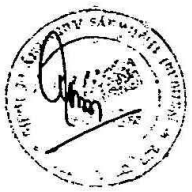
A detail Geological evaluation report is attached as **Appendix A-II**

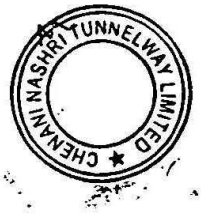
1.5 Traffic

Traffic count details as per the survey conducted by design consultant during the month / year June 2004 on the project highway are given at **Appendix A-III**

1.6 Land

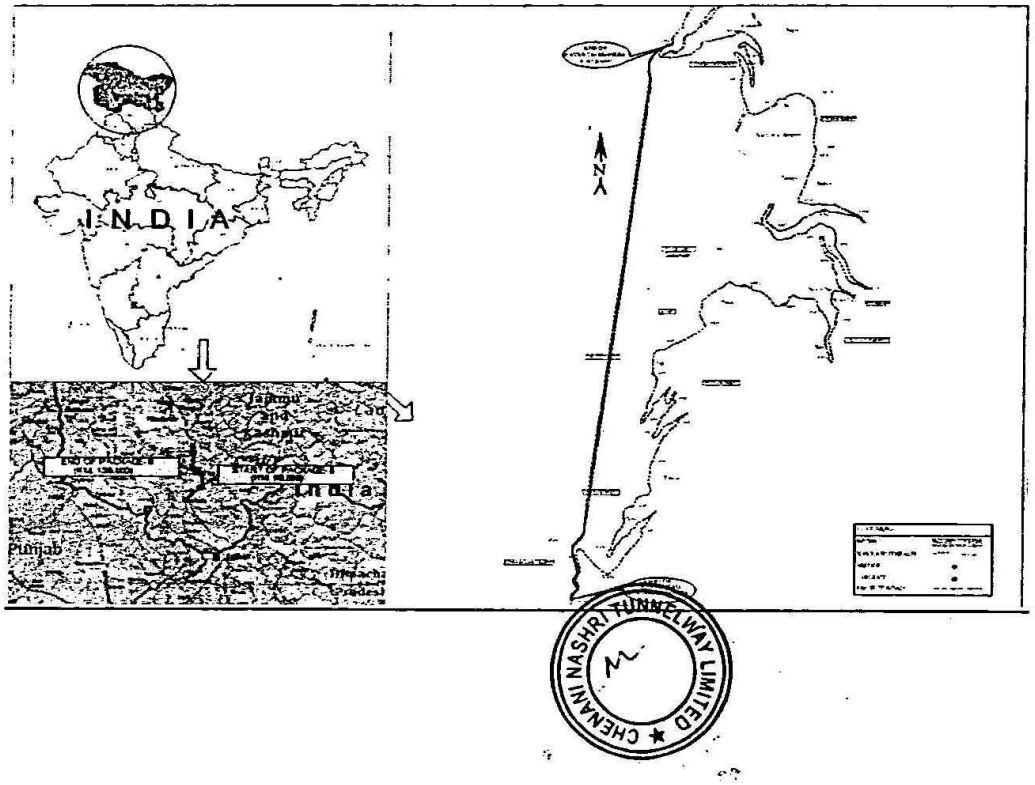
The existing available ROW for the project road was enquired from local BRO authorities and was informed to be 7.0m to 12.0m.





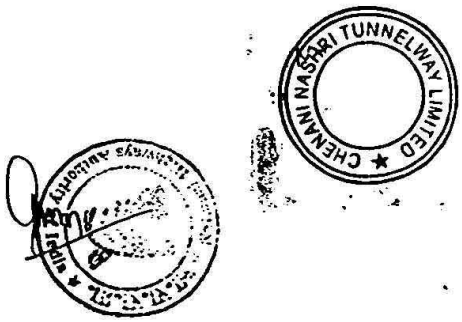
Appendix A-I

INDEX MAP OF PROJECT HIGHWAY



Appendix A-II

The Geotechnical Report : Attached Separately.



Appendix A-III

TRAFFIC TABLE

Year of Survey	Two wheelers	Car/Jeep/Van	Mini Bus	Full Bus	LGV	Trucks 2 axle	Trucks 3 axle	Truck Artic	Military Jeep	Milltary Bus	Milltary Truck	Total PCU
June 2004	109	1489	322	371	140	2293	54	10	81	135	293	11801

CHENANI NASHRI TUNNELWAY LIMITED

SCHEDULE - B
(See Clause 2.1)

DEVELOPMENT OF THE PROJECT HIGHWAY

1. DEVELOPMENT OF THE PROJECT HIGHWAY

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

2. CONSTRUCTION OF PROJECT HIGHWAY

2.1 Project Highway shall include construction of the Project highway as described in **Annex-I** of this **Schedule-B** and **Annex-I** of **Schedule-C.**

2.2 Construction of the Project Highway shall be undertaken and completed by the concessionaire in conformity with the specifications and standards set forth in Annex-I of Schedule-D.

CHENANI NASHRI TUNNELWAY LIMITED

Annex - I
(Schedule-B)

DESCRIPTION OF PROJECT HIGHWAY

1 Width of Carriageway

1.1 Main Tunnel :

The paved carriageway shall be 9.35 meters wide and 1.2 m wide footpath each side. The vertical clearance should be minimum 5.0 m.

1.2 Escape Tunnel :
The paved carriageway shall be 5.0 meters wide and the minimum vertical clearance should be 2.5 m.

1.3 Cross Passage:
The paved carriageway shall be 7.50 meters wide and the vertical clearance should be 4.5 m. These should be provided at every 300 m as shown in **Appendix B-I.**

1.5 Fire Fighting Niche
Fire Fighting Niche shall be provided at every 150 m on each side as shown in **Appendix B-I.**

1.6 Emergency Call Niche

Emergency Call Niche shall be provided at every 150 m on each side as shown in **Appendix B-I.**

1.7 Lay Byes

Lay Byes shall be provided every 1.2 km on each side as shown in **Appendix B-I.**

1.4 Approaches to both the portals :
As per Plan and Profile indicated in **Appendix B-II.**

1.8 Tunnel Operation, Control, Safety and Electro Mechanical provisions
The tunnel Operation, Control, Safety and Electro Mechanical Equipments and other provisions shall be as per **Appendix BIII.**

1.9 Except as otherwise provided in this Agreement, but subject to the provisions of Annex-II of this Schedule-B, the width of the paved carriageway shall conform to clause 1 above.

2 Project Facilities

Project facilities shall be constructed in conformity with Annex-I of Schedule-C.

3 Specifications and Standards

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

4. Other Features of Project Highway

4.1 Cross Sections

The cross section of the main tunnel, escape tunnel, cross passages Fire Fighting Niche, Emergency Niche and Lay byes should be as indicated in **Appendix B**

CHENANI NASHRI TUNNELWAY LIMITED

4.2 Alignment Plan and Longitudinal Section

An alignment plan and vertical profile of project highway is given at **Appendix B-II.**

4.3 Drainage System

The drainage system for the main tunnel, escape tunnel and the cross passages should be as indicated in cross sections indicated in **Appendix BIV.**

4.4 Service Road

No Service Roads has been proposed in this reach of Project Highway.

4.5 Proposed Right of Way for approaches

The width of proposed ROW is varying due to site conditions. The details of proposed ROW are marked in the Plan and Profile provided in **Appendix B-II.**

4.6 At Grade Intersection and Junctions

At grade intersections shall be provided at the intersection of all intersecting roads. The details of at grade junctions are provided in **Appendix BV.**

4.7 Grade Separated Intersections

No grade separator is required in this reach of the project Highway.

4.8 Underpasses

No Underpass is required in this reach of the project Highway.

4.9 Major bridges

Major bridges as listed in **Appendix BVI** shall be provided, widened, reconstructed, or extended

4.10 Minor bridges

Minor bridges as listed in **Appendix BVII** shall be provided, widened, reconstructed, or extended.

4.11 Culverts

Culverts shall be provided, widened, reconstructed, or extended as listed in **Appendix BVIII**

4.12 ROB/RUB

No ROB/RUB is required in this reach of the project Highway.

4.13 Entry /exit ramps

Entry /exit ramps for entering into or exiting from the project highway shall be provided wherever necessary.

4.14 Slope protection

The side slope shall be protected by using suitable slope protection measures all along the highway both on Hill Side, Median and Valley Side. The details of the protection work are listed in **Appendix BIX** and the typical sections for the protection work are given in **Appendix BX.**

4.15 Electrical and Mechanical Works.

The Electrical and Mechanical works including the Fire Fighting installation shall be

provided as per ANNEXURE BIII

4.16 Utilities

Provision of accommodating utilities shall be made both over as well as underground wherever required.

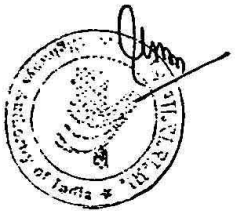
4.17 Rainwater Harvesting

As per Ministry of Environment and Forests Notification, New Delhi dated 14.01.1997 (as amended on 13.01.1998, 05.01.1999 & 6.11.2000), the construction of Rain water, harvesting structure is mandatory in and around Water Crisis area, notified by the Central Ground Water Board.

Annex - II
(Schedule-B)

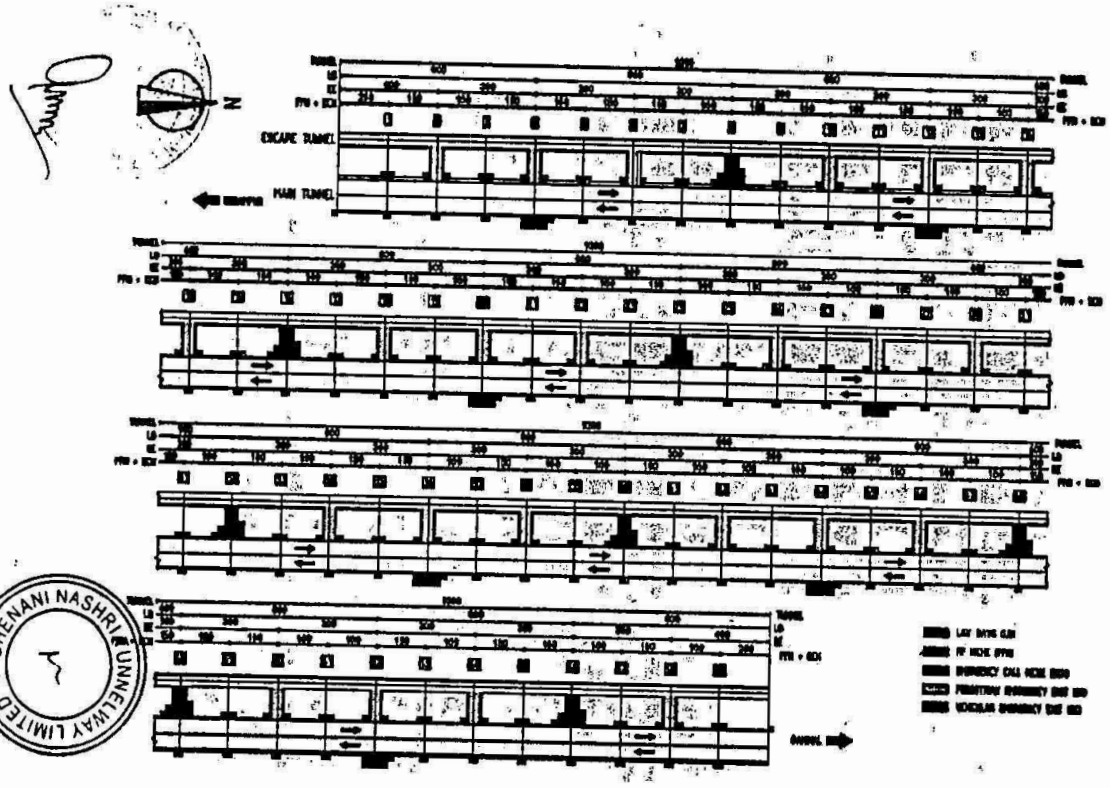
DESCRIPTION OF SIX-LANING

There is no built up areas/stretch for six-laning under the project.



Layout :

Appendix B I



Appendix B II

Plan and Profile – enclosed in CD

CHENANI NASHRI TUNNELWAY LIMITED

Appendix B III

1. Tunnel Operation Safety and Traffic Control:
   Enclosed in CD.

2. Electro - Mechanical Equipment
   Enclosed in CD.

Appendix B IV

1. Cross Section : Main Tunnel With Invert

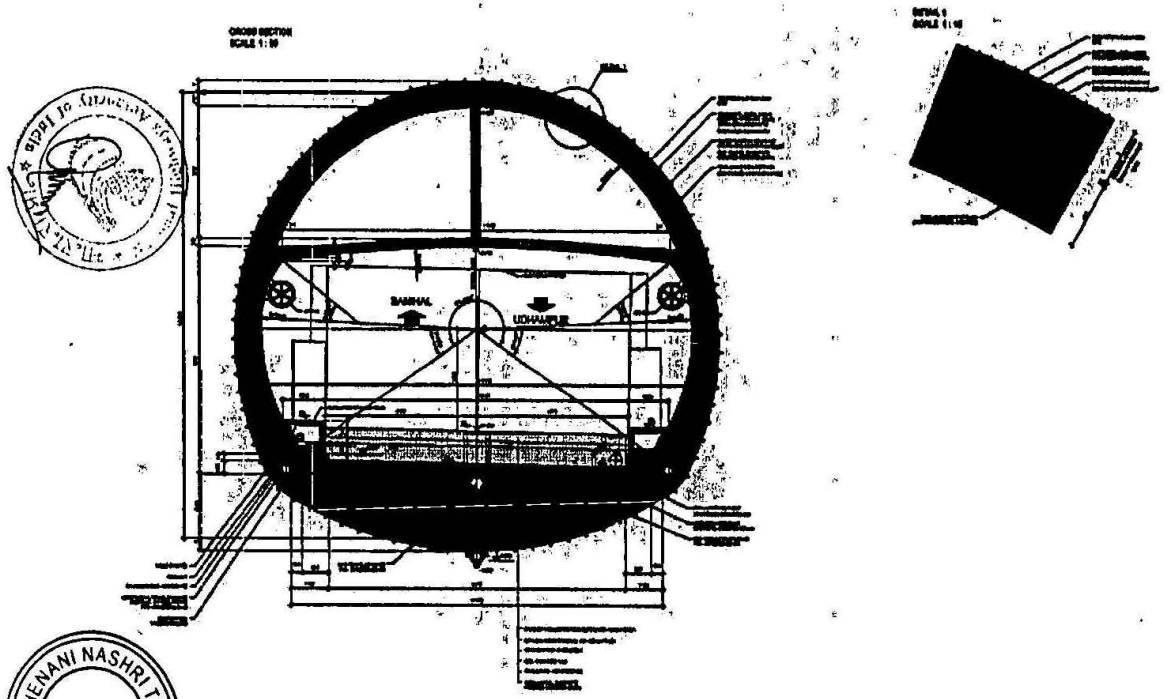


Fig B-1: TCS-1

2. Cross Section : Escape Tunnel With Invert

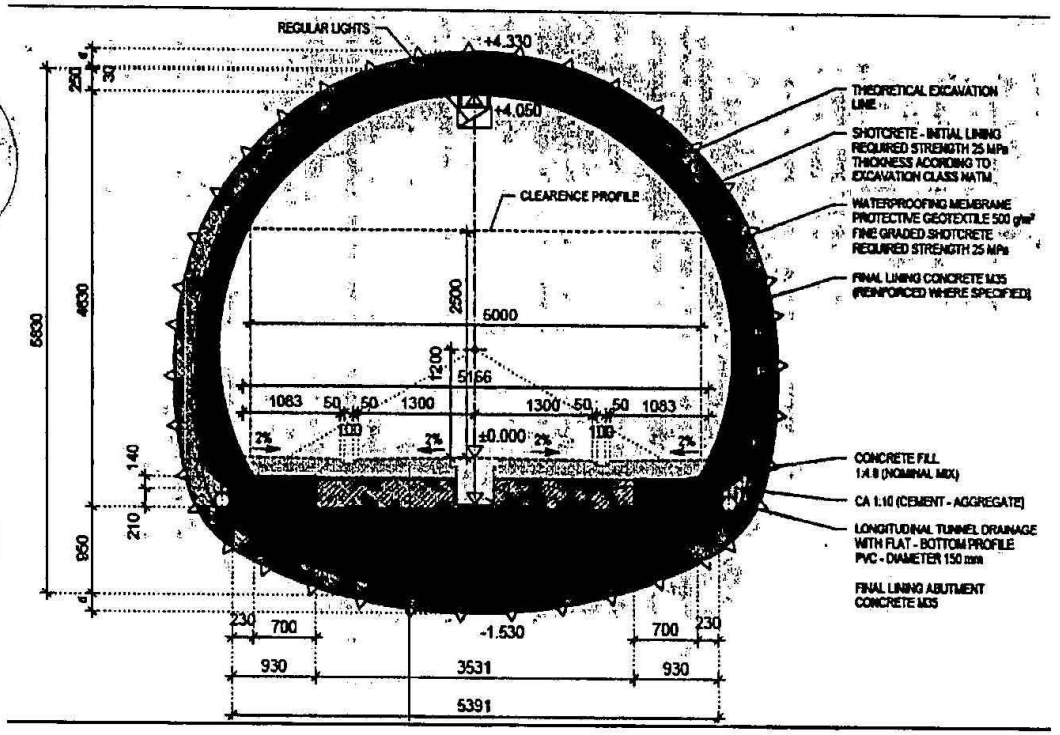
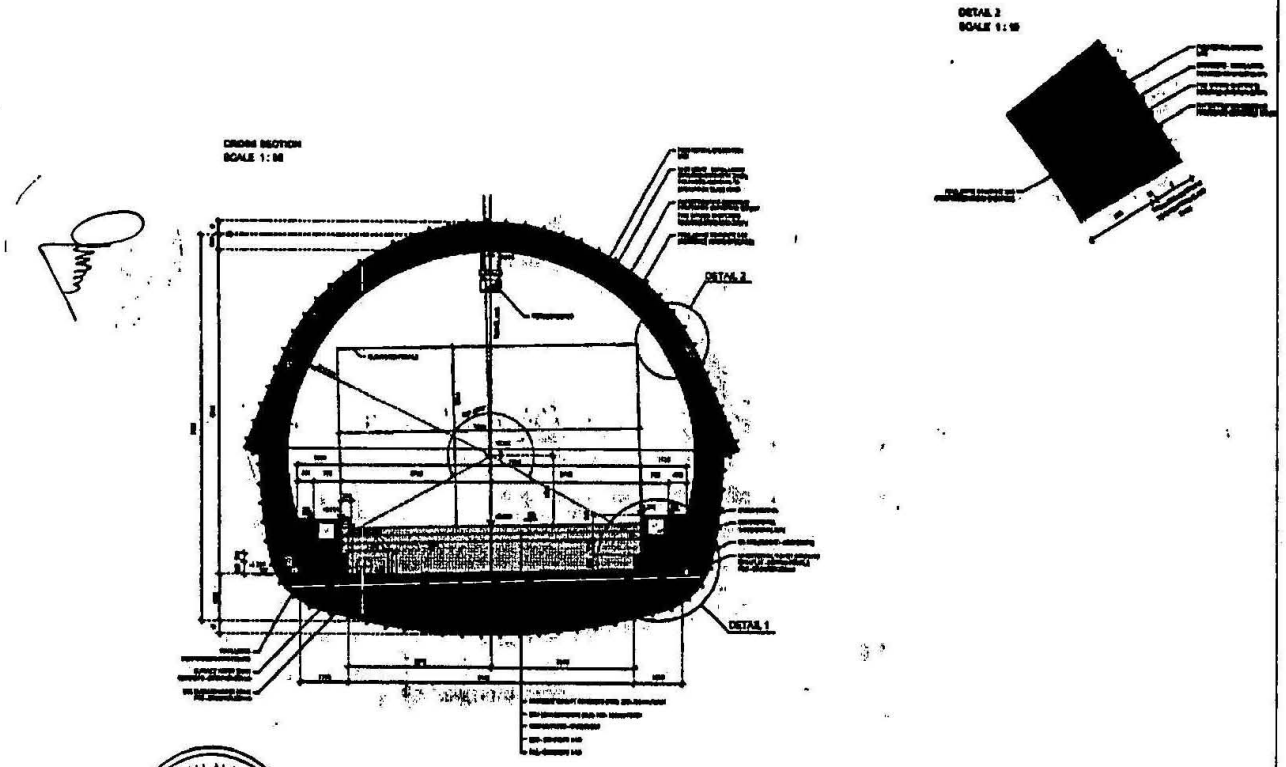


Fig B-2 : TCS-2

3. Cross Section : Cross Passage With Invert



CHENANI NASHRI TUNNELWAY LIMITED

Fig B-3 : TCS-3

Lay Bye :

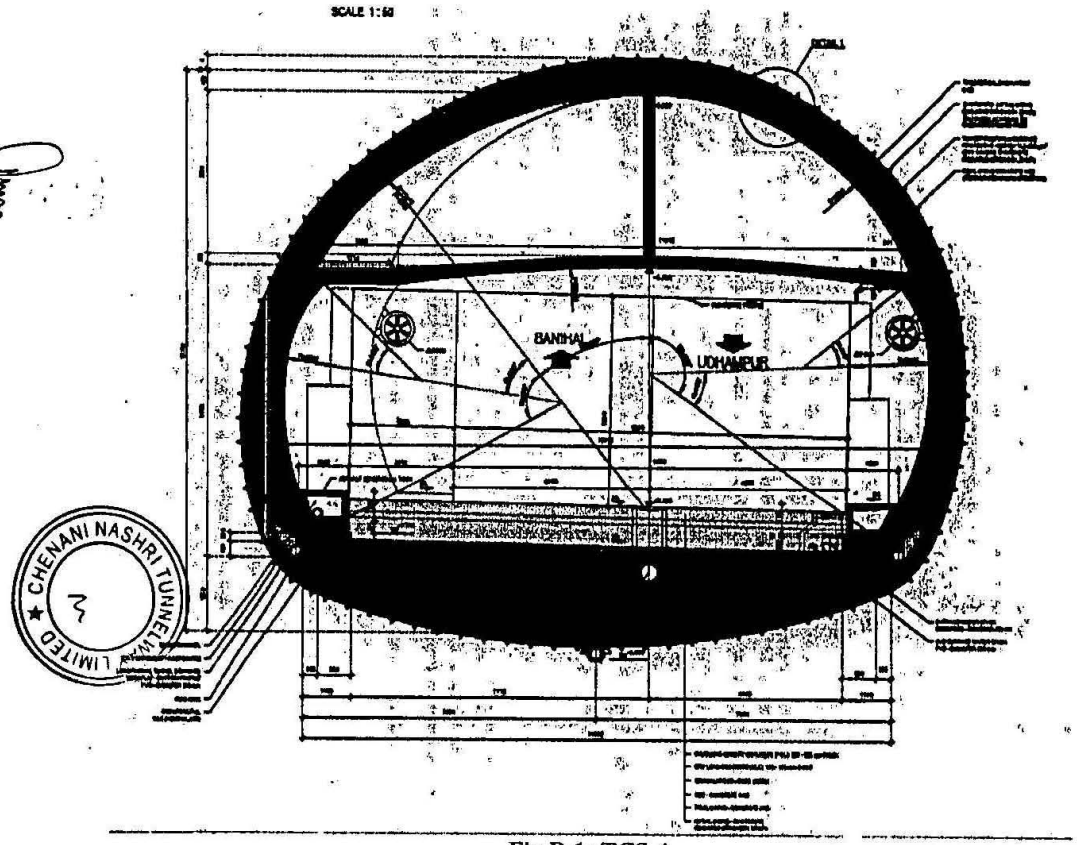


Fig B-1: TCS-4

Fire Fighting Niche:

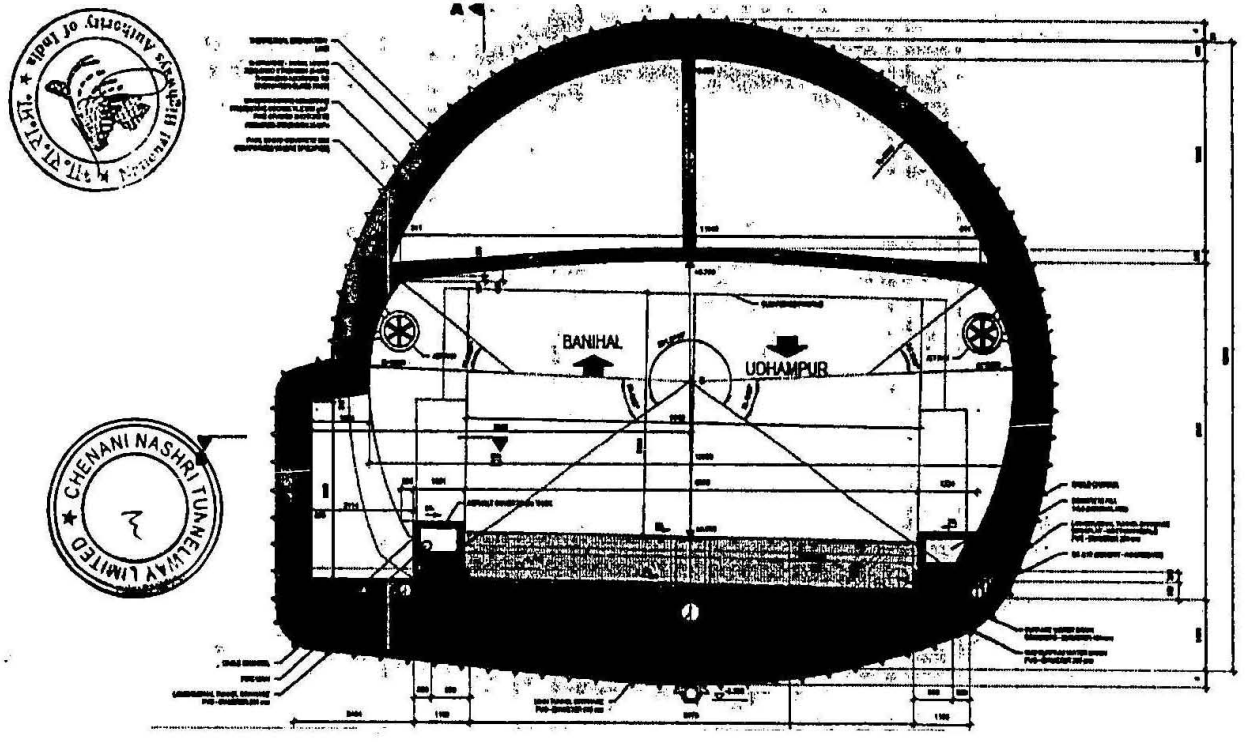


Fig B-1: TCS-5

Emergency Niche:

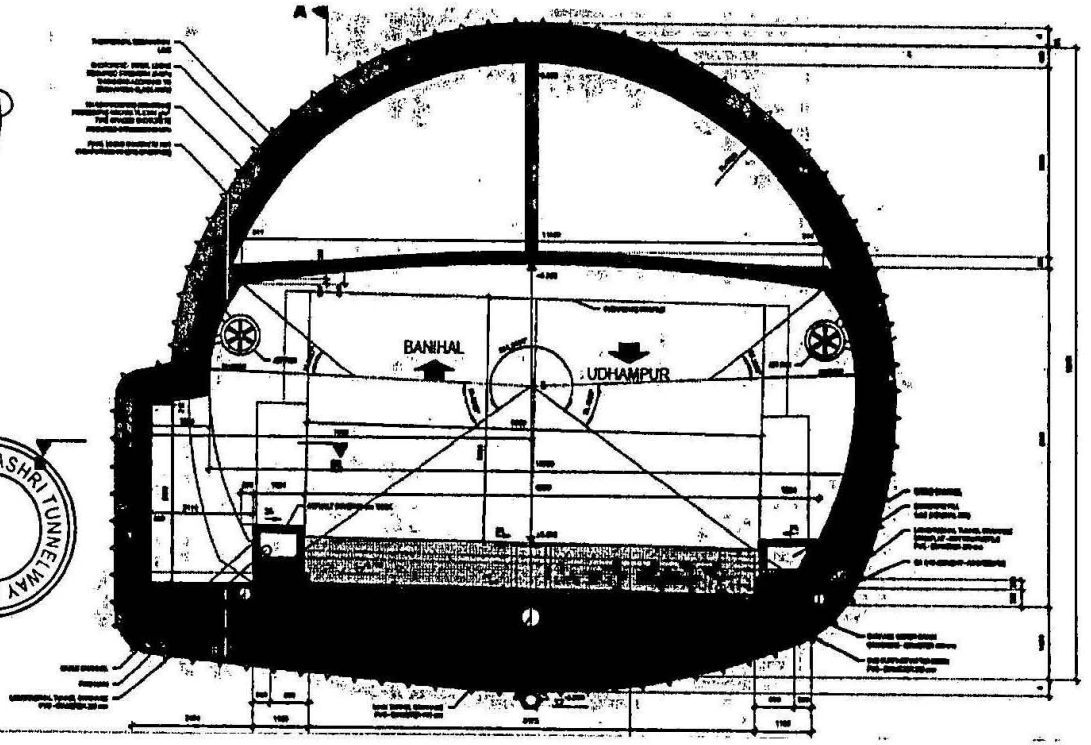


Fig B-1: TCS-6

Appendix-B -V

A) JUNCTIONS

1. Rotary junction at Km. 89
2. Merger at 1000
3. Diversion at 10400
4. Rotary Junction at Km. 130

B) U-Turns

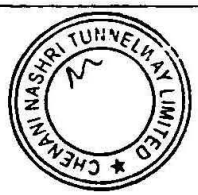
S.N.	Southbound Chainage
U-turn no. 1	0.300

CHENANI NASHRI TUNNELWAY LIMITED

Appendix B VI

MAJOR BRIDGES

Nil



Appendix B VII

MINOR BRIDGES

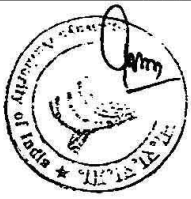
Details of New Bridges and Rehabilitation/Repair/Widening Scheme for Existing Bridges

Sl. No.	Carriageway	Chainage in km.	Old / New	Length of Bridge in 'm'	Formation Width (m)	Curved or Straight	Type of super-structure	Type of Abutment	Abutment Foundation	Type of Pier	Pier Foundation
1	Right	1.150	New	40.0	9.5	Straight	PSC Box Girder	Box type	Open	-	-
2	Right	10.300	New	50.0	9.5	Straight	PSC Box Girder	Box type	Open	-	-

Appendix B VIII

NEW CULVERTS TO BE PROVIDED

SL. NO.	DESIGN CHAINAGE	PROPOSED CULVERT TYPE	PROPOSED CULVERT SIZE
	Left		
1	0+190	Conc. BOX	1X2X3
2	0+340	Conc. BOX	1X2X2
3	0+450	Conc. BOX	1X2X2
4	0+760	Conc. BOX	1X2X2
5	0+820	Conc. BOX	1X3X3
6	0+900	Conc. BOX	1X4X4
7	10+500	Conc. BOX	1X3X3



Appendix B IX

DETAILS OF SLOPE PROTECTION WORKS

A) Valley Side

Chainage		Length, m	Type of wall
From	To		
-	120	120	Turfing
120	200	80	Stone Masonry Revetment
200	440	240	Turfing
440	580	140	SM1
580	680	100	Turfing
680	720	40	Stone Masonry Revetment
720	780	60	RE Walls
780	840	60	SM1
840	880	40	Turfing
880	1,060	180	SM1
1,060	1,120	60	SM1
1,120	1,160	40	Bridge
1,160	1,200	40	SM1
1,200	1,360	160	Rocknet + 30 % shotcrete
1,360	10,310	8,950	Tunnel
10,310	10,470	160	Turfing

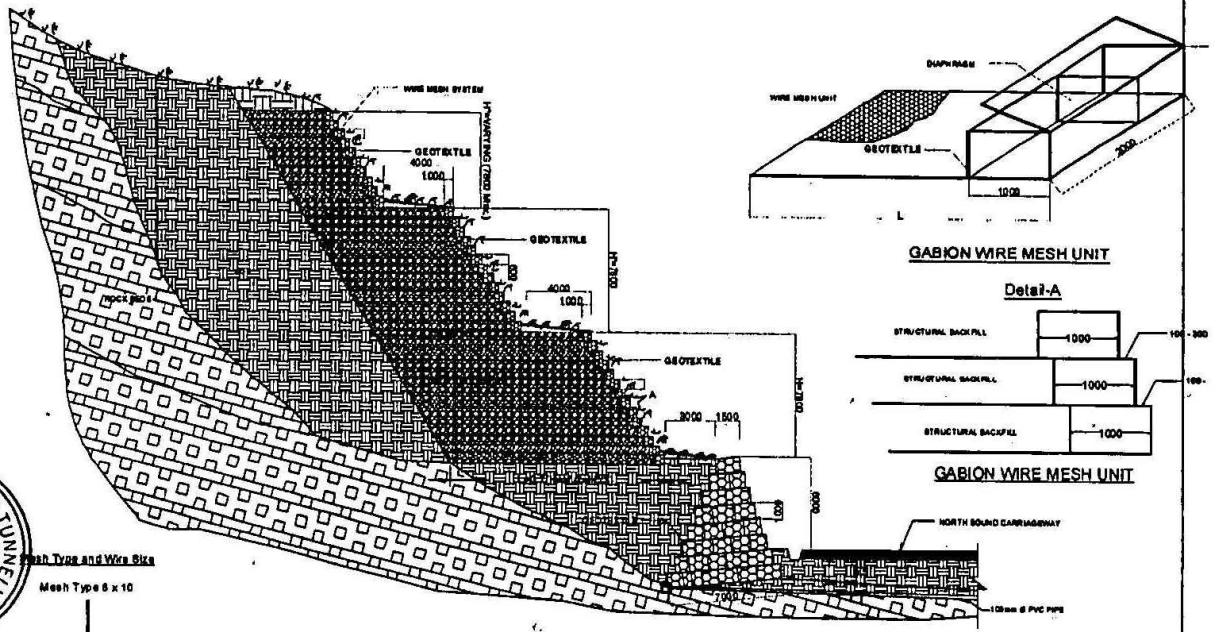
C) Hill Side

Chainage		Length, m	Type of wall
From (Km)	To (Km)		
-	300	300	Stone Masonry Revetment
300	440	140	Rocknet + 30 % shotcrete
440	560	120	Stone Masonry Revetment
560	600	40	Turfing
600	900	300	Rocknet + 30 % shotcrete
900	960	60	Turfing
960	1,040	80	Rocknet + 30 % shotcrete
1,040	1,120	80	Stone Masonry Revetment
1,120	1,160	40	Bridge
1,160	1,200	40	Turfing
1,200	1,360	160	Rocknet + 30 % shotcrete
1,360	10,310	8950	Tunnel
10,310	10,700	390	Rocknet + 30 % shotcrete

CHENANI NASHRI TUNNELWAY LIMITED

Appendix B X

TYPICAL SECTIONS FOR PROTECTION WORKS



GABION WIRE MESH UNIT

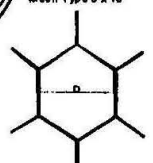
Detail-A

GABION WIRE MESH UNIT

GABION AND GABION WIRE MESH SYSTEM (FOR BALI LAND SLIDE AREA)

Mesh Type and Wire Size

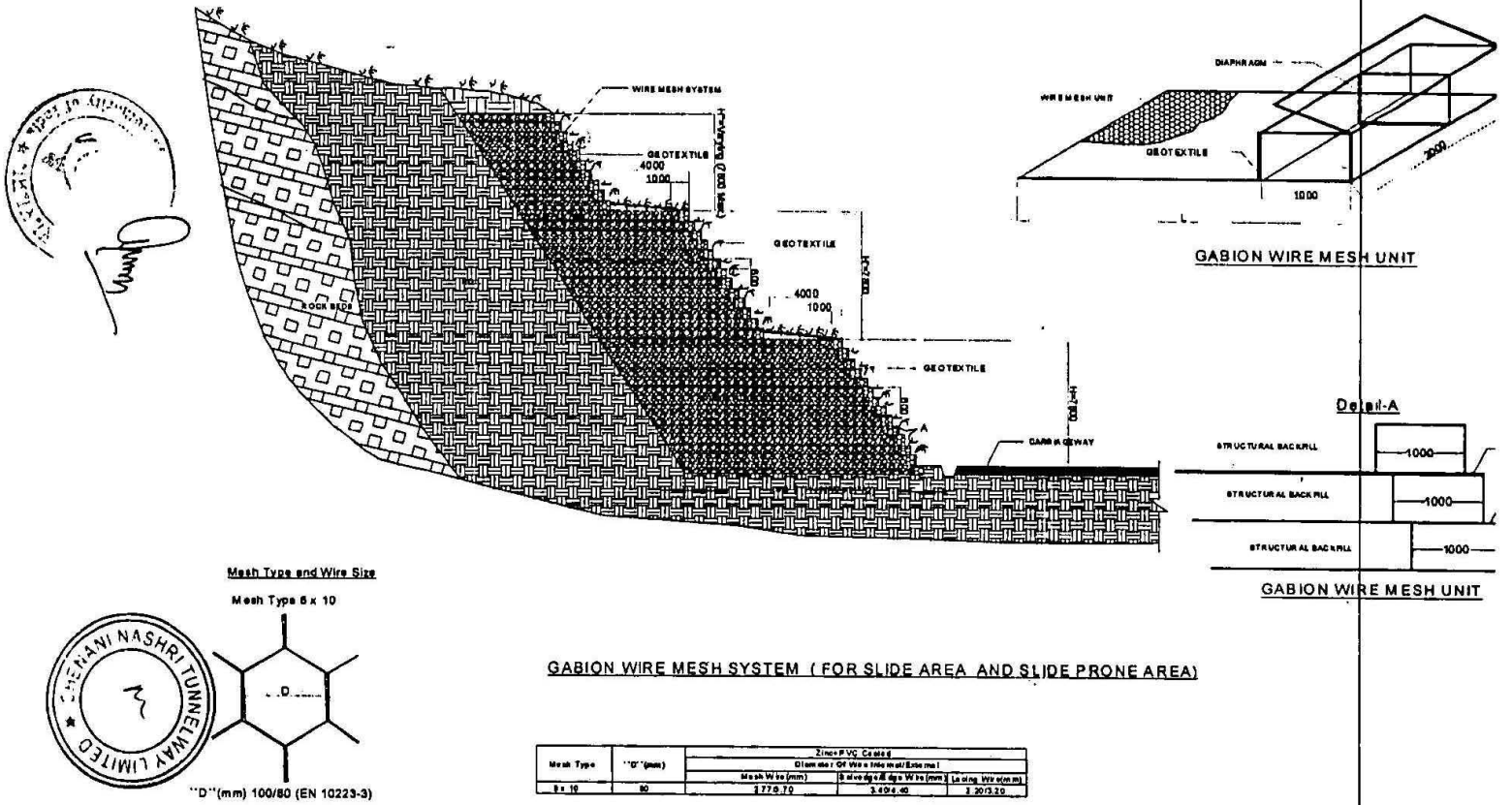
Mesh Type 8 x 10



"D"(mm) 100/80 (EN 10223-3)

Mesh Type	"D"(mm)	Zinc+PVC Coated Diameter Of Wire Internal/Selvedge		
		Mesh Wire(mm)	Selvedge Edge Wire(mm)	Lacing Wire(mm)
8 x 10	80	2.7/3.70	3.40/4.40	2.20/3.20

Fig. B-4 : PW-1



Mesh Type and Wire Size

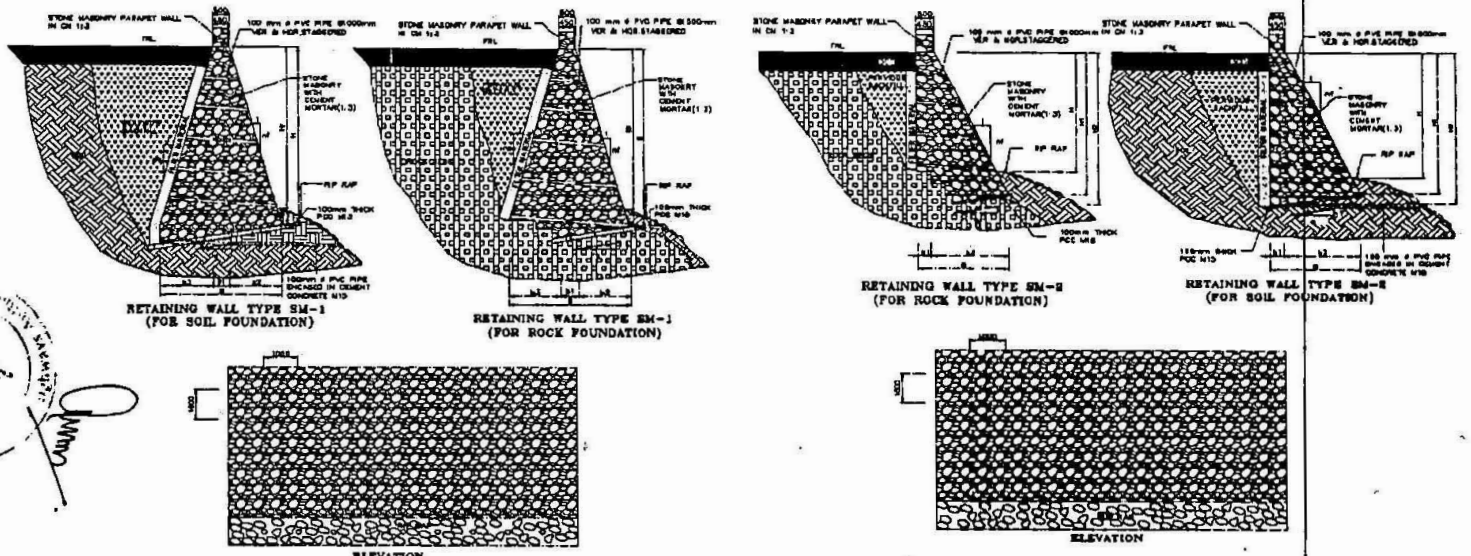
Mesh Type 8 x 10

"D"(mm) 100/80 (EN 10223-3)

GABION WIRE MESH SYSTEM (FOR SLIDE AREA AND SLIDE PRONE AREA)

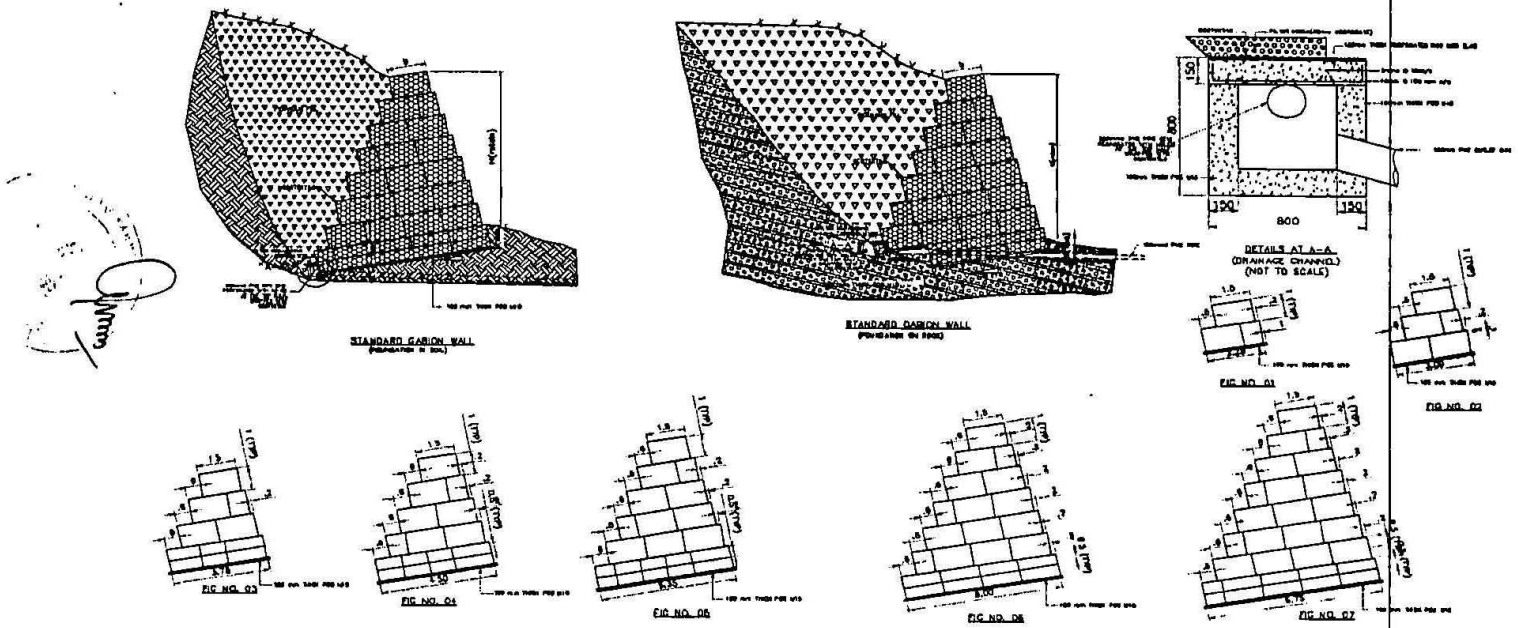
Mesh Type	"D" (mm)	Zinc+PVC Coated Diameter Of Wire Internal/External		
		Mesh Wire (mm)	Selvedge/Edge Wire (mm)	Lacing Wire (mm)
8 x 10	80	2.70/3.70	3.40/4.40	2.20/3.20

Fig. B-5 : PW-2



CHENANI NASHRI TUNNELWAY LIMITED

Fig. B-6 : PW-3



CHENANI NASHRI TUNNELWAY LIMITED

Fig. B-7 : PW-4

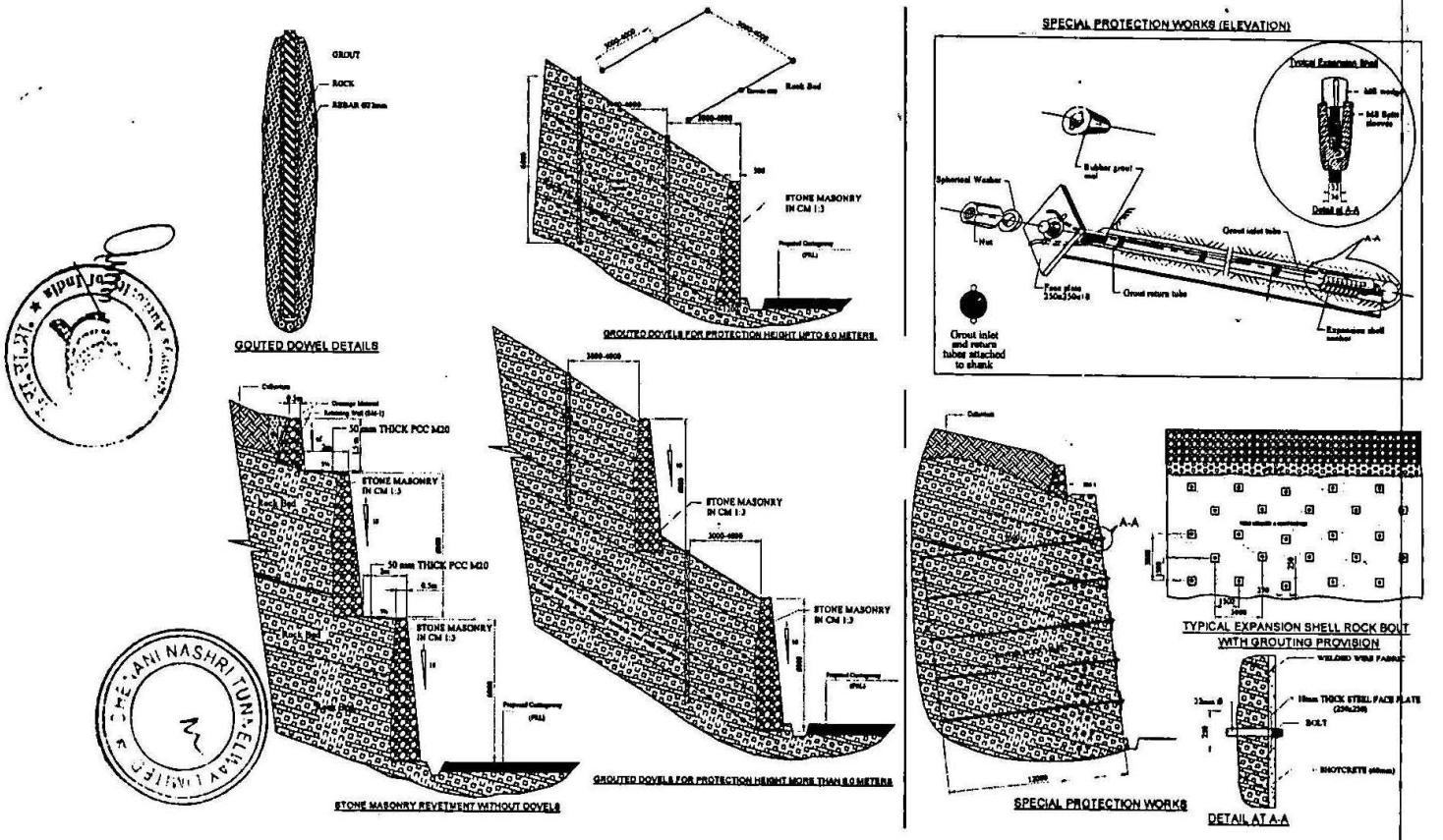

GROUT
ROCK
GROUTED DOWEL DETAILS
STONE MASONRY IN CM 1:3
GROUTED DOVELS FOR PROTECTION HEIGHT UPTO 6.0 METERS
50 mm THICK PCC M20
STONE MASONRY IN CM 1:3
STONE MASONRY REVETMENT WITHOUT DOVELS
GROUTED DOVELS FOR PROTECTION HEIGHT MORE THAN 6.0 METERS
SPECIAL PROTECTION WORKS (ELEVATION)
Spherical Washer
Nut
Grout inlet tube
Grout return tube
Grout inlet and return tubes attached to shank
Detail at A-A
A-A
SPECIAL PROTECTION WORKS
TYPICAL EXPANSION SHELL ROCK BOLT WITH GROUTING PROVISION
BOLT
DETAIL AT A-A

Fig. B-8: PW-5

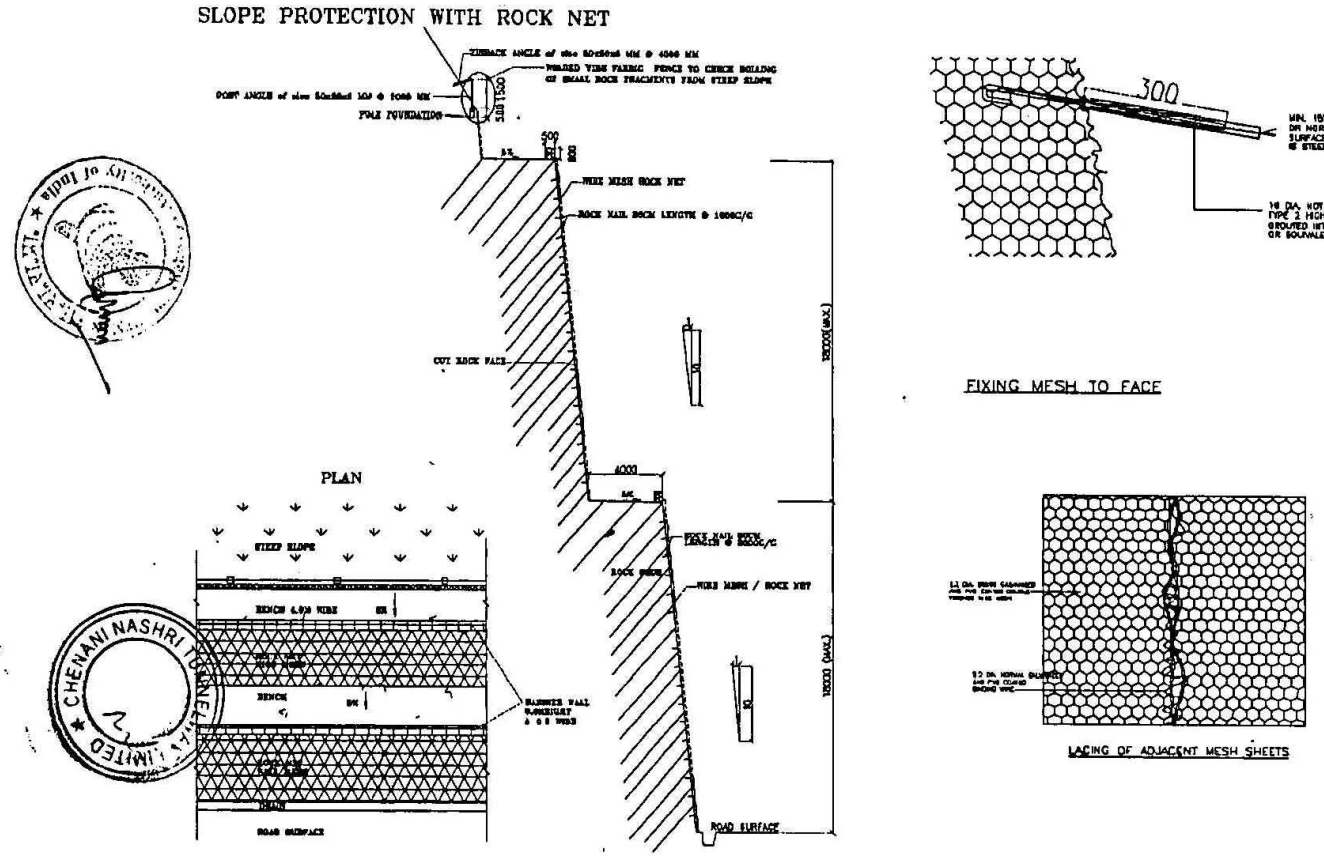

SLOPE PROTECTION WITH ROCK NET
PLAN
FIXING MESH TO FACE
LACING OF ADJACENT MESH SHEETS
300
ROAD SURFACE

Fig. B-9: PW-6

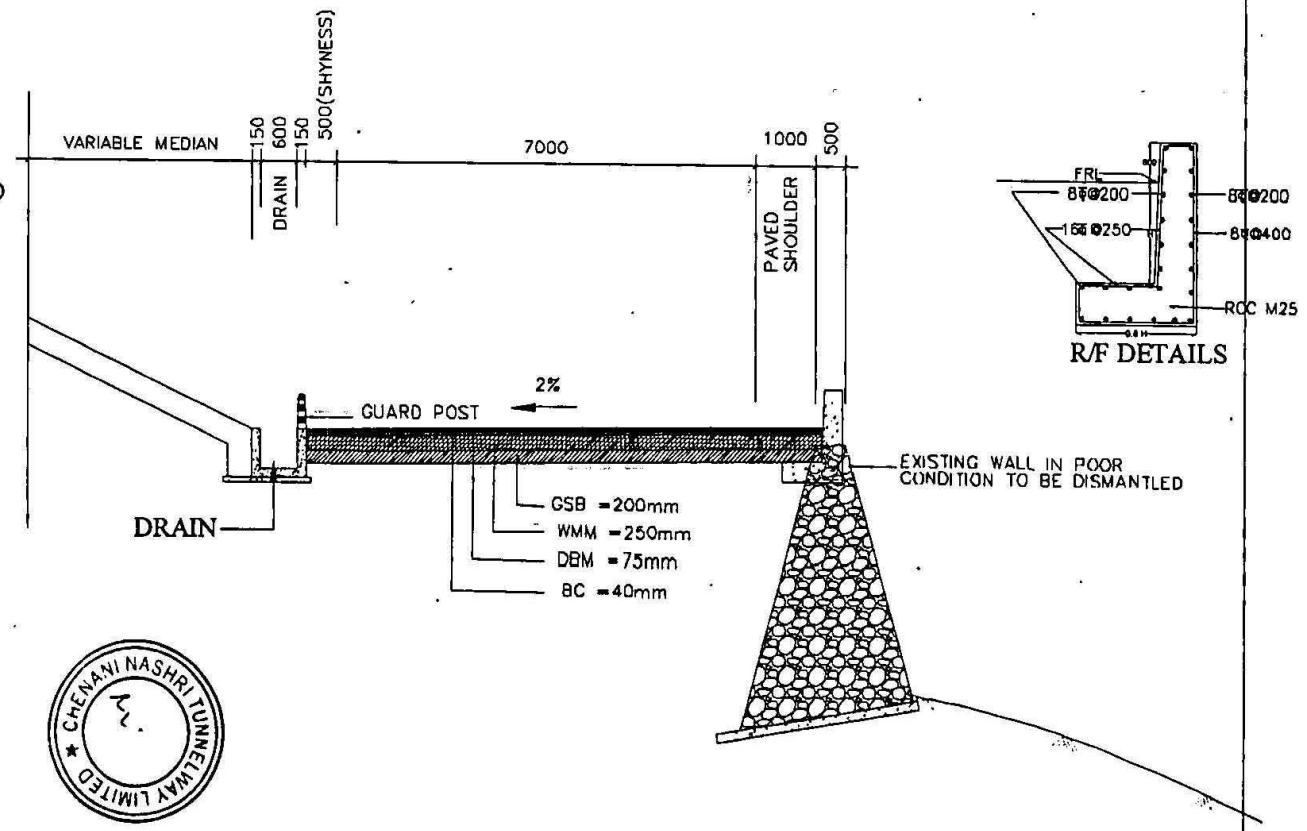

VARIABLE MEDIAN
150
600
150
500(SHYNESS)
7000
1000
500
DRAIN
PAVED SHOULDER
2%
GUARD POST
EXISTING WALL IN POOR CONDITION TO BE DISMANTLED
DRAIN
GSB =200mm
WMM =250mm
DBM =75mm
BC =40mm
FRL
R/F DETAILS
RCC M25

Fig. B-10: PW-7

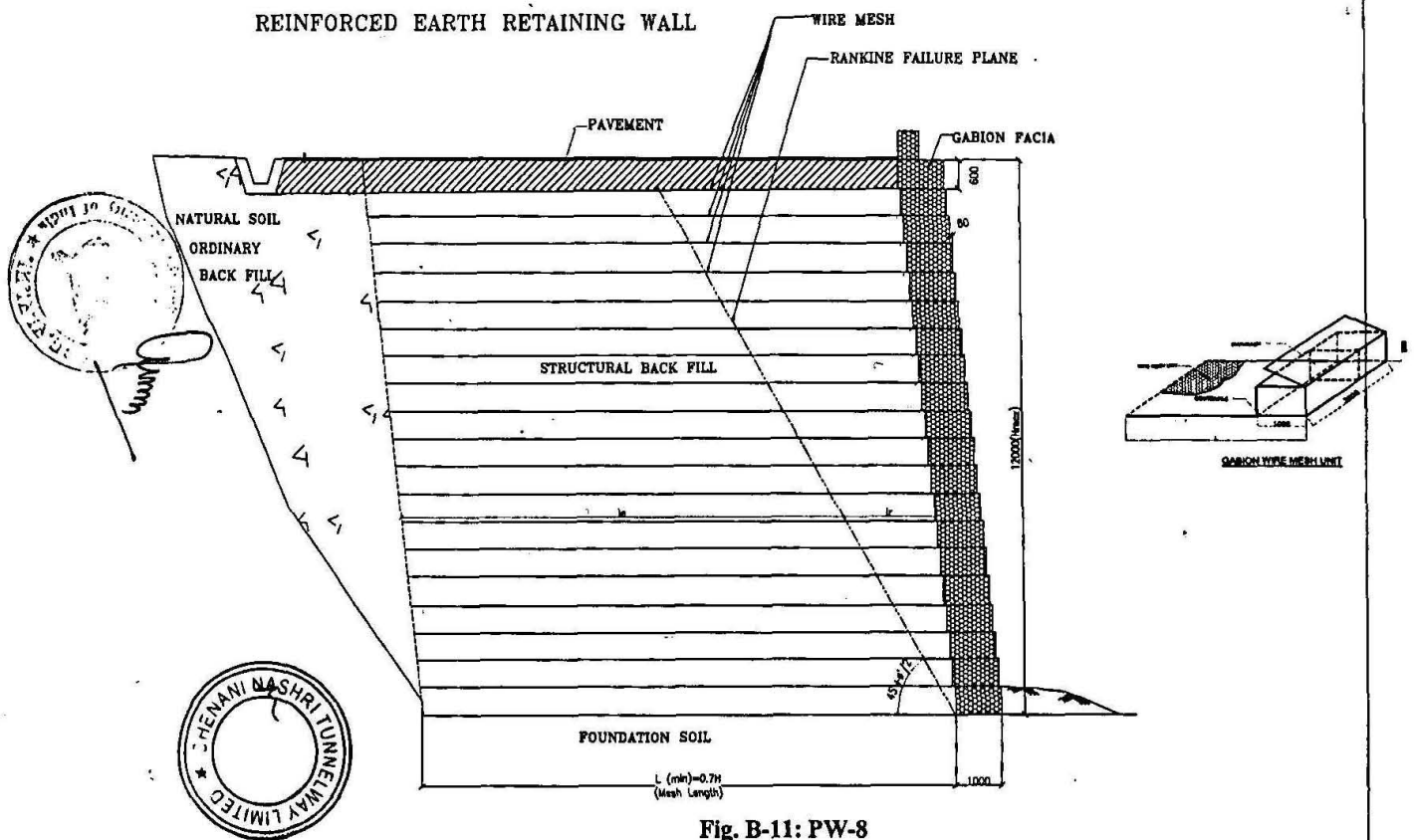

REINFORCED EARTH RETAINING WALL
WIRE MESH
RANKINE FAILURE PLANE
PAVEMENT
GABION FACIA
NATURAL SOIL
ORDINARY
BACK FILL
STRUCTURAL BACK FILL
FOUNDATION SOIL
600
60
12000(Max.)
45+ϕ/2
L (min)=0.7H
(Mesh Length)
1000
GABION WIRE MESH UNIT

Fig. B-11: PW-8

SCHEDULE – C
(See Clause 2.1)

PROJECT FACILITIES

1 **Project Facilities**

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

(a) Toll plazas;

(b) Roadside furniture;

(c) Street lighting;

(d) Pedestrian facilities;

(e) Landscaping and tree plantation;

(f) Rest areas;

(g) Truck lay-bys;

(h) Bus-bays and bus shelters;

(i) Cattle crossings;

(j) Development of site for wayside amenities;

(k) Traffic aid posts;

(l) Medical aid posts;

(m) Vehicle rescue posts;

(n) Telecom system; and

(o) Highway traffic management system.

2 **Project Facilities for Four-Laning**

Project Facilities forming part of Four-Laning and to be completed on or before the Project Completion Date have been described in Annex-I of this Schedule-C.

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Annex - I

(Schedule C)

Project Facilities for Four-Laning

1 **Project Facilities**

The Concessionaire shall construct the Project Facilities described in this Annex-I to form part of the Four-Lane Project Highway. The Project Facilities shall include:

(a) Toll plazas;

(b) Roadside furniture;

(c) Pedestrian facilities;

(d) Tree plantation;

(e) Truck lay-bys;

(f) Bus-bays and bus shelters; and

(g) Others

1. Highway Lighting
2. Highway Patrol
3. Ambulances
4. Cranes
5. H.T.M.S.
6. Development of site for wayside amenities;
7. Traffic aid posts;
8. Medical aid posts;
9. Vehicle rescue posts
10. Telecom system
11. Cattle Crossing.
12. Project Laboratory.

2 **Description of Project Facilities**

Each of the Project Facilities is briefly described below:

(a) Toll Plazas

To be provided at both ends of tunnel as decided by IC/NHAI. Specifications and other requirements of the toll plaza's shall be strictly as per Schedule "D"

(b) Road side Furniture

Road side furniture shall be provided in accordance with Manual of Specifications and Standards.

(c) Street Lighting:

Street lighting shall be provided in accordance with Manual of Specifications and Standards.

(d) Pedestrian Facilities

Pedestrian Facilities shall be provided in accordance with the Manual of Specifications and Standards.

(e) Landscaping and Tree Plantation

Landscaping and tree plantation shall be provided in accordance with the Manual of specifications and Standards.

(f) Rest areas:

Rest areas shall be provided at each Toll Plaza. They shall include toilets and drinking water facilities.

(g) Truck Lay-byes

Lay Byes shall be provided every 1.2 km on each side.

(h) Bus-byes and Bus Shelter

Bus-byes and Bus Shelter shall be provided at as per requirement and as decided by NHAI/IC.

(i) Vehicular Underpasses and Pedestrian/Cattle Underpasses:

A vehicular underpass shall be provided as mentioned in Schedule B

(j) Traffic Aid Posts:

Traffic Aid Posts shall be provided at the Toll Plaza in accordance with Agreement.

(k) Medical Aid Posts:

Medical aid posts shall be provided at the Toll Plaza in accordance with Agreement.

(l) Vehicle rescue posts:

Vehicle rescue posts shall be provided at the Toll Plaza in accordance with the Manual of Specifications and Standards.

(m) Telecom system:

Telecom posts shall be provided at the Toll Plazas for convenience of the users of the Project Highway.

SCHEDULE – D

(See Clause 2.1)

SPECIFICATIONS AND STANDARDS

1. Four-Laning

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

Annex - I
(Schedule-D)

Specifications and Standards for Four-Laning

1. Manual of Specifications and Standards to apply

Subject to the provisions of Paragraph 2 of this Annex-I, Four-Laning of the Project Highway shall conform to the Manual of Specifications and Standards for Four laning of Highways through Public Private Partnership published by Indian Roads Congress-2009. (An authenticated copy of the Manual has been provided to the Concessionaire as part of the bid documents).

2. Deviations from the Manual

Notwithstanding anything to the contrary contained in the aforesaid Manual, the following Specifications and Standards shall apply to the Four-Lane Project Highway, and for purposes of this Agreement, the aforesaid Manual shall be deemed to be amended to the extent set forth below:

S. No.	Clause referred in the Manual	Item	Provision as per Manual	Modified provision
	4.2.2.2	Urban/Built up Sections	-	
		(iii) Width of earthen shoulder	-	
		(a) Plain and Rolling Terrain	1.50m	1m earthern shoulder is being provided due to constraint on space
		(v) Minimum width of separation-island between main carriageway and service road	1.5m	No separation island has been proposed, instead the service road has been separated from the main carriageway by 0.5m wide separator
		(viii) Width of utility corridor on both sides	1.5m	1m width has been proposed due to space restriction
	4.2.9	**Geometric design requirement of additional features:**	-	
		d. Service Roads	-	
		Paved shoulder : 0.5m on both sides (may be dispensed with in exceptional circumstances)	-	Instead 1m wide earthern shoulder towards separator has been proposed due to space restriction
	4.3	**Embankment**	-	

S. No.	Clause referred in the Manual	Item	Provision as per Manual	Modified provision
	4.3.3	**Use of flyash for Embankment Construction**	-	
		(i) Fly ash shall be used for construction of embankment in accordance with guidelines of MOSRT&H. The embankment shall be designed and construction in accordance with IRC:SP-58. The thickness of soil cover shall not be less than 1 m for embankment upto 3m height. For high embankment the thickness of soil cover shall be increased as per design.	-	No flyash is being proposed to be used due to non availability of Thermal Power Station with in 100 km from the project corridor
	5.3	**Processed Materials**	-	-
	5.3.1	**Fly ash:** Fly ash to be used in embankment construction shall meet the requirement specified in IRC:SP:58.	-	Not proposed due to non availability of Thermal Power Station within 100 Km of project corridor

The Construction of road protection works shall conform to the Specifications laid down in **Annexure DIII.**

The Construction of Tunnel shall conform to the Specifications laid down in **Annexure DI and Annexure DII.**

Where the aforesaid codes, standards and specifications are silent on any aspect, the following standards in order of preference shall be adopted in consultation with the IC, unless otherwise specified in this Schedule:

a). Urban Road Tunnels Recommendations to managers and operating bodies for design, management, operation and maintenance by PIARC Technical Committee.

b). Model Specifications for Tunneling 2000 edition issued by British Tunneling society with amendments and modifications

c). European Standard Tunnel specifications

d). I.E.C./ I.S. specifications.

e). Other Standard Specifications being used world wide.

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List of IRC Codes / Standards / Acts for Road/Bridge Works

IRC:	2	-1968	Route Marker Signs for National Highways (First Revision)
IRC:	3	-1983	Dimensions and weight of Road Design vehicles. (First Revision)
IRC:	5	-1998	Standard Specification & Code of Practice for Road Bridges, Section I – General Features of Design (7th Revision)
IRC:	6	-2000	Standard Specifications & Code of Practice for Road Bridges, Section II – Loads and Stresses (Fourth Revision)
IRC:	7	-1971	Recommended Practice for Numbering Bridges and Culverts (First Revision)
IRC:	8	-1980	Type Designs for Highway Kilometre Stones (Second Revision)
IRC:	9	-1972	Traffic Census on non urban roads (First Revision)
IRC:	10	-1961	Recommended Practice for Borrow pits for Road Embankments Constructed by Manual Operation
IRC:	15	-2002	Standard Specifications & Code of Practice for Construction of Concrete Roads (Third Revision)
IRC:	16	-1989	Specification for Priming of Base Course with Bituminous Primers (First Revision)
IRC:	18	-2000	Design Criteria for Prestressed Concrete Road Bridges (Post-Tensioned Concrete) (Third Revision)
IRC:	20	-1966	Recommended Practice for Bituminous Penetration Macadam (Full Grout)
IRC:	21	-2000	Standard Specifications and Code of Practice for Road Bridges. Section-III Cement Concrete (Plain and reinforced) (Third revision)
IRC:	22	-1986	Standard Specifications and Code of Practice for Road Bridges. Section-VI Composite Construction (First Revision).
IRC:	24	-2001	Standard Specifications and Code of Practice for Road Bridges. Section-V Steel Road Bridges (First Revision)
IRC:	26	-1967	Type Design for 200-Metre Stones
IRC:	30	-1968	Standard Letters and Numerals of Different Heights for Use on Highway Signs
IRC:	32	-1969	Standard for Vertical and Horizontal Clearances of Overhead Electric Power and Telecommunication Lines as Related to Roads
IRC:	33	-1969	Standard procedure for evaluation and condition surveys of stabilised soil roads.
IRC:	34	-1970	Recommendations for road construction in waterlogged area.
IRC:	35	-1997	Code of Practice for Road Markings (with Paints) (First Revision)
IRC:	36	-1970	Recommended Practice for Construction of Earth Embankments for Road Works

IRC:	37	-2001	Guidelines for the Design of Flexible Pavements (Second Revision)
IRC:	38	-1988	Guidelines for Design of Horizontal Curves for Highways and Design Tables (First Revision)
IRC:	40	-2002	Standard Specifications and Code of Practice for Road Bridges. Section IV - Brick, Stone and Block Masonry (Second Revision)
IRC:	41	-1997	Type designs for check barriers (First Revision)
IRC:	42	-1972	Proforma for record of test values of locally available pavement construction materials.
IRC:	45	-1972	Recommendations for Estimating the Resistance of Soil Below the Maximum Scour Level in the Design of Well Foundations of Bridges
IRC:	52	-2001	Recommendation about the alignment survey and geometric design of hill roads. (Second Revision)
IRC:	54	-1974	Vertical Clearances at Underpasses for Vehicular Traffic.
IRC:	56	-1974	Recommended Practice for Treatment of Embankment Slopes for Erosion Control
IRC:	57	-1974	Recommended Practice for Sealing of Joints in Concrete Pavements
IRC:	58	-2002	Guidelines for the design of plain jointed Rigid pavements for highways (Second Revision)
IRC:	59	-1976	Tentative Guidelines for the design of gap graded cement concrete mixes for road pavements.
IRC:	61	-1976	Tentative Guidelines for the construction of Cement Concrete Pavements in Hot Weather
IRC:	65	-1976	Recommended practice for traffic rotaries.
IRC:	67	-2001	Code of Practice for Road Signs (First Revision)
IRC:	69	-1977	Space Standards for Roads in Urban Areas
IRC:	70	-1977	Guidelines on regulations and control of mixed traffic in urban areas.
IRC:	71	-1977	Recommended practice for preparation of notations.
IRC:	73	-1980	Geometric Design Standards for Rural (Non-Urban) Highways
IRC:	75	-1979	Guidelines for the Design of High Embankments
IRC:	78	-2000	Standard Specifications and Code of Practice for Road Bridges. Section-VII Foundations & Sub-structure (Second Revision).
IRC:	79	-1981	Recommended Practice for Road Delineators
IRC:	80	-1981	Type Designs for Pick-up Bus Stops on Rural (i.e., Non-Urban) Highways
IRC:	81	-1997	Tentative Guidelines for Strengthening of Flexible Road Pavement Using

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Benkelman Beam Deflection Technique (First Revision)

IRC:	83	-1999	Standard Specifications and Code of Practice for Road Bridges. Section-IX Bearings, Part-I: Metallic Bearings.
IRC:	83	-1987	Standard Specifications and Code of Practice for Road Bridges, (Part-II) Section-IX Bearings, Part-II : Electrometric Bearings
IRC:	83	-2002	Standard Specifications and Code of Practice for Road Bridges. (Part-II) Section-IX Bearings, Part-III : POT POT-CUM-PTFE, PIN AND METALLIC GUIDE BEARINGS
IRC:	84	-1983	Code of Practice for Curing of Cement Concrete Pavement
IRC:	85	-1983	Recommended practice for accelerated strength testing and evaluation of concrete for Road and Airfield Constructions.
IRC:	86	-1983	Geometric Design Standards for Urban Roads in Plains
IRC:	87	-1984	Guidelines for the design and erection of false work for road bridges.
IRC:	88	-1984	Recommended practice for lime fly ash stabilised soil base/ sub base in pavement construction.
IRC:	89	-1997	Guidelines for Design & Construction of River Training & Control Works for Road Bridges (First Revision)
IRC:	91	-1985	Tentative guidelines for construction of cement concrete pavement in cold weather.
IRC:	92	-1985	Guidelines for the Design of Interchanges in Urban Areas
IRC:	93	-1985	Guidelines on Design and Installation of Road Traffic Signals
IRC:	98	-1997	Guidelines on Accommodation of Underground Utility Services Along and Across Roads in Urban Area (First Revision)
IRC:	101	-1988	Guidelines for design of continuously reinforced concrete pavement with elastic joints.
IRC:	102	-1988	Traffic studies for planning bypasses around towns.
IRC:	103	-1988	Guidelines for Pedestrian Facilities
IRC:	104	-1988	Guidelines for Environmental impact assessment of Highway projects.
IRC:	SP: 11	-1988	Handbook of Quality Control for Construction of Roads and Runways (Second Revision)
IRC:	SP: 13	-2004	Guidelines for the Design of Small Bridges and Culverts.
IRC:	SP: 14	-1973	A Manual for the Application of the Critical Path Method to Highway Project in India
IRC:	SP: 15	-1996	Ribbon Development Along Highways and its Prevention

IRC:	SP:	16	-2004	Guidelines for surface evenness of Highways Pavements (First Revision)
IRC:	SP:	17	-1977	Recommendations About Overlays on Cement Concrete Pavements
IRC:	SP:	18	-1978	Manual for Highway Bridge Maintenance Inspection.
IRC:	SP:	19	-2001	Manual for Survey, Investigation and Preparation of Road Projects (First Revision)
IRC:	SP:	21	-1979	Landscaping of Road
IRC:	SP:	22	-1980	Recommendations for the Sizes for each Type of Road Making Machinery to Cater to the General Demand of Road Works
IRC:	SP:	23	-1983	Vertical Curves for Highways
IRC:	SP:	25	-1984	Gopi and his Road Roller-Guidelines on Maintenance of Road Roller
IRC:	SP:	27	-1984	Report Containing Recommendations of IRC Regional Workshops on Highway Safety
IRC:	SP:	32	-1988	Road Safety for Children (5-12 Years Old)
IRC:	SP:	33	-1989	Guidelines on Supplemental Measures for Design, Detailing & Durability of Important Bridge Structures.
IRC:	SP:	34	-1989	General Guidelines About the Equipment for
IRC:	SP:	35	-1990	Inspection and Maintenance of Bridge.
IRC:	SP:	37	-1991	Guidelines for Evaluation of Load Carrying Capacity of Bridges
IRC:	SP:	39	-1992	Guidelines on Bulk Bitumen Transportation & Storage Equipment
IRC:	SP:	40	-1993	Guidelines on techniques for strengthening and rehabilitation of bridges.
IRC:	SP:	41	-1994	Guidelines on Design of At-Grade Intersections in Rural & Urban Areas
IRC:	SP:	42	-1994	Guidelines on Road Drainage
IRC:	SP:	44	-1994	Highway Safety Code
IRC:	SP:	46	-1997	Steel Fibre Reinforced Concrete For Pavements
IRC:	SP:	47	-1998	Guidelines on Quality System for Road Bridges (Plain, Reinforced, Prestressed and Composite Concrete).
IRC:	SP:	48	-1998	Hill Road Manual
IRC:	SP:	50	-1999	Guidelines on Urban Drainage
IRC:	SP:	51	-1999	Guidelines for Load Testing of Bridges
IRC:	SP:	52	-1999	Bridge Inspector's Reference Manual
IRC:	SP:	53	-2002	Guidelines on Use of Polymer and rubber Modified Bitumen in Road Construction (First Revision)
IRC:	SP:	54	-1999	Project Preparation Manual for Bridges

IRC:	SP:	55	-2001	Guidelines for Safety in Construction Zones
IRC:	SP:	56	-2000	Guidelines for Steel Pedestrian Bridges
IRC:	SP:	57	-2001	Guidelines for Quality Systems for Road Construction
IRC:	SP:	58	-2001	Guidelines for Use of Fly ash in Road Embankments
IRC:	SP:	59	-2002	Guidelines for Use of Geotextiles in Road Pavements and Associated Works
IRC:	SP:	60	-2002	An Approach Document for Assessment of Remaining Life of Concrete Bridges

Ministry of Surface Transport Publications

MORT&H Pocketbook for Bridge Engineers, 2000 (First Revision)

MORT&H Pocketbook for Highway Engineers, 2002 (Second Revision)

MORT&H Specifications for Road and Bridge Works, 2001 (Fourth Revision)

MOST Standard Plans for 3.0 m Span Reinforced Cement Concrete Solid Slab Superstructure with and without Footpaths for Highways, 1991

MOST Standard Plans for Highways Bridges R.C.C. T-Beam & Slab Superstructure - Span from 10 m to 24 m with 12 m width, 1991

MOST Standard Plans for Highway Bridges PSC Girder and RC Slab Composite Superstructure for 30 m Span with and without Footpaths, 35 m Span with Footpaths and 40 m Span without Footpaths, 1991

MOST Standard Drawings for Road Bridges - R.C.C. Solid Slab Superstructure (15* & 30* SKEW Span 4.0 m to 10.0 m (with and without Footpaths), 1992

MOST Type Designs for Intersections on National Highways, 1992

MOST Computer Aided Design System for High Embankment Problems, 1993

MOST Addendum to Ministry's Technical Circulars and Directives on National Highways and Centrally Sponsored Road & Bridge Projects (Aug. 88 to Dec. 92), 1993

MOST Standard Drawing for Road Bridges R.C.C. Solid Slab Superstructure (22.5* SKEW) R.E. Span 4M to 10M (with and without Footpath), 1996

MOST Addendum to Ministry's Technical Circulars and Directives on National Highways and Centrally Sponsored Road & Bridge Projects (Jan. 93 to Dec. 94), 1996

Standard Plan for Highway Bridges - Prestressed Concrete Beam & RCC Slab Type Superstructure - Volume –II

MOST Addendum to Technical Circulars & Directives on National Highways & Centrally Sponsored Road & Bridge Works Projects (Jan. 1995 to Dec. 1997)

MOST Standard Plans for Single, Double and Triple Cell Box Culverts with and without Earth Cushion

Manual for Safety in Road Design

Annexure DI : ROAD TUNNELS - CIVIL WORKS

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MORT&H Manual for Construction and Supervision of Bituminous Works, 2001

BIS PUBLICATIONS

IS: 1944 (Part-I & II) 1970	Code of Practice for lighting of Public thoroughfare: Parts Land 2 For Main and secondary roads (Group-A and B) (First revision) (Amendments No. 1 and 2) Parts – I and 2 in one volume) (Amendments-2).
IS: 1944 (Part-V) 1981	Code of Practice for Lighting of Public Thoroughfares: Parts 5 Lighting for Grade separated junctions, Bridges and Elevated roads (Group – D).
IS: 1944 (Part-VI) 1981	Code of Practice for lighting of Public thoroughfare: Part-6 Lighting for Towns and city centres and areas of civic Importance (Group-E).
IS/ISO: 9000	Standards for quality management systems.
IS: 10748 – 1995	Hot rolled steel for welded tubes and pipes (First Revision)
NBC	National Building Code
Part-III, NBC:	Development Control rules and general building requirements.
Part-IV, NBC:	Fire Protection
Part-VI, NBC:	Structural Design
Part-VIII, NBC:	Building Services
Part-IX, NBC:	Plumbing Services

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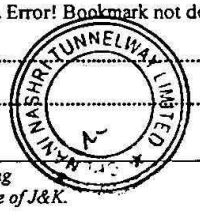


SECTION 1: GENERAL

1.1 INTRODUCTION

a. This specification has specifically been prepared for the tunnelling using the New Austrian Tunnelling Method (NATM).

b. This specification defines the requirements for the execution of tunnel works in any type of rock formation.

c. This specification does not cover surface excavation, open cuts and other earthworks which are covered in

i) Part-I : General Technical Specifications

ii) Part-II: Supplementary Technical Specifications of Volume II.

Hereafter these Specifications shall be referred to as the General Specification and deemed to be bound into this document.

d. This Appendix to the Volume II Specification defines the requirements for the main items for the tunnel works related to the New Austrian Tunnelling Method.

e. The item rates quoted by the Contractor shall, unless otherwise specified, also include any other item of work which is not specifically provided in the Bill of Quantities but which is necessary for complying with the provisions of the Contract.

f. General items not listed in Bill No. 7 (Tunnel Works), but listed in any other Bill No. of the Bill of Quantities found necessary to execute works shall be applicable for Tunnel Works.

g. This Specifications, unless otherwise specified, shall also include the provisions of Section 100 of General Specifications.

1.2. DEFINITIONS

For the words, Employer, Engineer, Contractor and any others that are listed in the Volume I, General Conditions of Contract, Part I – General Conditions, Clause No. 1.1 – Definitions, used in this Appendix to the Volume II Specification, the stated definitions shall apply.

This 'Appendix to the Volume II Specification' shall be referred to as 'this Specification' hereafter in this document.

1.3 SCOPE OF WORKS

a. Works under this Specification include construction of all underground structures (tunnels, niches etc.) including furnishing and servicing of all plants, labour, equipment, and all other consumables and incidentals required for the execution of temporary and permanent work required for completion of the tunnelling works as specified.

b. All works at tunnel entrances including support of front slope and lateral slopes and any protective safety measures which may extend into the open-cut section of the works.

c. The CONTRACTOR shall provide for and carry out, in whatever materials encountered all underground excavation and structural works as specified.

d. Geological mapping shall be performed by the CONTRACTOR'S qualified geologist to provide a documentation of rock and rock mass condition encountered during excavation. For reference please refer to Addendum.

1.4 GEOLOGICAL AND GEOTECHNICAL INFORMATION

a. The geological/geotechnical information presented represent the state of knowledge of the geological/geotechnical conditions along the line of the tunnels based on available information in stage of tender document preparation, i.e. before investigation campaign. Results and interpretations of the investigation campaign may be used for adjustments of the expected geological conditions prior to tendering.

b. Any further investigation needed is under the responsibility of the main Contractor subject to the approval of the ENGINEER.

c. This Specification defines excavation and support classes as assumed reasonable in stage of preparation of this document. Rock classification system shall be established in terms of the rock structure and its stability as exposed by excavation. This classification system shall be used by the CONTRACTOR at all locations in the tunnels to identify the rock classes. These rock classes shall be used to determine the excavation and support to be installed.

1.5 CONSTRUCTION

a. 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.

b. The provisions laid down in this Specification cover all main construction details in compliance with this specific tunnelling method, but they shall not relieve the CONTRACTOR from the responsibility to familiarize himself with the general construction concept and its consequences for the execution of the work.

c. Any proposed change to tunnel support requirements or any other aspect of tunnel construction shall be approved by the ENGINEER. Such approval shall not relieve the CONTRACTOR from his responsibility for the detail design and the construction of the tunnels.

d. Construction shall be carried out by the CONTRACTOR'S experienced personnel and suitably qualified supervisory staff. Adequate training must be given to personnel not experienced in underground works and written authorization for key-personnel made before employment at the face.

The CONTRACTOR shall not be relieved from the responsibility to familiarise himself with the general construction concept and its consequences for the execution of the works.

e. Any required ventilation, lighting and drainage shall be provided during the execution of the tunnel works.

1.6 CONTROL SURVEY AND SETTING OUT

a. The CONTRACTOR shall render all services for topographical surveys and measurements required for the performance of the work and have the overall responsibility for all surveying works.

Before the commencement of any work on the tunnels the CONTRACTOR shall agree with the ENGINEER on location and positioning of all survey control stations. The CONTRACTOR will record the survey control stations on a plan scale 1:1000 giving the coordinates and Chainage for each station and for each tunnel entrance and cross-over as agreed with the EMPLOYER and/or the ENGINEER.

b. The location, design and construction of reference pillars, bench marks etc. shall be

subject to the approval of the ENGINEER.

c. The CONTRACTOR shall be entirely responsible for the accuracy of the control survey and the plotting and periodic checking thereafter.

d. 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 ENGINEER sufficient time to check the initial control survey and subsequent setting out for the alignment and levels of the respective tunnels.

e. All excavation works shall be properly set out to the true line level, curve or slope required. Survey stations, centre lines, bench marks and grade lines shall be clearly marked in paint on the tunnel walls, chainages at 10 metre intervals or as otherwise agreed by the ENGINEER shall so be clearly marked in paint.

f. 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 ENGINEER 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 ENGINEER.'

g. All additional work found to be necessary because of negligence in/or incorrect setting out, shall be carried out immediately by the CONTRACTOR at the directions of the ENGINEER and on the CONTRACTOR'S own expense.

1.7 GEOLOGICAL MAPPING

a. The geological mapping during tunnel construction is a basic requirement and shall be carried out by the CONTRACTOR. The CONTRACTOR shall assign a qualified geologist approved by the ENGINEER to carry out the works as specified.

b. Comprehensive records of geological information as obtained during Tunnel excavation shall be prepared and maintained by the CONTRACTOR for submission to the ENGINEER as each 50 meters of excavation work is completed. If the advance rate is less than 50 meters per month a report shall be presented each month. These records (please refer to Addendum A1) shall include all descriptions of rock formations, their orientation (strike and dip), their characteristics in terms of fracturing, schistosity, weathering, location etc. and observations on size and nature of faults, groundwater appearance and other features which may be relevant to Tunnelling works. Digital photographs shall be taken at least for each tunnel face or as directed by the ENGINEER.

c. Geological sections shall be recorded at the face of the Tunnel top heading bench daily when excavation works are in progress or as required by the ENGINEER. Copies of the sections obtained shall be made available to the ENGINEER at any time.

d. In case of sudden and unexpected changes of the geological conditions the CONTRACTOR must inform the ENGINEER immediately.

e. The completion certificate in respect of tunnels will not be issued until the complete comprehensive records have been accepted by the ENGINEER.

SECTION 2: ROCK CLASSIFICATION AND SUPPORT CLASSES

2.1 GENERAL

a. This section covers the description of Rock Groups and Support Classes relevant to the underground excavation with respect to the geotechnical properties of rock encountered and its behaviour under the influence of tunnel construction.

b. As the defined Support Classes mainly reflect the behaviour of the rock material, they are derived not only from the rock parameters, but also from considerations of a number of external factors such as overburden, size of excavated section and length of round, driving sequence, ground water, results from geotechnical measurements etc., which can essentially influence the classification.

2.2 APPLICATION AND PROCEDURES

a. Rock classes are determined on the grounds of the appearance of the rock at the excavation face of the tunnel before the commencement of the respective excavation sequence.

b. The results of geotechnical measurements under similar rock conditions shall be taken into account for prediction of deformations and for distinction of support classes.

c. Depending on the size of the overall excavation and the ground conditions, subdivisions for the excavation may become necessary and may influence the classification and its evaluation.

In case of a regular excavation subdivided into top heading - bench - invert excavation, the rock conditions of the top heading excavation shall govern the classification. In case of an excavation sequence with side galleries, each excavation shall be regarded as a separate one and classified accordingly.

d. The behaviour of the rock at the face of a tunnel excavation is time dependent, i.e. rock mass quality will decrease within the free span if no support is installed within a reasonable time. Accordingly, the maximum length of a round which can be excavated and supported in time, is a criterion of rock quality and therefore is taken into account for evaluation of the support class.

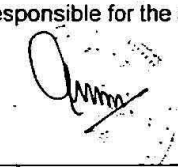
e. The rock classification at the face for each round of top heading shall be determined jointly by the ENGINEER and Contractor's representative. In case of disagreement, Engineer's opinion (classification) prevails.

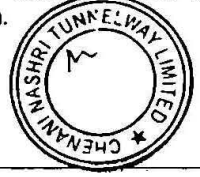
Determination of the support classes at the tunnel face shall be in accordance with the Rock Classification System established for this project and described in this section.

f. The Classification shall be done in writing on jointly agreed form-sheets. The Classification Record is a collection of all classification sheets, which shall be kept accessible for consultation and modification whenever excavation works are under progress.

h. Before the commencement of any cycle of operations the CONTRACTOR'S shift supervisor shall consult the rock classification records and ensure that work is carried out in accordance with the last entry.

i. Notwithstanding the duties of the ENGINEER, the CONTRACTOR is solely responsible for the safety of the works under construction.





2.3 SYSTEM DESCRIPTION

2.3.1 General

The rock classification system applied follows in general the standard classification adopted in Austria and widely in Europe.

Difficult ground conditions frequently require adjustments of the tunnel support during excavation works as experience is gained. The support shown on the drawings for a particular excavation class is regarded as the standard for that classification. Rock bolt types and numbers may be changed as well as the positioning and inclination. Shotcrete thickness and layers of mesh may be increased. The spacing of ribs or lattice girders may be decreased. Any change to the standard support system to suit varying ground conditions must be approved by the ENGINEER.

2.3.2 Classification System

The following Table shows the Rock Classification System established upon which support classes shall be determined.

Rock Classification System

Rock Class Description		Support Class (see 2.5)
A1	stable	A
A2	slightly overbreaking	
B1	friable	B
B2	heavily friable	
C1	pressure exerting	C
C2	heavily pressure exerting	
L	loose ground	Not Applicable

2.4 ROCK MASS GROUPS

The rock mass groups are designated from A to C.

2.4.1 A - Stable to Slightly Overbreaking Rock Masses

The behaviour of rock masses with the designation "A" is generally stable and show elastic behaviour. Isolated, shallow fall-outs, due to gravity, may occur if no local support is applied. The fall-outs are mainly caused by isolated, minor joint bodies. Elastic deformations decrease rapidly.

2.4.2 B - Friable Rock Masses

The behaviour of rock masses with the designation "B" generally tends to rapid loosening and disintegration mainly due to lacking structural interlocking and / or tensile strength.

The secondary stresses in the vicinity of the cavity at almost the whole periphery slightly exceed the strength of the rock mass, although failure mechanisms do not extent widely into it.

In case of a delayed installation of support, progressive failures occur.

2.4.3 C - Pressure Exerting Rock Masses

The behaviour of rock masses with the designation "C" generally shows that the stresses following the redistribution process of rock pressure and/or restraints are higher than the strength of the rock mass.

The overstressing of the rock mass yields failure mechanisms such as spalling, buckling and shearing and a plastic movement towards the cavity.

Plasticity and viscosity of the rock mass leads to a distinct, time dependant deformation behaviour and eventual large deformations.

Considerable loosening pressure and activation of self weight loads of rock will only occur when too large deformations are allowed, which due to detrimental loosening and disintegration of the rock mass, cause an extensive reduction of the rock's strength.

Large deformations and a long term time dependent behaviour of displacements of the cavity are the result of a non-elastic, plastic and viscose behaviour of the ground.

2.4.4 L - Loose Ground

This group contains rock masses such as disintegrated or decomposed rock, loose grounds and organic soils. The low properties of the rock mass yield to elastic or plastic over stressing, depending on the magnitude of cohesion and/or to over stressing following loosening pressure.

The behaviour and the stand up time are considerably influenced by the water inflow.

2.5 SUPPORT CLASSES

Installation should be done according to the approved related drawings.

2.5.1 Support Class A

Shall be performed at sections with rock classification A1 and A2 as shown on the drawings. In tender design stage only one support class A is defined, during detail design phase, this support class may be divided in 2 different ones if performed geotechnical investigation justifies it.

2.5.1.1 Behaviour of Rock Mass

Addressed as a "stable" and "slightly overbreaking" rock mass. The rock mass behaves elastically. Deformations are small and decrease rapidly. There is very little tendency towards overbreaking. Normally only shallow overbreaks in the tunnel roof and/or in the upper portions of the sidewalls caused by discontinuities after scaling of the rock portions disturbed by blasting, will sometimes occur. The rock mass is permanently stable without support.

2.5.1.2 Influence of Water

None or insignificant

2.5.1.3 Excavation

Theoretically, the excavation could be done "full face". In reality, a subdivision in top heading and bench will generally be maintained in case of large excavation profiles. Drill and blast will be required for excavation. The smooth blasting requirements and practical construction reasons limit the length of round to a range between 2.5 and 3.5 meters in top heading and to 4.0 meters in benching.

2.5.1.4 Support Installation and Timing

No installation of systematic support is required, or only in the tunnel roof and in the upper sidewalls. From practical safety and construction reasons in tender design stage support is defined as shown on the approved drawings, i.e. 10 cm of shotcrete with 1

layer of wire mesh, rock bolts shall be installed not later than one round behind the face, except in areas which tend to overbreak, which should be supported immediately.

2.5.2 Support Class B

Shall be performed at sections with rock classification B1 and B2 as shown on approved drawings. In tender design stage only one support class B is defined, during detail design phase, this support class may be divided in 2 different ones if performed geotechnical investigation justifies it.

2.5.2.1 Behaviour of Rock Mass

Addressed as "friable" and "heavily friable" rock mass. Some parts of the rock mass behave elastically and deformations are small and decrease rapidly. Low rock mass strength and limited stand-up times related to the prevailing discontinuity pattern yield overbreaks and loosening of the rock strata in tunnel roof and upper sidewalls if no support is installed in time.

Some parts are characterised by large areas of non- elastic zones extending far into the surrounding rock mass. Immediate installation of the tunnel support, will ensure deformations can be kept small and cease rapidly. In case of a delayed installation or an insufficient quantity of support elements, the low strength of the rock mass yields deep loosening and loading of the initial support.

Stand-up time and unsupported span are short. The potential of deep and sudden failures from roof, sidewalls and face is high.

2.5.2.2 Influence of Water

Dependent on amount, in general insignificant, but larger inflows in weathered or disintegrated rock masses have considerable influence on the strength of the rock mass.

2.5.2.3 Excavation

The cross section of excavation shall be subdivided into top heading and bench. Length of rounds will be in a range of 1.5 to 2.5 metres in the top heading and not longer than 3.5 metres in the bench. For the excavation, drilling and blasting is required. Generally excavation is done by smooth blasting; rock masses sensitive to vibration shall be excavated by roadheader. Invert excavation and installation of an invert concrete arch may be necessary in limited sections.

2.5.2.4 Support Installation and Timing

Tunnel roof and sidewalls require a systematic support which shall be installed at the face and before any further advance according to drawings. Forepoling may be required locally. The installation of a cast - in - place invert arch may if required shall be installed in accordance with the geotechnical requirements.

2.5.3 Support Class C

Shall be performed at sections with rock classification C1, C2 and L as shown on approved drawings. In tender design stage only one support class C is defined, during detail design phase, this support class may be divided in more different ones performed geotechnical investigation justifies it

2.5.3.1 Behaviour of Rock Mass

Described as "pressure exerting" and "heavily pressure exerting" rock mass. C is characterized by plastic zones extending far into the surrounding rock mass and failure mechanisms such as spalling, buckling, shearing and rupture of the rock structure, or by squeezing behaviour. Subject rock mass shows a moderate to significant time

depending squeezing behaviour; deformations decreasing very slowly. Support elements may be exceptionally overstressed.

2.5.3.2 Influence of Water

Seepage's and concentrated inflows have a considerable influence on the behaviour of the rock mass.

2.5.3.3 Excavation

The subdivision into top heading and bench is imperative. Invert excavation is required. Length of rounds will be in a range between 0.8 and 1.5 metres in the top heading and not more than 2.0 metres in the bench. Excavation may be done by smooth blasting or by road header, or tunnel excavator. Shotcrete sealing is required immediately after scaling.

A dense support pattern at all exposed surfaces will be required. The magnitude of deformations may locally require special features such as deformation slots in the shotcrete and/or the application of highly deformable support elements.

In case that the shortening of the length of round, the increase of the length of the forepoling, and a large central support body of the top heading face is not sufficient, a further subdivision of the face may be required. Possible solutions may be a half side excavation of top heading or side galleries. In case of excessive vertical movements of the complete excavation section, further measures such as widening of the lining foot, bolting and grouting of the abutment zone of the shotcrete shell or temporary invert arches may become necessary.

2.5.3.4 Support Installation and Timing

All tunnel support is applied systematically and before any further advance at the face of top heading and bench. Forepoling will be required over the whole roof section. Any negative influence on the rock mass of the face or roof following drilling for forepoling or similar shall be avoided. In accordance with the geotechnical requirements the invert arch is required to be installed. Subdivided cross sections and temporary ring closures of the top heading excavations may become locally necessary.

The ring closure of the invert arch may be required close to the top heading face.

2.6 Payment

The Contractor shall provide all necessary assistance to the Engineer to carry out rock classification which shall include, but not be limited to, providing experienced man power as Contractor's representative, stoppage of work, cleaning of site access to different parts of hading and walls.

The cost of all such works shall be deemed to be included in unit rates of Underground Excavations and nothing shall be payable extra on this accou

NASHRI TUNNELWAY LIMITED CHENAV

SECTION 3: UNDERGROUND EXCAVATION

3.1. GENERAL

3.1.1 Description

This section applies to the execution of all underground excavation works in any type of rock. This section does not deal with specific topics of rock classification; for rock classification see Section 2 of this Specification. Excavation may be carried out by drill and blast using pre-split or smooth blasting techniques or by road header or tunnel excavator.

The CONTRACTOR shall adhere to all procedures as detailed on the drawings, described in this Specification and in the submissions required in accordance with Clause No. 3.1.2 of this Specification or other procedure as agreed with and approved by the ENGINEER.

The CONTRACTOR shall carry out excavation and support work so as to accomplish the requirements of the particular support class nominated and to minimise the deterioration and loosening of the rock mass surrounding the excavation, to restrict overbreak and to prevent damage to the initial lining previously installed.

3.1.2 Submissions

a. Prior to commencement of any underground excavation, the CONTRACTOR shall submit to the ENGINEER for approval detailed drawings and/or descriptions of proposed excavation methods and sequences, including necessary site drainage, safety measures and the results of test programmes carried out.

b. The sequence of excavation of the various underground works of the tunnels shall be presented to the ENGINEER in a general schedule for all tunnelling works.

c. Based on the rock classification as defined in Section 2 of this Specification, the CONTRACTOR shall submit to the ENGINEER for approval a detailed schedule of the working cycle for excavation and support in each support class and for each type of excavation profile.

d. The method of excavation in each type of soil or rock, including the description, specification and pertinent manufacturer's literature for drilling, mucking and transporting, equipment shall be submitted to the ENGINEER.

e. The provisions in the General Specification, Section 302 " Blasting Operations" shall be applied to all portal and underground works carried out by drill and blast methods.

f. Particulars of the proposed blast design shall be submitted to the ENGINEER for each cross section or subdivided cross section, containing the following information:

- Drilling pattern, hole diameters, spacing, depth and inclination.
- Type, strength, amount in terms of weight and cartridges of explosives to be used in each hole, on each delay and the total for the blast.
- Distribution of the charge in the holes, and priming of each hole.
- Type, sequence and number of delays, delay pattern; wiring diagram for blast; size and type of hook-up lines and lead lines; type and capacity of firing sources; type of condenser discharge blasting machine.
- Stemming of holes and matting or covering of blast area.
- Written evidence of the qualifications of the persons who will be directly responsible for supervising the charging and firing of the round.

g. The material excavated in the tunnel found suitable for forming motorway embankments shall be used on the permanent motorway works unless otherwise instructed by the ENGINEER.

h. Prior to dumping or stockpiling of any material the CONTRACTOR shall submit layouts of stockpile and spoil areas for approval to the ENGINEER. The layouts shall show all pertinent data of working methods, stability, provisions for security and both temporary and permanent drainage arrangements and the final landscaping.

i. The ENGINEER shall be provided with all submissions in sufficient time ahead of construction works, or at dates mutually agreed upon.

3.2 EXECUTION

3.2.1 Equipment

a. Any mechanical equipment for underground excavation works and transportation shall be suitable for the works specified with respect to performance and current safety regulations, as well as for compliance with the requirements of the construction time programme, to the approval of the ENGINEER.

b. Underground mechanical plant and equipment shall be powered by electricity, compressed air or diesel engine. Diesel engines must be fitted with filters for the treatment of exhaust fumes. Petrol or paraffin appliances shall not be used underground.

c. Rock-drilling with air flushing shall not be allowed in underground excavations, unless required by the ground conditions as approved by the ENGINEER.

3.2.2 Electrical and Hydraulic Gear used for Construction

a. All electrical supply and distribution equipment shall comply with the recommendations of BS 6164 Section 7, Clause 25.

b. Do not use oil-filled switchgear underground. Switchgear shall be of the airbreak, vacuum or gas-filled type.

c. Do not use mineral oil filled transformers underground. Transformers shall be dry type, air-cooled.

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

e. Provide and maintain electrical installation on the load side of the power points of supply and take all precautions necessary to ensure the safety of every person on the site.

f. Operate the lighting system at low voltage. The lighting circuit shall be separated from other sub-circuits.

g. Provide and maintain two battery-operated hand lamps of 20 watts minimum power at each working face for emergencies and inspection of the works.

h. Provide 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 prevent flooding of the underground works besides operating all other systems so as to allow the work function smoothly in event of main power system failure.

i. Test-start standby fuel-driven generators, without load, weekly to ensure they are in good working order in case of emergency.

j. House electrical distribution panels and junction boxes in purpose-made sealed cabinets with approved entry and outlet sockets fully glanded. Provide sealed

electrical cabinets with automatic chemical-spray fire-extinguishing units discharging automatically at 68 C

k. Welding Equipment:

a. Perform burning and welding at the surface whenever possible.

b. Welders, equipment and electrodes shall comply with the requirements of AWS D1.1.

l. Electrical Cables:

a 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% miximum.

b Supply cables at 3.3 kv or below shall be 3-core with the armcuring used as the earth return in conditions where the cable is not subject to continous movement after installation or where the supply is to be a fixed point(s).

c 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.

d Hydraulic Equipment: Hydraulic oil shall have a minimum flash point of 230 C.

3.2.3 Site Communication

(1) 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 200m intervals along the driven tunnel.

(2) The CONTRACTOR shall install, operate and maintain a suitable communication system between the heading and the workstation near the outside portal, and shall maintain this system in working order at all times.

3.2.4 Lighting and Power during Construction

The Contractor will be fully responsibility for providing Power Supply and illumination during construction.

a. The Contractor shall make his own arrangement for the construction power through diesel generating set of suitable capacity or wherever possible the power can be taken from state government power lines on payment basis. The total power supply generation by the Contractor shall be as per the deployment of equipment at the site for which the Contractor shall provide details with 100% backup captive power plant.

b. The Contractor shall install, operate and maintain electrical distribution system which shall include transformers, circuit breakers, disconnection and safety switches, voltage regulators, lines, poles, pole hardwares, conductors, meters and other equipment necessary for power distribution throughout the Site and temporary facilities.

c. The Contractor shall ensure adequate illumination for all his operations on the Site

and at the Camps.

d. The vaults along the entire length of the tunnel shall be illuminated with electrical light throughout the duration of construction works. The lamps shall be located every 25 m. Each lamp shall have a minimum capacity of 40 W. The lamps shall be installed as instructed by the Engineer as close as 50 m to the work face.

e. The work faces have to be illuminated with higher capacities so that safe working conditions are guaranteed.

f. Electric cables shall be well insulated, protected and firmly fixed to the walls of the tunnel by means of adequate insulators. Lamps shall be well protected against damage.

g. 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.

h. No energised electrical cable shall be permitted nearer than 40 m to the heading face while charging explosives.

i. Lighting illumination by flame is expressly forbidden in the Underground Works.

3.2.5 Earthing of Wet work areas, control of electric discharges

a. All equipment and appliances which are exposed to lighting shall be earthed electrically and the effectiveness of such earthing shall be periodically checked by the Contractor's specialised personnel.

b. No equipment electrically powered by more than 24 volts shall be operated by personnel standing in water.

c. Only air, battery-powered or hydraulic tools shall be permitted in the wet areas.

3.2.6 Ventilation during Construction

The Contractor will be fully responsibility for providing Ventilation during construction.

3.2.6.1 Ventilation of Underground Works

(1) The CONTRACTOR shall design, install and operate ventilation system for the Underground Works and provide an underground atmosphere monitoring system.

(2) The CONTRACTOR shall check and record concentrations of noxious or other harmful gases and dust throughout the works at every shirt. Allowable concentrations shall be as stated in the applicable laws/ standards for underground construction. All items of inspection records and automatic record data of instructions shall be included in a daily working report and shall be maintained for the duration of the works.

(3) All parts of the Works shall be maintained in a state which will not be injurious to the health of the personnel. The air in underground works shall contain no less than 20% 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 of contaminants.

(4) The ventilating system shall be kept in operation also after break-through in tunnels in order to maintain the fresh air-volume requirements stated hereinafter.

(5) Intermediate fans attached to the main duct line shall be provided as required to ensure satisfactory removal of contaminated air. All ventilation ducts shall be maintained in an airtight condition.

(6) 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) The CONTRACTOR shall ensure the required quantity or fresh air at the heading face. The check of the air-tightness or joints and control of the air ducts for leaks shall be performed periodically. Any deficiency discovered or reported by the ENGINEER shall be immediately repaired by the CONTRACTOR.

(8) If the volume and quality of fresh air at the heading face is less than that specified, then the whole duct system shall be pressure and volume tested in portions not exceeding 500 metres[vb1]. Measuring stations shall be located not closer than 10 times the duct diameter from any fan or other flow disturbance within the duct.

(9) No work shall be permitted to be carried out unless the ventilation is provided to the satisfaction of the ENGINEER.

(10) The ventilation system used may be either an exhaust or forced fresh air system or a combination of both.

(11) Exhaust ventilation: Blasting fumes shall be exhausted as close as possible to the excavation face. Exhaust air and blasting fumes shall be discharged sufficiently away from the portal areas in such a way that they will not be re-used in any other working palace or re-circulated in the fresh air supply system.

(12) Forced fresh air ventilation: With this system of ventilation the CONTRACTOR shall ensure that the following aspects are enforced.

a. All labour shall evacuate the heading face area to a safe place before blasting and re-enter the heading face area only after blasting fumes have been completely removed from the working area by ventilation.

b. 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.

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

d. During excavation by hand or machines without use of explosives the ventilation system shall provide the fresh air quality requirements listed below in Clause No. 2.12.3 at all times in the vehicles in good condition and maintain them in good condition.

e. Do not permit gasoline-operated equipment anywhere underground.

f. 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.

g. Ventilation ducting shall be of non-combustible material.

(13) The ventilating system shall be of such efficiency that the average air velocity in the largest excavated profile is not less than 0.3 metre per second. In case the presence of methane gas is detected or suspected, this value shall be increased to 0.5 metre per second.

(14) The quantity of air supplied for ventilation shall not be less than 4.25 cubic meters of free air per minute per person in tunnels. Each diesel kilowall (kW) of power

applied for plant and equipment underground shall require a minimum of 3.5 cubic meters per minute of air supply. 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 Underground Works at any one time. Any estimated losses, e.g due to the leaks in the ducts, shall be added to the figures stated above,

3.2.6.2 The follwing are maximum allowable concentrations of some common haszardous gases:

H2S	----	10 ppm	(8h)
SO2	----	2 ppm	
CO	----	50 ppm	
NO_2	----	25 ppm	
CO_2	----	5000 ppm	
Silica dust concentration	----	10 mg/m^3	

3.2.6.3 Instruments to register the concentration of common noxious gases (CO, NO, CO2), flammable gases, duct and oxygen, etc. shall always be available on the site in good working order, condition and in sufficient numbers. These shall be supplied maintained and used throughout the duration of the underground work.

3.2.6.4 Where any concentration of methane is found to be present, precautions against flames, sparks and overheating shall be enforced including prohibition of burning in good order, condition and in sufficient numbers. These shall be supplied, maintained and used throughout the duration of the underground work.

3.2.6.5 When a methane 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.

3.2.6.6 All persons shall be withdrawn if the methane content exceeds 2%.

3.2.7 Air Cooling in Underground Works

(1) The CONTRACTOR shall make suitable arrangements for cooling of air so as to maintain the temperature in the underground construction sites below 30 degrees Centigrade.

(2) The temperature shall be jointly measured by the CONTRACTOR and the ENGINEER at weekly intervals. Temperature measurements shall be taken during normal working conditions with the specified degree of ventilation and with the air cooling system turned off.

(3) The maintenance of construction progress and control of temperature shall be entirely the responsibility of the CONTRACTOR. No claim or extension of time for the completion of Works shall be allowed on the basis of high/ low temperatures experienced in the course of the work for any reason, whatsoever.

3.2.8 Control of Dust, Silica and Noxious Gases in Underground works

The CONTRACTOR shall install and operate equipment for the monitoring and control of dust, silica and noxious gases in Underground Works as described herein under.

3.2.8.1 Dust and Silica

(1) 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 will not be permitted.

(2) The CONTRACTOR shall measure and monitor the concentration of fine dust and content of silicon dioxide (SiO_2) in all dust producing underground operations by a method to be approved by the ENGINEER.

(3) 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 ENGINEER. 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 ENGINEER. A copy of the test results shall be submitted to the ENGINEER within 2 weeks of the sampling date.

(4) The concentration of fine dust (diameter less than 0.005 mm) may not, in general exceed the value of 8.0 mg/cum of air and in relation to the silicon dioxide content in the rock this value is lowered as follows:

Content of SiO_2 in fine dust in percent by weight.	Concentration of fine dust in milligrams per cum of air.
1 – 15%	8.0 mg/cum
20%	6.0 mg/cum
30%	4.0 mg/cum
60%	2.0 mg/cum
80%	1.5 mg/cum
100%	1.3 mg/cum

(5) Should the concentration of the fine dust exceed the limits stated above, the CONTRACTOR shall undertake such necessary measures and install such additional equipment which will ensure that the dust concentrations are within the specified safe hygienic limits.

3.2.8.2 Noxious Gases

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

(2) The CONTRACTOR shall provide and maintain equipment for measuring and monitoring the content of noxious gases and oxygen at each heading face throughout the content if excavation works. Tests for determining concentrations of carbon monoxide, carbon dioxide, nitrogen dioxide, methane, other inflammable gases, and oxygen shall be made before and after each blasting and at the beginning of each shift by qualified personnel. A record of reading shall be maintained and be made available to the ENGINEER as and when asked for.

(3) Gas concentrations in underground Sites may not exceed the following limits:

0.005% (Fifty ppm) of carbon monoxide.

0.5% (Five thousand ppm) of carbon dioxide.

0.0005% (Five ppm) of nitrogen dioxide.

0.001% (Tem ppm) of hydrogen sulphide.

0.1% (One thousand ppm) of methane.

0.01 milligrams per litre if nitrous oxide.

(4) Concentrations of other inflammable gases shall not exceed 40% of the lower explosive limit at the heading face and 20% of the lower explosive limit elsewhere in the tunnel.

(5) If concentrations of noxious gases or other inflammable gases exceed the permissible limits set forth above, 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.

(6) The required measures will be mutually determined and agreed to by the ENGINEER and the CONTRACTOR. In case of need, the CONTRACTOR shall engage the services of an independent consultant experienced in gaseous tunneling. Re-entry and resuming of the Work shall be prohibited until the ENGINEER has authorised re-entry.

3.2.9 Definition of Excavation Profile

a. The excavation profile as indicated on the drawings (regular tunnel cross sections) refers to the theoretical profile (T-line, see FIG.3.1) for excavation.

b. Depending on the quality of the rock, an appropriate enlargement of the theoretical excavation profile shall be made in order to provide enough space for radial deformations and construction tolerances.

c. The excavation line defined as P-Line (practical excavation line, see FIG.3.1) to compensate for radial deformations and construction tolerances for the various rock classes considers allowances for deformation and practical constructability. The values given on related drawings are pay item values. Real 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 ENGINEER.

d. The T-line (theoretical excavation line) represents the minimum profile to be excavated if no deformations would happen. In general rock shall not protrude inside this line at the moment of excavation profile is stabilized except locally where a tolerance of one half of the nominal shotcrete thickness will be allowed for local protruding of edges and corners of sound rock.

e. The CONTRACTOR shall make all reasonable effort to maintain the profile after stabilization as defined by the T-Line by exercising careful control of drilling and by varying the various elements of smooth blasting or pre-splitting.

f. In order to maintain the excavation profile as close as possible to defined T-Line, the CONTRACTOR shall minimize space for construction tolerances and deformations in accordance with experience gained during performing excavation works. Excavation area defined by P-Line and shown on drawings for different excavation classes is a pay item not dependent on real deformations and real construction

tolerances.

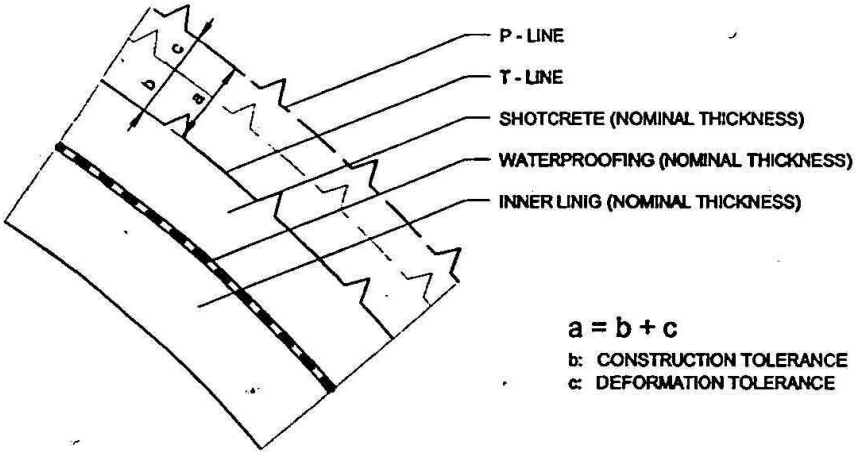


FIG. 3.1 Definition of Tolerances for Deformation and Construction

3.2.10 Overbreak

a. Overbreak is the void created in a tunnel when the ground breaks beyond the theoretical profile (T-Line) required for the various support elements in the different rock classes to be installed. Overbreak may be caused by improper workmanship or careless working techniques (avoidable overbreak), or by reasons which are beyond the control of the CONTRACTOR (unavoidable overbreak).

b. Unavoidable overbreak can be divided into:

- technological overbreak which cannot be avoided by careful and proper workmanship.
- geological overbreak caused by prevailing unfavourable geological conditions (discontinuities and blocks defined by discontinuities).

The average magnitude of the so-called "unavoidable technological overbreak" as defined for each rock class, is indicated on the drawings, between the T-Line and P-Line. This value also takes into account both the construction tolerances and the expected deformation tolerances due to rock class.

The actual extent of "unavoidable overbreak" may be greater or lesser than the predicted extent, indicated on the drawings by the P-line. However the value of "unavoidable overbreak" defined for each rock class and indicated on the drawings is a fixed value and shall be applied for measurement purposes of excavation. The extent of the ground where "unavoidable technological overbreak" occurs, shall be as determined by the ENGINEER

c. Excessive "unavoidable geological overbreak" may be caused by extremely unfavourable and/or unpredictable geological conditions. "Unavoidable geological overbreak" means that the CONTRACTOR exercised extreme care and practised the best possible workmanship but could not prevent overbreak due to prevailing unfavourable geological conditions.

d. In the event of excessive geological overbreak, support shall be installed immediately as required to stabilize the ground. The ENGINEER shall be informed immediately of such conditions. Remedial works shall be as agreed between the CONTRACTOR and ENGINEER. The design of the remedial works shall be done by the CONTRACTOR and approved by the ENGINEER. Remedial works shall be executed before further advance of the face unless otherwise directed by the ENGINEER.

e. Where it is decided that geological overbreak has been caused by physical conditions beyond the control of the CONTRACTOR and has not arisen due to incorrect working methods or carelessness, the void formed by the 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 ENGINEER and certified for payment.

f. 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.

3.2.11 Excavation Requirements

a. Drilling and blasting shall be done in such a manner as to ensure that the rock will break along the desired lines.

b. The diameter and the spacing of the blast holes shall be adapted to the actual rock conditions on site. The CONTRACTOR shall develop and continuously improve the blasting techniques as the works progress to obtain the best possible excavation surface after blasting.

c. Rock excavation shall be performed by using modern blasting methods. Controlled blasting methods such as "smooth blasting" or pre-splitting shall be used to limit the overbreak and to prevent shattering of the rock surfaces.

d. The excavation of niches in tunnel side walls and cross passages shall be carried out after installation of the initial support in the main tunnel. Shotcrete and steel ribs in the tunnel side wall shall be carefully cut along the profile of the niche or cross passages and excavation shall be carried out in such a manner that the remaining tunnel support will not suffer any damage.

3.2.12 Safety Precautions

a. Careful and proper scaling after each blast is imperative. The support elements are considered to be sufficient for the overall stability of the tunnels; however, the CONTRACTOR shall perform the installation of local rock bolts as required to prevent loosening of rock blocks in the immediate heading area. Periodical inspection of the tunnel sidewalls and roof areas shall be performed by the CONTRACTOR to detect possible cracks or signs of instability of the tunnel support. Assessment of cracks shall be made in association with the results of the

geotechnical measurements in co-operation with the ENGINEER.

b. Blasting will be permitted only after proper precautions have been taken for protection of all persons, work, and property.

c. Drilling, blasting, excavating and shotcreting operations shall be conducted by methods and with equipment which shall positively control dust, fumes, vapours, gases, fibres, fogs, mists or other atmospheric conditions in a manner meeting the requirements of the General Specification, Section 302 " Blasting Operations" Following each round, the broken rock or muck pile shall be wetted down sufficiently to prevent excessive dust during mucking operations.

3.2.13 Continuous Working

a. To ensure the safety and the security of the works, tunnel excavation shall be continuous by day and night except as otherwise approved by the ENGINEER. If the state of the work permits, intermissions will be allowed at weekends and general holiday periods, provided that the works are secured in a safe condition.

b. The intermission shall not be allowed to start until all the support elements in the support class at the particular locations have been completed.

c. In addition the face of any heading shall be sealed with shotcrete (minimum thickness 3 to 5 cm) except in stable rock as specified in Section 2. of these specifications.

d. The CONTRACTOR shall also carry out all additional support measures which may be required by and approved by the ENGINEER.

3.2.14 Drainage During Construction

3.2.14.1Scope

a. The CONTRACTOR shall supply, install, operate and maintain sufficient pumps and pipework to control and remove water from any part of the underground works. Standing water will not be allowed.

b. The capacity of pumps installed at each working face shall always be at least one and a half times the normal volume of the inflow of water plus the volume of flushing water used by the drilling equipment.

c. The CONTRACTOR shall store or immediately have available standby pumps in good working conditions of the same capacity as installed in the tunnels.

d. The CONTRACTOR shall provide settling tanks or other decontamination facilities as required by the ENGINEER before the water is discharged to waste.

e. The CONTRACTOR shall remove all accumulated slurry, silt or other debris from the underground works as required by the ENGINEER.

3.2.14.2Materials and Execution

a. Longitudinal Drainage: The tunnel shall be drained by trenches in the bottom of the respective heading which may be filled with gravel. In areas of large water inflows, installation of semi perforated or slotted hard-PVC pipes with a diameter of 150 mm to 250 mm depending on the amount of water to be diverted may be necessary.

In case of descending headings sumps shall be provided at regular intervals from where the water shall be pumped out of the tunnel.

b. Radial Drains: For concentrated water inflows, relief holes shall be made into the ground. Perforated steel pipes or hard-PVC pipes, diameter $1^1/_2$ inch, shall be installed into the holes. The space between the pipe and mouth of the borehole shall

be sealed with quick-setting mortar. Quick setting mortar is a material which provides setting and hardening within a couple of minutes used for temporary fixation or sealing. No specific properties are required. The mouth of the pipe shall be connected to a hose for diversion to the temporary longitudinal drainage, to sumps or longitudinal trenches in the bottom of the respective headings.

c. Ring drains: In wet areas on the rock surface, water shall be collected by half shells (preferably corrugated, soft-PVC pipes) which are fixed to the rock by quick setting mortar or shotcrete and diverted to sumps or longitudinal trenches in the bottom of the respective headings.

d. Later occurring wet areas in the shotcrete lining shall be drilled open and treated as above, (2) or (3).

e. In tunnels, constructed in permeable soil or highly fractured rock, ring drains with a diameter of 4 cm minimum shall be installed systematically to avoid the build-up of water pressure behind the shotcrete lining, if required and approved by the ENGINEER.

f. The CONTRACTOR shall ensure that the sumps installed are kept clean and the drainage system maintained so that all water during the construction period is adequately controlled.

3.2.15 Site Traffic on Final Excavation Levels

a. 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.

b. Ponding water and traffic through ponding water shall not be allowed.

c. Any deteriorated material shall be removed and replaced prior to pavement works as directed by the ENGINEER.

d. The backfill material used for protection purposes shall not be removed until immediately prior to pavement construction works.

3.2.16 Site Traffic on Invert Support

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.

SECTION 4: TUNNEL SUPPORT

4.1 GENERAL REQUIREMENTS

This section covers the requirements for materials and application of the initial tunnel support which shall be considered to comprise those elements of the tunnel lining which are necessary to establish the permanent stability of the excavated tunnels.

4.1.1 Construction Method

The CONTRACTOR shall understand and recognize the technical and design concepts of the NATM and shall appreciate the function and merits of each component of the tunnel support.

4.1.2 Submissions

a. Prior to the commencement of any works covered by this specification, the CONTRACTOR shall submit to the ENGINEER for approval a comprehensive programs for material testing and quality control covering all elements of the tunnel support.

b. Manufacturer's certificates of compliance shall be submitted certifying that the materials used meet specification requirements.

c. The method of installation of each type of support element including description, specification and pertinent manufacturer's literature for drilling, rock bolting, anchoring etc. shall be submitted to the ENGINEER.

d. The ENGINEER shall be provided with all submissions in sufficient time ahead of the construction works, or at such dates as mutually agreed upon.

4.1.3 Implementation of Tunnel Support Works

a. The type and amount of tunnel support to be installed immediately after excavation is directly related to the rock classification as established. The standard initial support associated with the established rock classification system is shown on the drawings. However, as a consequence of variations from the anticipated rock conditions the standard support systems as shown on the drawings for each support class may require modifications and adjustment during construction as directed and approved by the ENGINEER and in accordance with Clause No. 2.3.1 of this specification.

b. 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.

4.1.4. Clearance Profile

a. See Section 5 of this Specification

4.1.5 Records

a. 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 ENGINEER on a daily basis. These records shall include type, quantity and location of support elements installed, the clearance profile after installation of support, deviations from the standard support systems, observations of excessive deformations, shotcrete cracking, etc. Observations of excessive deformations, shotcrete cracking shall be notified immediately to the ENGINEER.

b. 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.

c. All the above records will be submitted daily to the ENGINEER for approval.

4.1.6 Equipment and Material Supply

a. Any mechanical plant and equipment for installation of underground support shall be suitable for the works specified with respect to performance and current safety regulations and shall also be of sufficient capacity to fulfill production requirements in terms of the construction programs.

b. Proper maintenance of equipment and adequate provision of spare parts shall be made to ensure the immediate availability of equipment required for support installation whenever underground excavation works are under progress.

c. Unimpeded supply of materials to all working faces required for support construction shall be ensured at all times. It shall be recognized that for excavation in poor rock this pre-requisite is strongly related to safety matters of tunnel construction.

d. The CONTRACTOR shall provide each tunnel heading with the necessary materials and equipment to deal quickly and effectively with emergency situations, such as unexpected unstable rock conditions, heavy water inflows etc., which cannot be handled with the regular procedures of tunnel support installation.

e. The CONTRACTOR shall maintain on site or have immediately available at least two weeks supply of any of the support elements required according to the Rock Classification scheduled on the drawings and according to the work programs.

4.2 SHOTCRETE

4.2.1 General

Definitions

a. Shotcrete is concrete which is conveyed to the place of installation in a closed hose or tube, applied and compacted by jetting onto a surface at high velocity. There are two basic methods:

b. Dry shotcrete method

c. Wet shotcrete method

d. The nozzle is an attachment at the end of the shotcrete material hose from which material is jetted.

e. Accelerator is a powder or liquid shotcrete agent to effect quick setting of the applied shotcrete.

f. Rebound is material that falls down from shotcreted surface during and after spraying.

4.2.2 Materials

4.2.2.1 Cement

As per the Clause No. 1006 of General Specification.

4.2.2.2 Aggregates

As per the Clause No. 1007 and 1008 of General Specification.

a. The aggregates shall be clean, strong, durable, suitably graded and shall not contain detrimental amounts of dust, mud, clay or organic impurities.

b. The chloride ion shall not exceed 0.35,

c. The coarse aggregates shall not contain a large quantity of long stone pieces.

d. The amount of fine particles under 0.1 mm grain size shall not exceed 2% of the total mixture.

e. The maximum size of the aggregates shall not exceed 16 mm

f. The grain size distribution shall be within values shown in Figure 4.1

g. Frozen aggregates must not be used. Minimum temperature of the aggregates shall be 5° Celsius plus.

h. During rainy and cold weather periods the aggregates shall be stored undercover for at least 48 hours before being used, in order to reduce the water content.

Aggregate size (mm)	Passing in % of weight
12.5	96 – 100
10	92 – 98
4.75	70 – 80
2.36	50 – 60
1.18	24 – 34
0.600	20 – 28
0.300	10 – 17
0.150	5 - 12

Figures in the table refer to passings in percentage of weight.

FIG. 4.1 : Grain size distribution of aggregates for shotcrete process

4.2.2.3 Accelerating Admixtures

a. General: As per Clause No. 1012 of General Specification.

b. 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 No. 4.2.6 of this specification.

c. The dosage rate to be used is evaluated following the suitability tests carried out in compliance with the requirements of Clause No. 4.2.6 of this specification (for reference see below). 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. Automatic 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.

4.2.2.4 Water

As per Clause No. 1013 of General Specification.

4.2.2.5 Additives

a. Additives for the improvement of performance, workability etc. may be added, with the approval of ENGINEER.

b. Additives intended to be used shall be included in the tests as described in Clause No. 4.2.6 of this Specification.

4.2.3 Mix Design

The mix for shotcrete shall be designed by laboratory tests and field trials as indicated hereafter to meet the requirements for strength development and final strength. The following factors shall be taken into consideration:

- Cement content
- Accelerating admixtures
- Water-cement ratio
- Setting and strength development
- Temperature of mix

4.2.3.1 Cement Content

For the dry shotcrete process the quantity of cement shall not be less than 350 kg/m^3 dry mix.

For the wet shotcrete process the minimum cement content shall be 400 kg/m^3.

The cement content shall be designed to meet the strength requirements of shotcrete applied in the field.

For the wet shotcrete process the minimum cement content shall comply with the standard mix of class 25 N/mm^2 concrete

4.2.3.2 Water Cement Ratio

a. Dry process:

The water content shall be controlled by the nozzlemen 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.

b. Wet process:

Field trials shall be carried out to determine and establish the suitable water/cement ratio.

4.2.3.3 Setting and Strength Development

a. Accelerating admixtures shall be used to meet the requirements for setting and strength development of shotcrete applied in-situ.

b. In order to determine a suitable dosage rate of accelerating admixtures suitability tests shall be carried out.

c. The compressive strength of shotcrete in situ (taken from the tunnel lining or panels sprayed in the tunnel) shall develop progressively to a final strength according to the minimum requirements specified in Fig.4.3. Uniaxial compressive tests shall be done in accordance with the provisions stipulated in Clause No. 4.2.6.

The strength development due to suitability tests must exceed the specified in situ strength by a factor of 1/0.85 (=1.18)

d. The 28-day-strength of shotcrete shall be minimum 25 N/mm^2. The strength development of shotcrete shall be such to meet 11 N/mm^2 after one day and 22 N/mm^2 after 7 days as.

4.2.4 Batching, Mixing and Transportation

Transit mixers to be used for the transport of shotcrete underground must be fitted with approved exhaust filters.

4.2.4.1 Dry Shotcrete Process

a. Cement and aggregates shall be batched in the proportions specified and designed. Measurement shall be done by weight. At the time of batching all aggregates shall have been dried or drained sufficiently to result in a stable moisture content, which shall not exceed 7 %.

b. Mixing of cement and aggregates shall be performed mechanically with a pan type mixer. Shotcrete shall not be used unless placing can be completed within a period of 90 minutes from the time of mixing. The time span shall be kept as short as possible, especially at seasons with high air temperatures and high humidity.

c. The mixing time shall be not less than 3 minutes.

d. A system of delivery notes shall be introduced to record the date, the time of mixing, design mix number, quantity, delivery point, time of delivery and completion of placing. The delivery notes shall be available to the ENGINEER for approval.

e. For the dry process, powder or liquid type accelerating admixtures shall be added to the dry-mix. The powder type accelerator shall be proportioned and added just before the dry mix enters the shotcrete machine trough a mechanical device (dispenser). Liquid type accelerator is delivered by a special dosage pump and added to the dry-mix at or near the nozzle. Dosage pump and the hoses to the nozzle shall be kept in good order.

f. During cold weather periods provisions shall be made to maintain the setting properties of the shotcrete either by means of heating the water or the aggregates or both, depending on the temperature.

g. During hot weather periods the water content of the aggregates for the dry process shall be kept above 4%, in order to avoid cement loss at the rotor of the shotcrete machine.

4.2.4.2 Wet Shotcrete Process

a. Only liquid types of accelerator apply to the wet process; these shall be added at or near the nozzle. The delivery from the accelerator pump must be controlled to be proportional to the output of the concrete pump. The nozzle must be such as to ensure a homogeneous mixture of the accelerator with the wet-mix.

4.2.5 Placing of Shotcrete

a. 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.

b. The optimum distance between nozzle and surface of application is 1.0 to 1.3 metres. The nozzle shall be positioned at right angles to the surface of application. Two nozzles shall be used at least for regular tunnel heading.

c. The maximum thickness of shotcrete to be applied at any one time shall not exceed 150 mm. If the thickness must be increased, 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.

d. Steel ribs, roof ties, wire mesh and other reinforcement shall be embedded in

shotcrete as shown on the drawings. The minimum cover of wire mesh and re-bars applied at the inner side of a tunnel lining shall be 20 mm or as shown on the drawings.

If more than one layer of reinforcement is used, the second layer shall not be positioned before the first one is embedded and covered with shotcrete.

e. In sound rock the shotcrete shall follow the rock surface with proper rounding of notches and corners. At projections of sound rock the actual shotcrete thickness may be locally reduced to one half of the specified thickness. This shall apply to Support Class A and B only.

f. Rebound shall be removed immediately after finishing of each shotcrete application. In particular at horizontal shotcrete connections due to separate excavation sequences and at all construction joints the rebound shall be removed, if necessary by pneumatic hammers, prior to further application of shotcrete.

g. Under no circumstances shall rebound material be worked back into the construction. The work shall be continuously kept free of rebound material.

h. Curing: required, where necessary.

i. Measures to establish the total thickness of shotcrete shall be set up by and approved by the ENGINEER. These may include visual guides installed prior to shotcreting or holes drilled after completion of shotcreting.

j. Surface Preparation: See Section 6 of this Specification

4.2.6 Testing of Shotcrete

4.2.6.1 Laboratory Tests

(for compatibility of cement and accelerating admixtures)

a. The compatibility of accelerating admixtures and cement shall be tested in the laboratory in order to establish setting times and whether the addition of the accelerator leads to an excessive reduction in the long terms compressive strength of the mix.

b. The setting times shall be determined by using the Vicat apparatus. Different percentages of accelerating admixtures with a water/cement ratio of 0.45 are subject to setting tests.

The preparation of samples and testing procedure shall be as follows :

a. Water temperature 20 +/-1 degrees Celsius, cement and accelerator at room temperature.

b. Prepare a mix of cement and the relevant percentage of accelerator with a total weight of 140 grams.

c. In the case of liquid accelerator a mix of water and accelerator shall be prepared with a total weight of 49 grams.

d. Fill dry mix (cement + dry accelerator or cement only) in a cylinder of 50 mm diameter mounted on a glass/plexiglas plate, height approx. 100 mm. The cylinder must have a coupling at a height of 40 mm.

e. Fill 49 grams of water (or water+liquid accelerator) into a rubber bulb.

f. Combine water and dry mix quickly (start timing !) and mix very quickly by mach... Mixing shall be finished 10 seconds after the addition of water.

g. Quickly press the mortar into the lower part and remove the upper part of the cylinder and flatten the surface.

h. Quickly adjust the Vicat needle to the surface of the mortar and release it. Determine the depth of penetration.

i. The initial setting time is specified, when the needle stops 3 to 5 mm above the glass/plexiglas plate.

j. Continue g. Final setting time is specified, when the depth of penetration is not more than 1 mm.

Requirements for setting of the samples in the laboratory are:

Time of initial setting	:	75 sec.
Time of final setting	:	150sec.

Meeting these requirements with a dosage of accelerating admixture of less than 4.5% of the cement by weight will provide proof that the type of accelerator is compatible with the cement used for setting speed. To determine the sensitivity of the cement, to each type of accelerator the laboratory tests shall be made with various doses of accelerator between 2% and 7% of the cement by weight. The percentages obtained by the compatibility tests shall not be directly transferred to shotcrete application.

In addition to the setting tests using the Vicat-Needle apparatus, the reduction of the final strength of the concrete specimen due to the use of accelerating admixtures shall be tested. The decrease of the compressive strength at 28 days of a test specimen made with accelerating admixture shall not exceed 40% compared with test specimens consisting of plain mix only. The tests for the strength decrease can be omitted if extensive field test for determination of the strength development and final strength are carried out for the different types and dosages of accelerating admixtures adopted, see Clause No. 4.2.6.2 following.

4.2.6.2 Suitability Tests

a. Field trials shall be carried out to determine setting and strength development and establish the suitable range of accelerator dosage of shotcrete applied in the field.

b. For each type of accelerating admixture found suitable by preceding laboratory tests a trial mix shall be sprayed into test panels (3 Nos. 500 x 500 x 200 mm per trial mix), cured under site conditions and shall be subjected to tests. As described hereunder, at least three different dosages of each type of accelerating admixture shall be tested. The range of accelerator dosage rates shall vary between 2% and 7% of the cement in weight.

c. The ambient temperature for the test shall be in accordance with the actual conditions in the tunnel.

d. One panel shall be subjected to penetration tests using a Proctor Penetrometer, Soiltest Model CN-419, with a penetration plunger of 9 mm in diameter. The penetration resistance measured gives an indication of the setting and early strength development of shotcrete.

The minimum penetration resistance required is specified as follows (time elapsed after spraying):

after 2 minutes : minimum 260 N

after 5 minutes : minimum 380 N

after 10 minutes : minimum 450 N

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The penetration plunger shall be pushed into the shotcrete in one continuous action to a depth of approximately 15 mm. The resistance required for each time step shall be met by the average value of 8 test readings to be taken in each case within a period of 60 seconds. To comply with the requirements specified above is of particular importance for a successful overhead application of shotcrete.

e. The strength development up to 1.2 N/mm2 can be determined by the Penetrometer using a plunger of 3 mm diameter, depth of penetration shall be approximately 15 mm. The penetration resistance can be converted to compressive strength, corresponding to a specimen with a length to diameter ratio of 1:1, by the following formula:

$U = (Pr - 30)/550 \quad (N/mm^2)$

Pr= penetration resistance in N

These strength results shall be treated as approximate values and shall mainly be used for comparison of mixes.

f. The development of the compressive strength shall be tested by the crushing of cylindrical shotcrete specimens at the age of 1, 7 and 28 days. The specimens shall be prepared by means of core drilling from the test panels which shall be cured under similar condition to those in the tunnel and shall have a diameter of 100 mm and be cut to a height of 100 mm. For the 1 day test the cores shall be drilled not before 20 hrs. after spraying, the other cores shall be drilled approximately 48 hrs. after spraying. A minimum distance of 100 mm shall be kept from the edges of the test panel.

g. Five cores shall be tested at each shotcrete age specified. The average value of the five test results shall comply with the strength requirements specified.

4.2.7 Quality Control

To ensure the specified quality of shotcrete during construction, the aggregate gradation, accelerating admixtures and shotcrete strength shall be tested as follows.

4.2.7.1 Aggregate Gradation

During construction, the aggregate gradation shall be tested at least once a week or as directed by the ENGINEER and shall comply with Clause No. 4.2.2.2 of this Specification.

4.2.7.2 Accelerating Admixtures

a. For each type of accelerating admixture and, in addition, whenever the brand, source or characteristics of the cement are changed, the compatibility between cement and accelerator shall be tested by suitability tests according to Clause No. 4.2.6.

b. Every 100 m^3 of shotcrete applied (quantity measured in place) the setting properties shall be tested on the tunnel sidewall or in a test panel according to Clause No. 4.2.6.2.

4.2.7.3 In-situ Compressive Strength

a. One test panel shall be sprayed for every 100 m^3 of shotcrete applied, measured in theoretical quantities. Fifteen cores of 100 mm diameter shall be drilled from the panel. Five cores each shall be tested for compressive strength after 1, 7 and 28 days in accordance with Clause No. 4.2.6. The average strength of the cores shall not be less than the strength specified in Clause No. 4.2.3.3 for every age.

b. In addition to the specimen obtained from test panels, 15 cores shall be drilled from certain locations and limited areas of the tunnel lining for every 500 m^3 of shotcrete

applied, measured in theoretical quantities and shall be tested for compressive strength in accordance with Clause No. 4.2.6. The average strength of the cores shall not be less than the strength specified in Clause No. 4.2.3.3 for every age.

4.2.7.4 Compressive Strength Failures

This Clause deals with the course of action to be taken in the event of cores not meeting the strength requirements as specified in Clause No. 4.2.3.3 of this Specification.

a. Failure of cores of 1 day test :

- Inform the ENGINEER
- Immediate examination of tunnel lining in suspect area
- Immediate examination of elements concerned in making, transporting and placing of shotcrete
- Continuous monitoring
- Prepare to take further tests at three days
- Take further test panels as soon as possible and institute penetrometer and crushing tests as specified previously (Clause No. 4.2.6.2).

It will be necessary to reduce the number of cores to be tested for each age, if 3 day testing has to be introduced.

b. Failure of cores of.7 day test :

- Inform the ENGINEER
- Install a measurement section
- Monitor as per specification, for geotechnical instrumentation and measurements

If the interpretation of the convergency measurement is such that additional support is not required, further tests shall be carried out at 28 days.

c. Failure of cores at 28 days :

- Inform the ENGINEER
- Cores to be taken from the tunnel lining
- Establish the suspect area
- Cores to be then tested and if failure
- Prepare proposals for the strengthening of the area
- Submit proposals for the approval of the ENGINEER before remedial work is done.

If the required 28-days-strength of shotcrete is not achieved the ENGINEER may require that the theoretical thickness of shotcrete d_s is increased by the value d_1, calculated with the following formula:

$$d_1 = ((F/M) - 1) * d_s$$

F ..... required 28-days-strength in N/mm^2

M ..... measured actual strength of shotcrete lining in N/mm^2

d_1 ..... additional thickness of shotcrete to be sprayed in cm

d_s ..... theoretical thickness of shotcrete lining in cm

Alternatively the ENGINEER may require the failed shotcrete to be cut out and supports re-installed in accordance with the support classes specified.

e. It should be noted that Engineer may require additional strengthening measures to be taken at any time after failure of 1 day cores. These are subject to the approval of the ENGINEER.

f. The result of compressive strength failures in Clause No. 4.2.7.4 is the responsibility of the CONTRACTOR. Because of the strength failures in shotcrete, additional strengthening precautions (commented and approved by the ENGINEER) may be taken but CONTRACTOR can not claim extra payment for this work.

4.3 REINFORCING STEEL

4.3.1 Wire Mesh (Welded Wire Fabrics)

4.3.1.1 Material

a. Section 1600 of the General Specification

b. Mesh 150 x 150 mm, 6 mm diameter shall be used for initial linings and 150 x150 mm, 10 mm diameter for outer (final) linings. It shall consist of structural steel with a minimum yield strength of 415 N/mm^2.

4.3.1.2 Installation

a. Welded wire fabrics shall be installed such that it follows as closely as possible the irregularities of the excavation surface or previous layers of shotcrete. For initial linings, it shall be firmly fixed to prevent vibration and change of position during spraying of shotcrete. 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 and one pitch distance in longitudinal direction.

4.3.2 Reinforcing Steel Bars

For tunnel support purposes, steel reinforcing bars are required as an additional reinforcement in heavily stressed areas such as portal areas, junctions of tunnels and cross passages depending on the local ground conditions and as shown on the design drawings.

4.3.2.1 Materials

a. Reinforcing steel bars shall comply with Section 1600 of General Specification.

4.3.2.2 Installation

a. Reinforcing steel bars shall be attached securely to the previously placed shotcrete layer, bars or wire mesh.

b. Overlaps shall be arranged as shown on relevant drawings.

4.3.2.3 Bar diameters (mm)

a. Cut and cover sections: main - 25 to 32, secondary - 12, stirrups – 10 or 12

b. Driven tunnel: in foundation beam, main - 25, stirrups - 10 or 12; and for other locations, main -12, stirrups – 10

4.4 STEEL RIBS

4.4.1 General

(1) This part of section 4 applies to the supply and installation of the lattice girders re-

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quired and used as support in underground excavations. They shall be effective as primary support immediately after excavation and shall subsequently act as reinforcement and load distributing members for the shotcrete lining.

(2) The steel ribs shall be manufactured to meet the geometrical requirements for the excavation geometries for each of the support class including the relevant tolerances as specified in Clause No. 4.4.4.1.

4.4.1.1 Submission

a. Section 4, Clause No. 4.1.2 of this Specification.

b. Shop Drawings.

Prior to the beginning of the work, the following shall be submitted:

- Complete fabrication details of the steel ribs
- Installation procedures and layout
- Details of joints, rib connections, rib spacers, geometry etc.
- Certificates of compliance of the materials.

4.4.2 Design

a. Lattice girders are three dimensional, lightweight steel frames manufactured of round steel bars in compliance with the required excavation geometry of the tunnel.

b. Lattice girders shall consist of three prmari bars, connected by stiffening elements of the manufacturer's design. They shall be designed so as to:

i. Facilitate shotcrete penetration into and behind the girder, thereby minimizing the creation of projection shadows.

ii. Provide good quality bounding between the steel and shotcrete, to form a composite structure in the sense of a continuous reinforced shotcrete lining.

c. A minimum 5% of the total moment of inertia shall be provided by the stiffening elements. This percentage is calculated as an average value along repeatable lengths of the lattice girder.

d. To ensure stability against buckling, the maximum spacing between stiffening elements shall be less than three times the cross sectional height of the girder.

e. In case of fabrication on site, the contractor shall submit a detailed method statement for approval to the ENGINEER.

f. The related detailed drawings will show the number of sections in the frame and the detail at the connection between the sections. The detail to be approved by the ENGINEER.

4.4.3 Materials

Lattice girders shall be composed of high strength steel having characteristic strength of 415 Mpa in compliance with Section 1600 of General Specification.

The primary bars of lattice girder segment shall be composed of only one piece.

4.4.4 Manufacturing of Steel Ribs

4.4.4.1 Geometry

a. The steel ribs shall be manufactured to meet the geometrical requirements for each of the support classes requiring their use as shown on the design drawings.

4.4.4.2 Welding

Testing of materials and workmanship shall be carried out in accordance with the Section 1600 and 1900 of General Specification. If the testing performance is of low quality an approved testing agency shall execute this work.

a. The manual metal-arc welding process shall be employed. The manufacturer shall be responsible for ensuring that the capacity of the welding plant and ancillary equipment is adequate for the welding procedure to be used and for maintaining all welding plant and ancillary equipment in good working order.

b. Covered electrodes complying to German Standard DIN 1913 shall be used. Electrodes shall be selected with regard to the particular application (welding position, joint design). Electrodes shall be stored in their original containers in a dry, preferably heated place adequately protected from the effects of the weather and in accordance with the manufacturers specification.

c. Surfaces to be welded shall be dry. Fusion faces and the surrounding surfaces shall be free from heavy scale, moisture oil, paint or any other substance which might affect the quality of the weld. Slag shall be removed from each run of weld metal before a further run is superimposed. The most favourable welding position for each case shall be chosen.

d. For the cutting of the steel profiles the manual flame cutting process may be employed. Also sawing is permitted.

e. Further preparation of joint and fusion faces shall be done by grinding.

f. Parts to be welded shall be assembled such that the joints are easily accessible and visible to the operator.

g. Slag shall be removed from all welds in order to allow visual inspection.

h. Welding operations shall be supervised by a suitably trained supervisor who shall have particular production experience. The welding supervisor is responsible for the following duties listed hereunder:

   i. employment of the welders or skilled operators and supervision of their work.

   ii. selection, use and storage of suitable welding filler metals and auxiliary materials.

   iii. selection and use of satisfactory welding apparatus, welding plant and welding fixtures.

   iv. visual and dimensional checking of the weld seams as described under l.

i. Welders shall pass the acceptance test as described under j.

j. Prior to commencement of welding each connection type, 3 no. joints shall be manufactured by each welder under conditions of the regular manufacturing process for inspection. These joints shall be inspected by the ENGINEER.

k. Routine inspection of welded joints shall be done by spot checking of not less than 10 per cent of the welded joints in compliance with paragraph l. by the ENGINEER.

l. Acceptance Test and Routine Inspection shall be done in accordance to the criteria as described in the table below. Visible defects exceeding the limits as shown in the table shall be removed and replaced by adequate means.

Undersize welds	0.1 a permitted (10 %)
Undercuts	Permitted to a limited extent

Visible pores	some, 10% by area
Visible slag inclusions	permitted to a limited extent not continuous
Open end craters	slight depressions permitted
Lack of fusion	permitted, but no large and no continuous areas
Cracks	Individual small local cracks permitted
Excessive asymmetry of welds	side ratio <1.0 : 0.6

4.4.5 Installation

a. Steel ribs shall be erected to the lines and levels as indicated on the drawings. The exact excavation levels will however be determined by the CONTRACTOR to match best his equipment and construction method subject to the approval of the ENGINEER .

Hardwood footblocks and wedges shall be used to bring the steel ribs to the required line and level. Tie bars shall be provided to connect the rib to the adjacent steel rib and fix it securely in place.

b. 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 20 mm.

c. The steel ribs shall be erected perpendicular to the tunnel axis.

d. The joints of the ribs shall be such that the static efficiency of the cross section is maintained.

4.5 FOREPOLING

Forepoling is a pre-excavation support element required for the tunnel excavation works. Forepoling shall be applied in rock and soil conditions, which tend to produce overbreak, collapses or material inflows immediately following excavation. Forepoling may be applied locally or systematically, as ground conditions dictate, for the safe operation of the works. Forepoling should always be used in conjunction with the installation of steel ribs.

4.5.1 Material

a. Steel bars or dowels (spiles) consisting of deformed high yield steel bars, diameter minimum 25 mm, shall be used.

Alternatively, hollow steel pipes, internal diameter 30 mm and minimum wall thickness of 3 mm may be used.

b. The length of the steel pipes or bars shall be at least 1.00 metre longer than the instructed length of round. However, the minimum length of any bar or pipe shall be 3.0 metres.

c. Grout mortar shall comply with Clause No. 4.7.4.1 of this Specification.

4.5.2 Installation

a. Forepoling shall be applied as shown on the drawings or as instructed by the ENGINEER.

b. Steel pipes, bars or dowels at 300 to 400 mm centres shall be inserted into the predrilled holes from the face of the drivage towards the unexcavated ground.

c. Forepoling requires the installation of steel ribs.

d. Grouting of forepoling pipes with mortar, either before or after the insertion of the pipes, to be determined by the ENGINEER.

e. Forepoling shall be properly supported by the steel rib and the shotcrete above the steel rib. Therefore the shotcreting of the gap between rib and rock in the portions of forepoling shall be completed after the installation of forepoling.

f. Spacing between consecutive forepoling pipes or bars around the crown of the excavation profile must comply with the distance specified on the drawings, but must be adopted to the prevailing geological conditions of the tunnel face.

4.6 ROCK BOLTS

4.6.1 General

a. The provisions contained hereunder apply to all rock bolts installed either locally or in a systematic pattern in the roof, side walls, and invert of the tunnels. Rock bolts are part of the primary support, with the purpose of activating the composite action between the surrounding rock and the shotcrete, contributing to the load bearing capacity of the primary tunnel lining. Rock bolts occasionally required for the support of the tunnel face during the advance are covered likewise under these provisions.

b. Rock bolts shall be installed according to the lengths and rock bolt patterns shown on the drawings for each relevant standard support system unless otherwise determined by and subject to approval of the ENGINEER

4.6.1.1 Definitions

a. SN-Bolts are made of deformed steel bars and fully bonded with the surrounding rock by cement mortar. The hole is filled with grout before insertion of the bolt. The abbreviation SN descends from the mine "Store Norfors" where applied first.

b. PG - bolts (post - grouted or injection bolts) are made of deformed steel bars with a hose attached. Grouting is done after installation of the bolt through the hose.

c. IBO-bolts (injection-bore-bolts) are a combined system of rock bolt and drill rod. During drilling, the bolt is used as the drill rod fixed with a drill bit. Rod and bit remain in the hole as a rock bolt, which is grouted through the flushing hole. In case of collapsing boreholes, this system still enables the installation of rock bolts.

d. Swellex Rockbolts (friction anchored rock bolts) are mechanically folded steel tubes. High water pressure inflates the tube and adapts its shape to the irregularities of the borehole.

4.6.2 Materials

4.6.2.1 SN-Bolts and PG-Bolts

a. Bolts shall have a minimum diameter of 28 mm for steel grade ST 42 and 25 mm for steel grade ST 52 .

b. The breaking load shall also apply to the thread, nut, anchor plate and coupling, if any.

c. Rock bolts shall be made of deformed reinforcing steel with a corrugated surface. One end shall be fitted with a suitable thread which is to receive an anchor plate and fixing nut.

d. Anchor plates on all types of bolts with a size of 150 x 150 mm and a thickness of 8 mm shall be used unless instructed otherwise by and approved by the ENGINEER based on support necessities. The shape shall allow a uniform seat, even if the bolt is not installed exactly perpendicular to the surface below.

e. Washers and nuts shall allow the secure transfer of the anchor force to the anchor plate.

4.6.2.2 IBO-Bolts

a. IBO-bolts shall have a minimum breaking load of 250 kN.

b. The breaking load shall also apply to threads, nuts, anchor plates and couplings.

c. The steel rods shall have a corrugated surface.

4.6.2.3 Swellex Rockbolts and Super Swellex

a. Super Swellex Rockbolts for systematic rock bolt patterns shall have a minimum breaking load of 200 kN.

b. For local bolting and for rock bolting of construction stages, bolts with a breaking load of 110 kN ("Standard" Swellex) may be used.

c. Bolt face plates shall be such as to allow transfer of the anchor force at the head of the rock bolt to the shotcrete, steel rib or rock surface.

d. For inflation of bolts, equipment as recommended by the manufacturer of the bolts shall be used.

4.6.2.4 Cement - Mortar Grout

General Specification

a. The cement mortar grout shall consist of sand, cement and water or neat cement and water.

b. Ordinary Portland Cement shall be used.

c. Sand for grouting purpose shall be a clean, mineral sand, uniform in quality and from an approved source. This material should be approved by the ENGINEER.

d. Water shall be clean, free from oil, acid, alkaline, organic and other deleterious substances.

e. Additives for the improvement of workability may be used.

f. The cement mortar grout shall be mechanically mixed to produce a uniform consistency.

4.6.3 Execution

The introduction of cement mortar grout to the borehole may be carried out by pump or compressed air displacement vessel.

4.6.3.1 SN-Bolts

a. Boreholes for all rock bolts shall be drilled to the depths as required by the lengths of rock bolts specified for the respective support 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 rock bolts/ couplings installed.

b. The boreholes shall be cleaned of all drill cuttings, sludge and debris. The installation of rock bolts shall follow the drilling and preparation of the borehole within 3 hours.

c. 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 bolt is then pushed into the hole.

d. The nut of the grouted rock bolts shall be tightened not later than 2 rounds behind the face or 12 hours after installation to achieve a force at the anchor plate of approx. 20 kN. This force shall be applied by a calibrated torque wrench.

e. 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.

4.6.3.2 PG - Bolts

a. In case of coupled rock bolts or partly collapsed boreholes, grouting may be done after installation of the bolt. The hole is then grouted by a special attachment which allows the mouth of the borehole to be sealed whilst the grout is pumped in. Air is displaced from the hole via a tube which is attached to the full length of the rock bolt as it is installed. Grout is then pumped in and the hole can be seen to be full, when grout escapes from the end of the tube.

b. Same as Clause No. 4.7.3.1, except paragraph c of this Specification

4.6.3.3 IBO- Bolts

a. IBO-bolts shall be used in ground conditions where the effective installation of other types of rock bolts is impossible.

b. IBO-bolts shall be placed by drilling the rod into the ground without withdrawing the rod.

c. IBO-bolts shall be grouted through the flushing hole immediately after completion of the drilling operation.

d. The grout mix, grouting pressure and quantity shall be determined according to the ground conditions encountered and approved by the ENGINEER.

4.6.3.4 Swellex Rockbolt

a. Boreholes for the rockbolts shall be drilled to the depths as required. The boreholes shall be cleaned of all drill cuttings, sludge and debris

b. The installation of rock bolts shall be done not later than two hours after drilling of the borehole.

c. Installation / inflation of the bolts shall follow the manufacturer's recommendations. Specific inflation plant shall be used. The rock bolt shall be drained after inflation.

4.6.4 Testing

General Specification and OENORM B2270

4.6.4.1 Grout Mortar

a. 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.

b. Additives may be used to improve workability. The influence of the additive to the strength development shall be followed by tests as described under this Clause.

c. The grout mortar shall be tested on cubes 50 x 50 x 50 mm. The cubes shall be cured in water.

d. 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.

e. 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.

4.6.4.2 Pull Out Tests on Rock Bolts

Pull-out tests shall be performed on basis of ISRM Doc.2, Part 1 "Suggested Method for Rockbolt Testing".

4.6.4.2.1 Proof Tests

a. A detailed test program set up on basis of above mentioned document shall be approved by the ENGINEER prior to all testing work.

b. Specifically deviations from the ISRM suggested method shall be approved by the ENGINEER.

c. A test report shall be issued immediately after completion of the tests. It shall be submitted for approval to the ENGINEER.

d. For each type of rock bolt submitted, information shall comprise of:

- type of bolts
- testing equipment
- location and installation records
- applied testing loads and records of deformation
- evaluation of test results as specified in ISRM's document
- interpretation and suggested action for failed pull-out tests.

e. Proof tests shall be carried out for all types of bolts to be used for this project prior to the commencement of tunnelling to demonstrate the effect and the service capacity of the bolts in the field.

f. The tests shall be performed in similar geological ground conditions as expected during tunnel drivage. The location of the bolts to be tested shall be selected by the ENGINEER.

g. A minimum of five bolts of each type shall be tested. Depending on the testing procedure and the test results the ENGINEER may require further bolts to be tested.

h. Adequate testing equipment, as specified in the above mentioned ISRM document shall be provided to record bolt elongation, movement of the bolts and tension forces.

i. The maximum load to be applied is 250 kN or as otherwise approved.

4.6.4.2.2 Testing during Tunnel Driving

a. The ENGINEER will select rock bolts for testing of production bolts. For each type of rock bolts five bolts will be selected from the first 100 bolts placed in the tunnel. From the remaining bolts five per 200 bolts will be selected for testing purposes. The testing force to be applied has to be at least 80% of the bolt breaking load.

b. Bolts which fail the tests or which are pulled out shall be replaced.

c. For each failure, the ENGINEER shall require further bolts to be tested in the vicinity.

d. Otherwise as Clause No. a to i, chapter 4.7.2.1 of this Specification.

4.6.4.3 Installation Records.

a. Comprehensive records about details of the installation of rock bolts during drivage, such as grout consistency, drilling depth, length and type of rock bolts, deviations from the theoretical position, type and time of grouting, time of tightening, special observations, etc. shall be kept for each round by the CONTRACTOR and countersigned by the ENGINEER'S supervisory personnel. Copies of these records should be submitted to the ENGINEER.

4.7 STEEL PIPE ROOF UMBRELLA

Steel pipe roof umbrella is a pre-excavation support element required for the tunnel excavation works. Pipe umbrella support shall be applied in soft and/or broken rock or other soil conditions which tend towards overbreak, collapse or material inflows immediately following excavation. Pipe umbrella systems shall be applied systematically over the full (or a substantial part of) top heading above the circumference of the proposed tunnel profile. Steel pipes shall be always grouted.

4.7.1 Material

a. Mild Steel pipes 115 mm outer diameter with a minimum wall thicknesses being 6.5mm.

b. Grout mortar shall comply with system provider requirements, but available min. grouting pressure shall not be less than 10 bar

4.7.2 Installation

a. Steel Pipe Roof Umbrella support shall be applied as shown on the drawings or as instructed by the ENGINEER.

b. Steel pipes at 300 mm to 400 mm centres shall be inserted into the pre-drilled holes from the face of the drive towards the unexcavated ground.

c. Grouting shall carried out to system provider requirements. The grouting pump must allow controlled grouting, i.e. control and records of time, pressure and volumes

d. Spacing between pipes or bars around the crown of the excavation profile shall be as indicated on the drawings. If the prevailing geological conditions of the tunnel face indicate a more optimum spacing should be applied, this shall be as agreed with the ENGINEER.

4.8 STRATA GROUTING

This section must be read and applied in conjunction with the applicable parts of the Specification.

4.8.1 General

a. This section specifies grouting of materials under pressure in rock strata for consolidation of fractured rock or for filling of cavities and voids in the rock surrounding the tunnel. This section does not cover injections for loose ground areas.

b. In addition to Clause No. 4.1.2 of this specification, the CONTRACTOR shall prepare a detailed grouting specification, since grouting works are manifold and a wide range of methods and techniques are available for ground improvements to suit best the actual conditions encountered. This grouting specification shall be submitted to the ENGINEER for approval unless otherwise agreed or directed by the ENGINEER.

c. Grouting operation shall be performed without major interruptions.

d. In case of an interruption before completion of grouting (plant breakdown), the hole shall be washed with clean water.

e. Until experience of the ground conditions is gained, grouting shall proceed with caution. Safety valves shall be tested before each application.

f. Grouting in the tunnel shall be performed in a manner that pressures are equally distributed and do not overstress the initial tunnel lining and in accordance with Clause No. 4.9.1c of this Specification.

g. Strata grouting shall start with neat cement grout. Depending on the grout taken the water/cement ratio may be reduced subsequently. In case of large grout takes, injections shall be continued with cement mortar grout. Final injections shall be done with neat cement grout again.

h. In case of no pressure building up when using a sand/cement mix, grouting shall be stopped and the hole washed. After a few hours, grouting shall recommence using a sand/cement grout until the desired pressure builds up.

i. In case of any grout communicating between holes, grouting shall be done simultaneously or holes where grout issues shall be plugged.

j Grouting is completed, when the required pressure can be kept constant over a period of 10 minutes.

k. Records of all details of grouting works such as location, inclination, diameter of boreholes, drilling time, equipment used, water pressure tests, mix, quantity, pressure of grouting, development of and special events during grouting operation etc. shall be kept by the CONTRACTOR, countersigned on site by the Engineer's supervising personnel and submitted to the ENGINEER.

c. The Contractor will specify the maximum pressures to be used for grout injection at each location. These pressures are subject to approval of the ENGINEER.

4.8.2 Materials

a. The grout may consist of
   - neat cement grout
   - cement mortar grout (cement/sand)
   - cement grout with clay or bentonite

b. Ordinary Portland Cement shall be used.

c. Sand for grouting purpose shall be a clean, mineral sand, uniform in quality and from an approved source.

d. Water shall be clean, free from oil, acid, alkaline, organic and other deleterious substances.

e. Additives for the improvement of grouting performance may be used.

f. Quality control of grout mortar in compliance with Clause No: 4.7.4.1 and 4.7.2.4 of this Specification.

4.8.3 Drilling

a. Grout holes shall be drilled either with percussion type or rotary type drilling equipment.

b. 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.

c. Only water shall be used for flushing during drilling unless directed otherwise by the ENGINEER. 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.

4.8.4 Water Pressure Tests

a. As directed by the ENGINEER, water pressure tests shall be carried out in accordance with Clause No. 4.9.1c of this specification.

4.8.5 Mixing of Grout

a. All grout mixes shall be prepared using high speed, high shearing action mixers to produce a grout of uniform consistency.

b. When, prior to pumping, mixed grout is to be stored for short periods, purpose made agitator tanks shall be used.

c. When clay or bentonite additives are used, separate mixing tanks shall be provided for mixing and agitation.

d. 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.

4.8.6 Grouting Operation

a. Provisions shall be made to permit accurate control of grouting pressures and volumes as above.

b. All hoses and piping should be of a small diameter to ensure a high velocity flow without segregation.

SECTION 5 - PROFILE CONTROL AND TOLERANCES

5.1 PROFILE CONTROL

5.1.1 Scope

The CONTRACTOR is required to perform a careful and systematic checking of the final clearance of the primary tunnel lining in order to accommodate the designed nominal thickness of the inner concrete lining.

5.1.2 Method of Profile Control for Final Concrete Lining

a. 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 (see Section 7 of this Specification).

The CONTRACTOR is solely responsible for the accuracy in setting out and the construction of the footing beams with their cast in fixings which will align the rail track at each side of the tunnel and on which the tunnel shutter will be mounted.

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 gantry may also be designed to be used as a working platform for the re-shaping of the initial lining should this prove to be necessary and for the surface preparation work outlined in Section 6.1.3.1 of this specification.

The CONTRACTOR shall submit full details of the design of the gantry with its template for the approval of the ENGINEER. On approval the ENGINEER will issue instructions with regard to the systematic checking of the geometry of the template during profiling operations.

b. The CONTRACTOR may prefer to use advance surveying techniques and data processing to establish the final clearance profile. In which case he shall define a method of marling out areas of deviation from the theoretical profile to be approved by the ENGINEER.

5.1.3 Execution

a. The checking of the final clearance shall not proceed before the geotechnical measurements show that the rate of radial displacement at any position of the tunnel periphery is less than 2 mm per month.

b. The final clearance profile after the completion of support works of tunnels, after surface preparation as described in section 6 of this specification and after deformation as per (1) of this Clause, shall conform to the minimum clearance profile as indicated on the drawings.

c. 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 reshaping any parts of the tunnel support protruding into the clearance profile. CONTRACTOR is responsible for these works without any extra payments.

d. The CONTRACTOR shall submit a proposal for the remedial works to the ENGINEER.

e. No reshaping of the tunnel support shall be carried out without the approval of the ENGINEER.

f. Geotechnical measurements before, during and after the respective measures shall be carried out in compliance with the relevant design specification. The measurement points such as convergency bolts and / or extensometers shall be retained or substitutions shall be installed well in advance of the heading in order to establish "transfer - zero - readings".

g. Geotechnical measurement stations shall not be removed and abandoned without the approval of the ENGINEER.

5.1.4 Records

a. Records shall be kept for each stage the remedial measures executed.

b. 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 and approved by the ENGINEER.

c. The final checking of the clearance profile after completion of re-profiling and surface preparation in compliance with section 6 of this specification shall be done in presence of the ENGINEER.

5.2 CONSTRUCTION TOLERANCES

5.2.1 Tolerances in Plan

The tunnel axis of the completed tunnel cross section may deviate from the calculated tunnel axis (alignment) not more than +/- 50 mm in plan.

5.2.2 Tolerances for the Initial Lining

a. No reduction of the theoretical thickness of the inner concrete lining is permitted unless approved by the ENGINEER. 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.

b. In the area of the invert and the foundation beams no rock parts or rock peaks may protrude into the theoretical excavation line.

5.2.3 Tolerance for Excavation Level of Invert

a. 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 ENGINEER.

b. 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. The inside face of the invert arch may deviate not more than +/- 50 mm in elevation from the theoretical cross section.

5.2.4 Tolerances for the Inner Concrete Lining

a. 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 lowest part (walkway level/cable duct) the deviation of the inner face is limited with 30 mm 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.

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.

b. Niches, recesses and similar structures are to be constructed with a tolerance of +/- 50 mm related to the designed stationing.

c. 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.

SECTION 6 - WATERPROOFING AND PERMANENT DRAINAGE SYSTEMS

6.1 WATERPROOFING AND PROTECTIVE FELT

6.1.1 General

Clause No. 6.1 covers the waterproofing for all underground structures by means of a continuous waterproofing membrane installed to the outside of the final concrete lining. It does not include provisions for other elements such as water stops in concrete, sealing of joints etc.

The waterproofing shall be such, that all underground structures are watertight. In case of leakage, provision shall be made for these to be repaired.

6.1.1.1 Description

a. The purpose of the membrane waterproofing to underground structures is to prevent leakage of groundwater into the tunnels and to protect the final concrete lining against deleterious chemical influences. 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 are not immersed below a distinct groundwater table no membrane waterproofing will be provided for tunnel inverts.

b. The waterproofing system shall consist of two layers: the first shall consist of a protective felt fastened to the shotcrete surface; the second layer shall be the actual waterproofing membrane properly fixed by special means as recommended by the manufacturer.

c. While the sealing function shall be provided by the membrane, the layer of felt is required to protect the waterproofing membrane against damage from contact with the shotcrete surface, to prevent interlocking between concrete and shotcrete in case of differential movements of shotcrete support and final lining, and to provide a drainage layer allowing to drain off groundwater into the longitudinal lateral drainage pipes, thus preventing a build-up of hydrostatic pressure on the tunnel lining.

6.1.1.2 Submission

The following submissions shall be furnished for approval in accordance with the contract requirements:

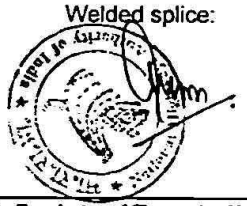
a. Certificates of compliance attesting that the materials meet specification requirements.

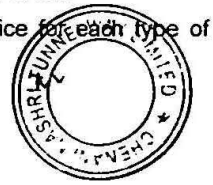
b. Manufacturer's instructions for installation of felt backing and waterproofing membrane, including procedures for preparation, fixing, welding and splicing, flashing etc.

c. Manufacturer's and installer's qualifications to include evidence of experience of the manufacturer and the installers, as well as resume of lining installation supervisors.

d. Samples as listed hereafter:

Membrane:	One square meter of each type membrane.
Protective felt:	One square meter of each type of felt.
Welded splice:	1 m of welded membrane splice for each type of membrane.





Fixings and fittings: 10 samples from different lots of rondels and nails, 2 samples of sealing flanges for projections passing through the membrane.

e. Shop drawings shall be submitted for approval showing all necessary installation details for felt and waterproofing membrane, including installation sequence, position of joints, treatment of projections, connection to water stops, connection to waterproofing of structures in open cut, local reinforcements etc.

6.1.1.3 Quality Assurance

a. General

Supply and install suitable products designed and manufactured specifically for application in tunnels under conditions similar to those encountered on this project and having had acceptable performance.

b. Manufacturer's Qualifications

Select a manufacturer (or manufacturers) who is (are) regularly engaged in the production of similar materials for tunnel structure and has demonstrated successful application on at least five recent projects of comparable nature.

c. Supervision and Training

Manufacturer's representative shall be present at least during the first 10 working days of installation and later as often as necessary.

Execute all installation and testing under the direct supervision of an individual with recent, continuous, acceptable experience in the installation of tunnel membrane linings.

Provide all personnel involved in lining installation and testing with adequate training prior to beginning lining work.

d. Installation records are to be submitted to the ENGINEER for approval with all relevant data for all seam checks etc. these records shall form part of the submission to obtain approval to proceed with the installation of the inner concrete lining, see also Clause No. 7.1.3 of this Specification.

6.1.2 Materials

6.1.2.1 Protective Felt

The protective felt shall be non-woven poly-propylene geotextile of uniform thickness and surface texture meeting the requirements listed below.

Property	Specified Value	Standard
Unit weight	500g/m^2 min	DIN 53854
Thickness at 0.02 bar	3.9 mm min	DIN 53855/3
Thickness at 2.0 bar	1.9 mm min	DIN 53855/3
Tensile strength	1000 N/5cm min	DIN 53857/2
Extension at break	70 % min	DIN 53857/2
Extension at 30% of tensile strength	20 % min	DIN 53857/2
Permeability in plane		

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Property	Specified Value	Standard
at 0.02 bar	5x10-1 cm/s min	*
at 2.00 bar	5x10-2 cm/s min	*
Resistance against acid and alkaline solutions, pH 2-13	Loss of strength 10% max.	SN 640 550 DIN 53857/2
Resistance to Punching	2000 N	DIN 54307

* Test according to Franzius Institute, Hannover, BRD

6.1.2.2 Waterproofing Membrane

a. The waterproofing membrane shall be made of one of the following materials, or similar and shall meet the requirements listed below.

b. The membrane shall be supplied with a signal layer, i.e. a thin sheeting of different colour, bonded to one side, which is intended to facilitate the detection of damages.

ECB Waterproofing Membrane (ethylene-copolymer bitumen)

Property	Specified Value	Standard
Thickness	2.0 mm min	DIN 53370
Tensile strength	10 N/mm^2 min	DIN 53455
Elongation at failure	500% min	DIN 53455
Compressive strength at 20% strain	2.5 N/mm^2 min*	DIN 53454
Tear propagation strength	150 N/mm min	DIN 53363
Resistance under water pressure	waterproof at 10 bar for 10 hours	DIN 16726
Strength of welded seam	7.2 N/mm^2 min	DIN 16726
Dimensional stability after accelerating ageing	+/- 2% max	DIN 16726
Material characteristics during and after storage at 80° C:		DIN 16726
- General appearance	no blisters	
- Dimensional stability, long. and transverse	<-3%	
- Variation of tensile strength, long. and transverse	<±10%	
- Variation of elongation at failure, long and transverse	<±10%	
- Folding at a temperature of -20° C	no fissures	
Water absorption	1% max	DIN 5349

Property	Specified Value	Standard
Behaviour after storage in acid and/or alkaline solutions:		DIN 16726
- Variation of tensile strength, long. and transverse	<±20%	
- Variation of elongation at failure, long. and transverse	<±20%	
- Folding at a temperature of -20° C	no fissures	
Shear strength of splice with bitumen	100N/50 mm	DIN 16726
Behaviour during perforation test	No perforation at 750 mm height of fall	DIN 50014

* Cubic specimen with edge length of 10 mm.

PVC Waterproofing Membrane (poly-vinyl-chloride)

Property	Specified Value	Standard
Thickness	2.0 mm min	DIN 53370
Tensile strength	15 N/mm^2 min	DIN 53455
Elongation at failure	250% min	DIN 53455
Compressive strength at 20% strain	2.5 N/mm^2 min*	DIN 53454
Tear propagation strength	100 N/mm min	DIN 53363
Resistance under water pressure	waterproof at 10 bar for 10 hours	DIN 16726
Strength of welded seam	13.5 N/mm^2 min	DIN 16726
Dimensional stability after accelerating ageing	+/- 2% max	DIN 16726
Material characteristics during and after storage at 80° C:		DIN 16726
- General appearance	no blisters	
- Dimensional stability, long. and transverse	<-3%	
- Variation of tensile strength, long. and transverse	<±10%	
- Variation of elongation at failure, long. and transverse	<±10%	
- Folding at a temperature of -20° C		

	no fissures	
Water absorption	1% max	DIN 53495
Behaviour after storage in acid and/or alkaline solutions:		DIN 16726
- Variation of tensile strength, long. and transverse	<±20%	
- Variation of elongation at failure, long. and transverse	<±20%	
- Folding at a temperature of -20° C	no fissures	
Shear strength of splice with bitumen	100N/50 mm	DIN 16726
Behaviour during perforation test	no perforation at 750 mm height of fall	DIN 50014

* Cubic specimen with edge length of 10 mm.

6.1.2.3 Accessories

Fixing material, flashing, reinforcement for expansion joints, sealing flanges and preparation of corners and intersections shall be made as recommended by the manufacturer of the membrane.

6.1.3 Execution

6.1.3.1 Surface Preparation

a. All surfaces to which waterproofing is to be applied shall be sufficiently clean, smooth and free from deleterious materials and projections.

b. The following treatment of surfaces shall be performed prior to the installation of waterproofing:

For the fixing of the protective felt and the waterproofing membrane, a minimum shotcrete cover of 50 mm to rock is required.

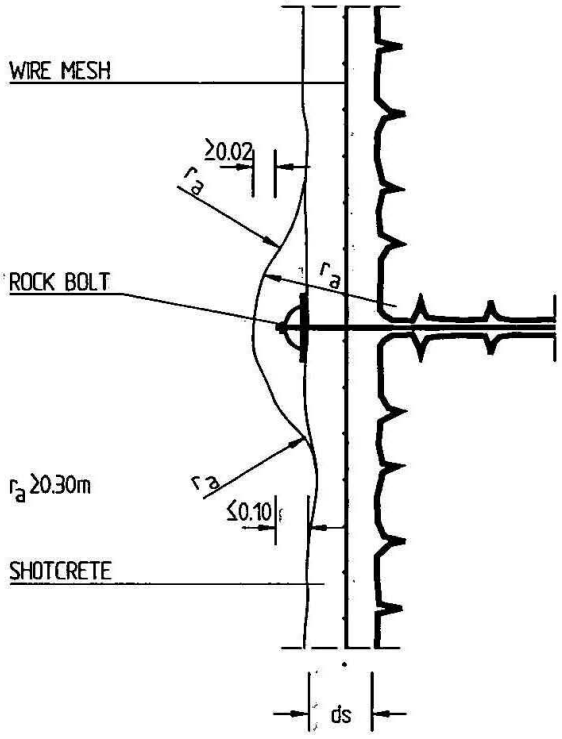
Irregularities of the shotcrete lining surface shall be eliminated by means of additional shotcrete. The ratio of the diameter to depth of irregularities shall be not less than 5:1 (see FIG.6.1). Roundings at rock bolts etc. shall have a min. radius r of 0.3 m.

Transitions and intersections of tunnel profiles shall be rounded off with a minimum radius of 500 mm.

Protruding steel bars, wires, spacers, pipes etc. shall be cut off unless treated with additional shotcrete cover.

Exposed steel parts such as rock bolts, if not intended to remain accessible, shall be covered with shotcrete.

All shotcrete surface shall finally be smoothened with fine-graded shotcrete (rounded aggregates, grain size 0 - 8 mm), applied in a layer of 20 mm minimum thickness.



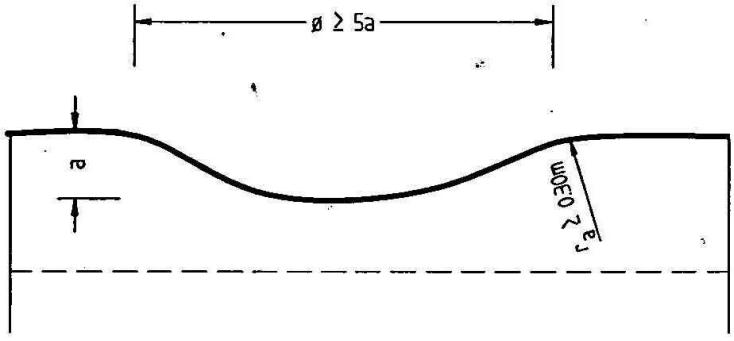


FIG.6.1: Requirements on surface irregularities of shotcrete.

6.1.3.2 Application

Prior to the application of the waterproofing, all surfaces to which it shall be applied, shall be inspected and approved by the ENGINEER.

The application shall follow the written instructions of the manufacturer. Generally procedures are the following:

6.1.3.2.1 Preparations

Special preparations will be required for waterproofing at tunnel intersections and for projections passing through the membrane. They shall be carried out according to the manufacturer's recommendation.

6.1.3.2.2 Fixing of Felt

The protective felt shall be attached to the shotcrete surface using suitable fixings specified by the manufacturer. Depending on the location 2 to 4 nos. fixing elements shall be used per square meter. The felt shall be laid with sufficient slack to avoid overstress during concreting. Adjacent sections of felt shall be overlapped by 10 cm and joined by point welding or similar suitable method. Along the bottom of the tunnel side walls the felt shall extend sufficiently to cover the lateral drainages as shown on the drawings.

6.1.3.2.3 Fixing of Waterproofing Membrane

The waterproofing membrane shall be installed to cover the felt and shall be attached to the felt fixings by means of thermal welding. 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. Adjacent sheets of waterproofing shall be joined by a double weld. Along the bottom of the tunnel side walls the membrane shall extend sufficiently to cover the lateral drainages as shown on the drawings. Connections to waterstops and to the waterproofing of structures in open cuts shall be carried out according to drawings to be furnished by the supplier.

6.1.3.3 Testing of Seam

All seams shall be tested and records of these tests shall be submitted by the CONTRACTOR to the ENGINEER. (See Clause No. 7.1.3.(c) of this Specification).

6.1.3.3.1 Seam Test with Compressed Air

For seams between adjacent sheets of waterproofing membrane the testing for tightness shall be carried out by means of compressed air pumped into the test channel which is formed by the double welded joint. Initial test pressure shall be 2 bar for a test period of 5 minutes or 1.5 bar for a test period of 10 minutes. The joint shall be considered waterproof if the loss of air pressure is in both cases not more than 20%.

6.1.3.3.2 Seam Test with Vacuum Equipment

For the testing of areas of membrane of limited size such as special configurations of joints or local repairs with patches, vacuum equipment may be employed. This consists of a vacuum bell which, after being fitted tightly over the area to be tested, is evacuated by pumping in order to detect leaks in the membrane.

6.1.3.4 Protective Measures

Every care shall be taken not to damage the waterproofing membrane during or after installation. Any damages occurred shall be repaired and tested before the casting of the final concrete lining.

6.2 PERMANENT DRAINAGE SYSTEMS

This Clause applies to the installation and maintenance (during the construction period) of the permanent drainage systems in the tunnels. If during the construction process, ground water is encountered below the designed level of the longitudinal groundwater drainage system, then a re-design of the system may be required. Any re-design of the drainage system shall be carried out by the Contractor and shall be approved by the Engineer.

6.2.1 General

a. This Clause covers the requirements for permanent drainage systems in tunnels. The treatment of surface and sub-surface water outside the tunnels ie in portal areas, shall be dealt with separately.

b. The Clause can apply to separated drainage systems (groundwater and waste water), and/or combined systems.

c. The carriageway drainage systems in the tunnel shall comply with the appropriate Sub-Clauses of Clause 309 of the General Specification.

6.2.2 Materials

a. Concrete Pipes: IS: 458-1988

b. Plastic (PVC) Pipes with ISI marks.

Longitudinal, semi perforated, drainage pipes shall consist of circumferential slotted, polyvinylchloride (PVC) plastic pipes as shown on the drawings. The upper section of the pipe shall be longitudinal corrugated and slotted, with the bottom section being flat. The width of slots shall not exceed 1.0 mm. The total area of the slots for water intake exceed 100 cm^2 per metre length of pipe.

c. Bedding: Dry Lean Concrete to Clause No. 601 of the General Specification.

d. Pipe Surround: No-fines Concrete to Clause No. 6.3 of this Specification.

e. Structural Concrete: Section 1700 of the General Specification.

f. Brick Masonry: FPS Brick - Class Designation 75.

g. Cement Mortar: Clause No. 1304 of the General Specification.

h. Cast Iron: IS:1030

6.2.3 Execution

a. The water appearing and/or collected during the construction behind the waterproofing membrane shall be diverted permanently by longitudinal drainage pipes installed at both sidewalls of the tunnels.

b. The longitudinal ground water drainage pipes shall be covered and protected by no-fines porous concrete between the inspection niches inside the tunnel.

c. Inspection Chambers (Revision Shafts) shall be installed beneath the tunnel invert for permanent maintenance (flushing) of the drainage system as shown on the drawings.

d. The Contractor shall ensure that the permanent ground water drainage system is used only for the control of groundwater. Throughout the construction and maintenance periods, regular inspection and servicing shall be provided.

e. All drainage pipes shall be installed to line and grade as indicated on the drawings.

6.3 NO-FINES POROUS CONCRETE

6.3.1 General

a. No-fines porous concrete shall be used for the surround of ground water drainage pipes in tunnels at locations indicated on the drawings.

b. The appropriate Sub-Clauses of Clause No. 601 of the General Specification shall apply.

6.3.2 Materials

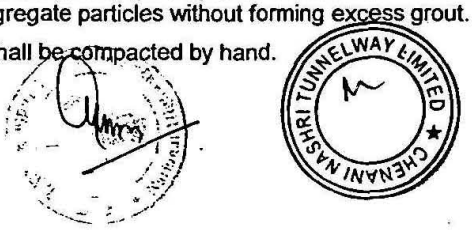
a. No-fines porous concrete shall be composed of ordinary Portland Cement and 37.5 mm single size aggregate complying with the General Specification

b. The ratio of aggregate to cement shall be 8:1 by volume or 10:1 by mass.

6.3.3 Execution

a. 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.

b. No-fines concrete shall be compacted by hand.



SECTION 7 - INNER LINING CONCRETE

7.1 GENERAL

This section contains specifications for the construction of the final tunnel lining, the foundation beams and the invert arch. These structures are predominantly un-reinforced, but they may also be reinforced locally, as approved by the ENGINEER.

7.1.1 Description

a. The final tunnel lining, a cast-in-situ concrete lining increases the safety factor of the tunnel lining system, provides a uniform interior surface and improves the water tightness of the tunnel lining. A smooth interior surface is required for air flow, aesthetic, lighting and maintenance reasons.

b. The foundation beams form the abutment for the final tunnel lining. They also form the connecting link in the case an invert arch is required. Cable ducts and side walks are mostly founded on these longitudinal concrete beams.

c. The invert arch forms the ring closure of the tunnel lining (tunnel tube) where poor geological conditions prevail. The concreted invert arch has to resist ground pressures and to provide stability for the whole tunnel structure.

d. The formwork or shutters for the foundation beams invert and arch and roof arch provide the necessary tools for the construction of the final tunnel lining. They shall be designed and constructed of steel in such a manner that the shape, dimensions and surface finish of the concrete are obtained, as specified.

e. Contact grouting is the injection of grout material under pressure to fill voids between in-situ concrete lining and the rock or shotcrete or the membrane lining (waterproofing). A systematic contact grouting shall be carried out in the roof section of the tunnel after hardening of the concrete lining, and satisfactory results from the 28 day cube test. Provision shall be made in the roof arch shutter for the casting of the necessary holes for contact grouting. Positioning of these grout holes shall be approved by the ENGINEER.

7.1.2 Submissions

a. Working drawings shall be submitted showing the camber of formwork as required for compensation of deflection by concrete placing operation.

b. The CONTRACTOR shall submit detailed shop drawings of the formwork for approval by the ENGINEER.

c. Separate shop drawings for the formwork for the tunnel cross section, cross passages and niches shall be submitted by the CONTRACTOR for approval by the ENGINEER.

d. Test reports shall be submitted for the concrete to be used in accordance with General Specification.

e. Method statement, plant and material description for contact grouting shall be submitted to the ENGINEER for approval before commencement of inner lining concreting works.

7.1.3 Job Conditions

a. The inner concrete lining in the tunnel shall not be placed until the rate of displacement at any position on the tunnel periphery and normal to the periphery is less than 2 mm per month, unless otherwise approved by the ENGINEER.

b. The inner concrete lining shall not be placed before the re-profiling operations have been accepted and approved by the ENGINEER.

c. The inner concrete lining in the tunnel shall not be placed before the waterproofing system installed is accepted and approved by the ENGINEER.

7.1.4 Quality Assurance

a. General Specification.

7.2 MATERIAL

7.2.1 Formwork

a. Section 1500 of the General Specification.

b. Formwork shall be held to comprise all temporary staging and formwork required and used for the construction of the final lining.

c. Formwork shall be sufficiently rigid to maintain the forms in their correct position, shape and profile so that the final concrete structure is within the limits of tolerances (± 10 mm).

d. The formwork shall be made of steel and suitable for repetitive use, and to give a class F5 finish.

The formwork shall be provided with openings along each side wall and in the crown. The opening shall be so designed as to permit the use of vibrators for compacting the concrete, and to permit inspection of the concrete during placing and of the hardened concrete surface prior to the striking or the removal of the formwork. They shall be a minimum of 600 mm square. Openings for pouring of concrete shall be located at such heights as to prevent segregation of the concrete. Joints in the forms shall be sufficiently tight to prevent leakage of grout and absorption of water from concrete.

e. The forms shall be maintained at all times in good condition as accuracy of shape, strength, rigidity, water tightness and smoothness of surface is warranted. All forms shall be kept clean, free of corrosion and in good repair.

f. The design of the formwork shall be to the approval of the ENGINEER.

g. The upper sector of the formwork shall have facilities for mounting external vibrators at regular intervals to ensure thorough compaction of the arched soffit.

h. The steel form shall be furnished with suitable devices for the erection of stop ends and to enable chamfers along the periphery at the start/end of each concreting section in order to produce a regular surface between pours where the tunnel is on curve.

7.2.2 Concrete

a. Section 1700 of the General Specification.

b. The concrete grade for inner concrete lining, abutment and invert arch shall be 30 N/mm^2 according to Section 1700 General Specification.

c. Maximum aggregate size is to comply with the Section 1700 General Specification.

d. The consistency of the mix shall be chosen to allow placing of concrete by pumping.

e. Plasticizers may be used in the concrete mix to improve flow and compaction. Details of such additives shall be submitted to the ENGINEER for approval prior to their use.

7.2.3 Grout for Contact Grouting

a. Grout shall be based on a mixture of cementious materials and water, but may contain additives to improve the performance, subject to the ENGINEER'S approval.

All sources of water to be used with cement shall be approved by the ENGINEER. If at any time during construction, water from an approved source becomes unsatisfactory, the CONTRACTOR shall provide satisfactory water from other main sources.

b. Cementious materials shall conform to current Standards. The grout shall be a uniform mixture of which the consistency shall be sufficiently fluid but not more to ensure that the grout flows freely under pressure into all parts of the void.

c. The grout mix shall have low or no bleedability and low shrinkage characteristics. When set the grout should have the lowest permeability possible.

7.3 EXECUTION

7.3.1 Preparation of Formwork before Concreting

a. Section 1500 General Specification.

b. The inside surface of forms, except permanent formwork or unless otherwise agreed by the ENGINEER, shall be coated with an approved non-staining mould oil to prevent adhesion of the concrete.

c. Release agents shall be applied strictly in accordance with the manufacturer's instructions and shall not come into contact with reinforcement and anchorage's.

The composition of the release agent shall be such that it will not interfere with future surface treatments.

d. Before concreting, all forms shall be thoroughly cleaned. Faces of formwork in contact with concrete shall be free from adhering foreign matter, projecting nails and the like, splits or other defects.

e. The formwork shall be erected and anchored in such a way that it rigidly retains its shape and position during concreting and that surface irregularities in the concrete are avoided.

f. Formwork shall be erected to such levels as to make allowance for anticipated deflection of the formwork under load.

g. The CONTRACTOR shall not place any concrete in the forms until the ENGINEER has given written approval on the standard form.

7.3.2 Preparation for Placing Concrete

Before the concrete lining is cast the CONTRACTOR shall thoroughly clean the invert, sides and roof of the excavation of loose or unsound fragments of rock, mud, debris, standing water, oil and any other foreign matter.

7.3.3 Transport of Concrete

Clause No. 1709 of the General Specification.

7.3.4 Placing of Concrete

a. Clause No. 1709 of the General Specification.

b. The CONTRACTOR shall submit full details of his proposed tunnel concrete placing methods, including a description of the equipment to be used.

c. Concrete shall be placed by a displacement type pump or by such method as may be approved by the ENGINEER. The method of placing concrete shall be such that the concrete is not introduced into the formwork at a high velocity and shall be such that segregation of the concrete does not occur, the concrete pump shall produce a continuous stream of concrete without air pockets.

d. The casting of the side beams and the structural invert shall be done in separate operations before placing the inner lining arch of the tunnel. The method of placing concrete in the invert shall be subject to approval of the ENGINEER.

e. The concrete beams on each side shall be used as abutments for the rails which are necessary for moving the tunnel formwork. They shall be cured for at least 7 days before the formwork for the inner lining arch is allowed to be placed.

f. Concrete shall be pumped into the formwork through suitable temporary openings.

g. Concrete in the walls and crown of tunnels shall be brought up in horizontal layers not exceeding 50 cm, evenly distributed over the concreting section and

h. Maximum level differences shall not exceed the values as specified by the manufacturer of the formwork.

i. Concrete shall not be pumped into the crown of the arch and allowed to flow down into the walls and invert. Concrete shall be forced into all irregularities in the ground or initial support surface by submersive vibrators to fill the void between that surface and the formwork.

j. Particular care shall be taken to ensure the complete filling of the crown of the tunnel arch. The CONTRACTOR shall include with his details of tunnel concrete placing methods proposals for satisfying this requirement. Air pockets in the tunnel roof shall be relieved by ventilation hoses where necessary beyond the relevant stop-end of the formwork.

k. Cold joints in final lining shall be avoided where practicable. A standby concrete pump and placement line shall be provided during concreting operations. In the event of continuous placing being interrupted by equipment breakdown or for any other reason, the CONTRACTOR shall thoroughly consolidate the concrete at such joints to a reasonably uniform and stable slope while the concrete is plastic and any concrete which remains unconsolidated shall be removed.

l. Final lining for tunnels shall be cast in sections of 10 to 12 meters length measured along the tunnel axis. Each section shall be cast in one continuous operation without interruption and construction joints. All construction joints at the ends of the sections shall be perpendicular to the gradient.

m. When the ambient temperature at the place of pouring is greater than 32 degrees Celsius, hot weather concreting techniques as described in the American Concrete Institute Standard ACI 305R-77 shall be used.

n. For cold weather concreting refer to Section 1712 of the General Specification.

7.3.5 Compaction of Concrete for Final Lining

a. Section 1709 of the General Specification.

b. The concrete shall be compacted by vibrators anchored to the formwork and immersion vibrators operated through the inspection openings in the formwork.

c. The operating time of the external vibrators shall be kept short in order to avoid segregation.

7.3.6 Removal of Formwork

a. Section 1508 of the General Specification.

b. Formwork shall be so designed as to permit easy removal without resorting to hammering or levering against the surface of the concrete or injuring the concrete.

c. Any damages occurring during striking of the formwork shall be made good by the CONTRACTOR during "rubbing up" as described in Clause No. 7.3.8 of th

specification.

d. Form removal shall not be started until the concrete has attained a strength so that most unfavourable load conditions do not cause any damages to the structure. The strength of the concrete shall be measured after removal of the stop-end shutter in the tunnel roof. The minimum strength for removal of the formwork must satisfy the structural requirements for "dead load" of the lining. This strength shall be checked by a Schmidt pendulum type hammer, or similar approved, for low strength concrete, with a piston of 40 mm diameter. Prior to the commencement of concreting works, the instrument shall be calibrated for each approved concrete mix under particular application.

The following equipment or similar shall be used:

Manufacturer: Wykeham Farrance, Slough, England

Model No: WF 53932

7.3.7 Curing of Concrete

a. Section 1713 of the General Specification.

b. The sealing agent shall not interfere with the bonding of any subsequent surface treatment.

c. Curing can be omitted if the humidity and shrinkage measurements prove that no effect is attained by curing measures.

7.3.8 Remedial Treatment of Surfaces

a. Section 1714 of the General Specification.

7.3.9 Contact Grouting

a. Prior to the commencement of inner lining works, the CONTRACTOR shall submit to the ENGINEER for approval full details of the working method and equipment to be used.

b. At all times the CONTRACTOR shall ensure that the grouting operation is under the direct control of skilled and experienced operatives. The TUNNEL DESIGNER'S REPRESENTATIVE will state the maximum pressures to be used approved by the ENGINEER.

c. Grouting and ventilating pipes shall be positioned prior to concreting.

d. Upon completion of grouting, the CONTRACTOR shall cut off all surplus lengths of pipes and make good the surface to the satisfaction of the ENGINEER.

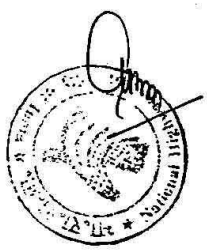
e. The CONTRACTOR shall provide to the ENGINEER as required, records of grouted areas, injection pressures, grout consumption and mix details.

f. The ENGINEER will require tests to be carried out to confirm that the grout mix and its constituent materials are in accordance with the specification. The CONTRACTOR shall carry out such tests and submit the results for the ENGINEER'S approval when required.

g. Where dry premixes of grout of an acknowledged manufacturer are used, they shall be mixed to the manufacturer's recommended water/solids ratio. All grout mixes shall be prepared using high speed, high shearing action mixers.

h. The CONTRACTOR may choose to propose a method of concreting in order to eliminate contact grouting of the tunnel lining. However, if the proposed method is accepted by the ENGINEER the requirements of Clause No. 7.1.1e must still be met and the cast-in holes used to check that the tunnel lining is complete as directed by

the ENGINEER.



SECTION 8 – FILL MATERIAL, ANCILLARY CONCRETE AND CONCRETE PAVEMENT

8.1 Plain Cement Concrete

8.1.1 General

Section 1500 and 1700 of the General Specification shall apply.

8.2 Structural Cement Concrete

8.2.1 General

Section 1500 and 1700 of the General Specification shall apply.

8.3 Granular Sub-Base

8.3.1 General

Clause No. 401 of the General Specification shall apply.

8.4 Concrete Pavement

8.4.1 Dry Lean (Rolled) Concrete Base Course

8.4.1.1 General

Clause No.603 of the General Specification shall apply.

8.4.2 Concrete Pavement

8.4.1.1 General

Clause No.602 of the General Specification shall apply.

NASHRI TUNNEL WAY LIMITED CHENANI

SECTION 9 - GEOTECHNICAL INSTRUMENTATION AND MEASUREMENT

9.1 GENERAL

9.1.1 Scope of Specification

a. This section specifies the requirements for the geotechnical measurements in tunnels designed according to the NATM for the purpose of observing and recording deformations and load variations on supporting elements and in the adjacent rock.

b. As part of the safety concept 3-dimensional deformations of the tunnel lining shall be monitored by means of optical methods. The points to be observed are marked by targets or reflectors mounted on standard convergency bolts.

c. Measurements shall be carried out with a free-stationed high precision electronic theodolite 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 +/- 1 mm in minimum.

d. Works under this section include the installation of geotechnical instrumentation and device, readings, plotting and interpretation of measurement results.

e. 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 utilization of the supporting elements.

f. The locations and spacing between geotechnical measurement sections depends on geological conditions, frequency of geological alterations, rock mechanical behaviour, length of tunnels, primary stress conditions, size of tunnels. The location of measurement sections designed, shall be modified during tunnelling according to the local geological conditions and the experience gained during tunnel driving and as required and approved by the ENGINEER.

9.1.2 Description of Instruments

a. Level points are fixed markers, pins or bolts placed in the roof and invert and/or sidewalls of the tunnels and are measured by optical survey methods to determine vertical displacements.

b. Convergency pins are pins or bolts installed in the tunnel lining. Measurements are made by opto-electronical method to determine relative and absolute displacements of the tunnel lining or tunnel opening in general.

c. Borehole extensometers are used to measure displacements of the surrounding rock at various depths. The extensometer readings inform about the absolute amount of displacements around a tunnel and the depth and pattern of the deformations in the rock environment of the tunnel and shall be used by the ENGINEER to check and determine the length of rock bolts required.

9.1.3 Submissions

a. Samples of convergence pins and strain meters

b. Specifications and catalogues for the instrumentation and readout devices intended to be used.

c. Complete layout of instrumentation sections: Instrumentation equipment for main and secondary measuring sections, location of sections, distances and monitoring schedule.

d. A description of the software necessary for the calculation of the three dimensional deformations and presentation of results.

e. A description of the data transfer system, data storage, availability of the processed data and interpretations to involved parties, and presentation of results.

All submissions are subject to the approval of the ENGINEER.

9.2 MATERIALS

9.2.1 Level Points

For the determination of elevation of tunnel crown or at other points only approved pins or bolts shall be used.

Levelling of the tunnel crown and other specific points (invert, sidewalls etc.) shall be done during tunnel excavation to monitor vertical settlements and bottom heaves and to be able to interpret and figure out the absolute amount of displacements together with convergency readings.

The method of performing the level measurements shall be such as to ensure an accuracy of +/- 1 mm.

9.2.2 Convergency Bolts

Convergency bolts or pins shall consist of ribbed bars protected against corrosion with a minimum length of 250 mm. 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.

9.2.3 Targets or Reflectors

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. This device shall be designed for high precision measurements with two axes of rotation and to be observable from both sides.

This plastic reflector can be replaced by a positive centred prism if required with the same standard as the reflector above.

9.2.4 Theodolite

An opto-electronical theodolite with integrated coaxial electronic distance meter (EDM) shall be used. The equipment shall be such as to ensure an accuracy of 3^{cc} for directions as well as an accuracy of +/- 0,5 mm for distances.

The measuring arrangement shall include further equipment as follows:

- Illuminated matrix display
- Numeric and alphanumeric input options
- Plug-in data recording module

9.2.5 Borehole Extensometer

Borehole extensometers shall be multiple position rod type or single rod type with mechanical anchors at fixed points. The remaining length of each rod or wire shall be in a pipe so as to be able to move freely. Multiple rod type extensometers shall be designed to read at leasi at three positions spaced 2 to 3 meters. The instruments shall be resistant to corrosion. The diameter of the bore hole for installation of the extensometers depends on the type (single/multiple rod type) and it shall be in accordance with the manufacturer's recommendations.

The readings shall be done by a dial gauge or by using electrical transducers for remote reading. The accuracy of the extensometer readings shall be 0.05 mm.

The manufacturer's literature, specification and instructions shall be supplied to the ENGINEER.

9.3 EXECUTION

9.3.1 General Requirements

a. The instruments shall be installed at locations and in accordance with a schedule as agreed by approved by the ENGINEER.

b. The geotechnical instrumentation and monitoring program may always be subject to alterations and modifications if required by the actual geological or geotechnical conditions.

c. The installation of all major instrumentation shall be supervised by the CONTRACTOR and approved by the ENGINEER.

d. All instrumentation shall be installed in accordance with the manufacturer's recommendations and with the additional requirements specified in this section.

e. The installation of all instrumentation shall be carried out close to the face within the last round of excavation.

f. The installed measuring instrumentation as well as the required space for measuring must be kept free and accessible for all the duration of construction.

g. All instruments shall be protected against damage by blasting and tunnel traffic. Where required protective covers or housings may be used to prevent damage of the instruments.

h. Damaged instruments due to construction operations shall be replaced immediately without additional costs.

i. Readout units as dial gauges or tape extensometers shall be available at any time during tunnel construction. Spare parts and spare units shall be maintained on site.

j. The CONTRACTOR shall provide, arrange and maintain all the equipment throughout the construction period which is required for the installation and monitoring of the measuring sections.

k. All instruments and equipment used and required for the geotechnical measurements shall be made available to the ENGINEER throughout the construction period.

9.3.2 Reading, Plotting and Interpretation

a. Reading, plotting and interpretation of the instruments and measuring results shall be carried out by qualified personnel of the CONTRACTOR subject to approval of the ENGINEER.

b. For the optical displacement monitoring a software package shall be used which allows a direct data flow. This software shall include features as follows:

- 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.

c. The CONTRACTOR shall provide and maintain adequate lighting, ventilation and platforms including operator for access to all instruments for the personnel to carry out the readings. This requirement applies also to the ENGINEER as deemed necessary by the ENGINEER.

d. The first measurements (zero-readings) shall, for each measuring instrument, be made immediately after installation or as soon as practically possible.

e. The frequency of the further measurements or readings can be envisaged for each measuring section as follows:

1st week :	daily
2nd week :	twice a week
3rd & 4th week:	once per week
Later:	monthly and bi-monthly

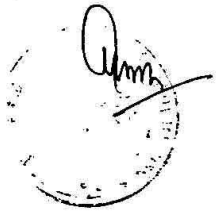
The actual frequency of readings will however be influenced by the construction stages top heading/bench heading in one tunnel and by the staggered parallel driven tunnels.

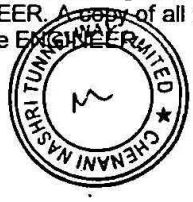
When the bench is approaching the instrumentation section installed during top heading, reading frequencies shall be increased again. When the parallel tunnel tube approaches the station of an instrumentation section installed in the first tunnel tube, readings shall be activated again and reading frequencies increased respectively.

f. 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.

g. Measurements shall continue until construction work on the inner lining stops the taking of measurements.

h. All measurements shall be plotted within 4 hours of the reading on suitable diagrams which shall at any time be available to the ENGINEER. A copy of all records shall be permanently kept on site and made available to the ENGINEER.

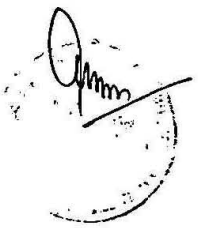


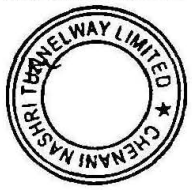


ADDENDUM 1

GEOLOGICAL MAPPING

GUIDELINES FOR
ENGINEERING GEOLOGICAL DOCUMENTATION





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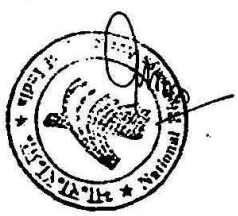

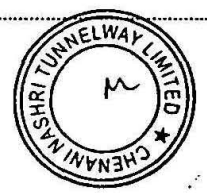

1 INTRODUCTION

The purpose of engineering geological mapping is the documentation of rock - and rock mass conditions as encountered during excavation. The documentation shall enable the verification of the suitability of the designed support and excavation measures, the prediction of rock mass conditions ahead as well as the interpretation of results of the geotechnical monitoring concerning ground deformations.

The mapping and documentation of encountered geological conditions during the excavation shall be based on a uniform legend and shall use uniform terms for the description of features which have to be recorded.

To facilitate this procedure form sheets shall be used which include all the topics which have to be recorded if encountered.

In general the mapping shall be performed in a scale 1:100. If necessary details shall be mapped in a suitable scale.

Based on the follow-up mapping a vertical as well as horizontal cross section shall be drawn, where the actual mapping results are incooperated continuously on a daily basis.

The vertical section shall be located along the axis of the tunnel, the horizontal section has to be fixed according to the chosen excavation cross section (top heading - bench, side galleries etc.). In case the tunnel is excavated by top heading - bench excavation the horizontal cross section shall be drawn on the level of the invert of the top heading. The proposed scale is 1:200 or 1:500; horizontal and vertical scale shall be the same.

2 GEOLOGICAL DOCUMENTATION

2.1 General

The geological documentation shall include one page showing the mapping of the exposed rock face in a scale 1:100, the full periphery mapping of the crown and side walls in a scale 1:100 as well as a data sheet with all recorded features.

Mapping shall be performed at fresh excavated faces, right after installation of measures, which enable safe entry to the excavated section.

Terms as given in Clause 2.2.2. are examples and can be adjusted or supplemented according to the encountered features.

2.2 Terminology

2.2.1 Rock Types/Rock Mass Types

The rock types shall be referred to using standardised names and terms.

The rock mass can occur in different qualities according to the influence of weathering, tectonic stress and/or strain (shearing, faulting, folding). Therefore the rock mass type shall be described when different qualities can be distinguished.

2.2.2 Discontinuities

Possible types of discontinuities and abbreviations:

B : bedding plane
S : schistosity
J : joint
SL : slickenside

F : fault

A : axis (of fold etc.)

ST : striation

Orientation of discontinuities:

Discontinuities shall be measured in dip direction /Shape of discontinuities and abbreviations:

P : planar

U : undulating

S : stepped

Roughness of discontinuities and abbreviations:

P : polished

S : smooth

R : rough

Persistence of discontinuities and abbreviations:

The persistence of discontinuities shall be related to the size of the unsupported area (e.g. tunnel face).

H : high, discontinuities can be traced in a length exceeding the unsupported area

M : medium, discontinuities can be traced within the unsupported area exceeding the half of its span

L : low, discontinuities can be traced within the unsupported area less than half of its span

Spacing of discontinuities:

The spacing of discontinuities shall be classified according the following ranges:

> 60 cm, 20 - 60 cm, 6 - 20 cm, 2 - 6 cm, < 2 cm

Filling/Thickness of discontinuities and abbreviations:

The type and the thickness of fillings of open discontinuities shall be described. Possible types with abbreviations are stated below.

Cl : clay (weathering product)

Qu : quartz

Ca : calcite

Gy : gypsum

MFG : mylonitic fault gouge

MFB : mylonitic fault breccia

MCB : mylonitic crush breccia

O : open without filling

The thickness shall be measured in cm

2.2.3. Jointing of Rock Mass

The jointing of the rock mass shall be described by determination of the maximum average spacing of discontinuities using the prepared chard shown on the data sheet, and the degree of dilation of the rock mass.

The dilation of the rock mass is related to the degree of opening of the discontinuities exposed in the mapped area.

2.2.4. Water

Water seepage shall be described by the determination of location, amount (dry, damp, wet, dripping, running [l/sec]) and condition [colour, smell] of the water as well as by the impact of the water on the rock mass [soaking, break down].

2.2.5. Weathering

The description of the degree of weathering shall be based on the terminology shown in the table.

Descriptive term with abbreviation	Field identification test
Fresh (F)	Rock shows no signs of weathering (discoloration, decomposition).
Slightly Weathered (SW)	Rock is locally discoloured (stains of discontinuities, discoloured adjacent to discontinuities).
Moderately Weathered (MW)	Rock is discoloured, discontinuities have discoloured surfaces with weathering starting to penetrate inwards.
Highly Weathered (HW)	Rock is discoloured almost throughout. Weathering penetrates deeply inwards, but corestones are still present.
Completely Weathered (CW)	Rock is decomposed to soil but original fabric and structure are still visible, occasionally small corestones are possible.
Residual Soil (RS)	All rock material is converted to soil. The mass structure and material fabric are destroyed, change in volume but no significant transportation.

2.2.6. Rock Strength

The description of rock strength shall be to terminology shown in the table.

Descriptive term and abbreviation	Field estimate of strength
Extremely Strong (ES)	Rock material only chipped under repeated hammer blows
Very Strong (VS)	Requires many blows of a geological hammer to break intact rock specimens
Strong (S)	Hand held specimens broken by single blow of geological hammer
Medium Strong (MS)	Firm blow with geological pick indents rock to 5 mm, knife just scrapes surface
Weak (W)	Knife cuts material but too hard to shape triaxial specimens
Very Weak (VW)	Material crumbles under firm blows of geological pick, can be shaped with knife
Extremely Weak (EW)	Indented by thumbnail

2.2.7. Behaviour of Rock Mass

The behaviour of the rock mass during excavation and at recently excavated faces until support installation shall be described.

Terms which shall be used are stated below.

- stable
- afterbreaking
- friable
- squeezing
- loose

2.2.8. Overbreak

In case overbreak due to geological reasons has been encountered, which exceeds the tolerance location, shape, and reasons of the overbreak shall be recorded where possible.

3. EXECUTION

3.1. General

The documentation of the tunnels shall be based on the mapping of the face and the full periphery mapping method. The full periphery mapping method shall be applied for the permanent walls only.

The frequency shall be adjusted to the variability of the encountered ground conditions. In case ground conditions are frequently changing within one round length each round shall be mapped. Each drive which is under construction shall be checked at least once a day.

3.2. Face Mapping Sheet

The form sheet for mapping shall show the area to be mapped in a scale of 1:100 and shall have a grid of 1 x 1 m for easier drafting, marked with "+".

The position of the laser beams on the face as well as the steel rib connections may be marked as drafting guides.

The sketch of the exposed face shall contain:

- interfaces of different rock types (e.g. lithology), respectively rock mass types
- visual features of rock mass (e.g. weathering)
- major structural discontinuities
- points of water inflow
- position and shape of overbreak.

The different degrees of weathering of the rock mass can be depicted as its independent feature separated from the lithology.

Remarks can be stated directly on the mapping sheet or can be referred to the data sheet.

3.3. Data-Sheet

The data sheet contains the topics as explained below.

- TUNNEL

  Name of construction area (e.g. name of tunnel).

- LOCATION

  Name of the drive, working face (side gallery, top heading, bench etc.).

- CHAINAGE

  Chainage of the face

- EXCAVATION

  Excavation method (excavator, hydraulic hammer, bulldozer, road header, blasting).

- MAPPED BY

  Name of mapper

- DATE/TIME

  Date and time of recording.

- ROCK TYPES/ROCK MASS TYPES

  Rock types shall be described with standardised names and terms according to the legend. The description shall include

  * Type of rock
  * colour
  * remarks on mineralogy
  * short remarks on rock strength (for terminology see chapter 2.2.6).

Rock mass types shall be described with standardised names and terms

- DISCONTINUITIES

Discontinuities shall be recorded by the determination of type, orientation, shape, roughness, persistence, spacing, filling, thickness of filling and additional remarks if necessary (for terminology see chapter 2.2.2).

- JOINTING OF ROCK MASS

Jointing of rock mass shall be described by determination of the maximum average spacing of discontinuities and general shape of joint blocks using the prepared chard as well as by the degree of loosening of the rock mass (for terminology see chapter 2.2.3- WATER/WEATHERING

Water seepage shall be described by the determination of location, amount and condition of the water as well as by the impact of the water on the rock mass (for terminology see chapter 2.2.4).

Weathering shall be described as its own feature, not combined with the description of the rock types (for terminology see chapter 2.2.5).

- BEHAVIOUR OF ROCK MASS

The behaviour of the rock mass during excavation and at fresh excavated faces until support installation shall be described (for terminology see chapter 2.2.7).

In case overbreak due to geological reasons has been encountered, which exceeds the tolerance location, shape and reasons of the overbreak shall be recorded where possible.

- GENERAL REMARKS

Additional remarks concerning the encountered conditions shall be noted.

Photos shall be taken of areas of special interest as well as to complete the geological documentation. Motive and number of photos shall be recorded. A scale shall be shown on the photos.

Samples shall be taken of representative rock types or in case specific geological and hydrogeological conditions are encountered (e.g. fault zones, coloured or smelling water). Location, kind and purpose of samples which have been taken shall be recorded.

4. ATTACHMENTS

4.1. Face Mapping Sheet

The face mapping sheets will be generated according to the construction drawings. The copy of a form sheet, showing an example is attached.

4.2. Data Sheet

A copy of the data sheet is attached

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GEOLOGICAL MAPPING - DATA SHEET

TUNNEL:	LOCATION:	CHAINAGE:	EXCAVATION:	MAPPED BY:	DATE/TIME:
ROCK TYPES/ROCK MASS TYPES:					

DISCONTINUITIES	NR.	TYPE	ORIENTAT-ION	SHAPE	ROUGHNESS	PERSIST-ENCE	SPACING	FILLING/ THICKNESS	REMARKS

JOINTING OF ROCK MASS	SHAPE OF JOINT BODIES: Remarks:	DILATION OF ROCKMASS: ☐ Discontinuities closed ☐ Discontinuities partially open ☐ Discontinuities mostly open
WATER WEATHERING	WATER, ENCOUNTERED DURING EXCAVATION: (LOCATION, AMOUNT, CONDITION, IMPACT ON ROCK MASS) Remarks:	DEGREE OF WEATHERING: ☐ F HW ☐ SW CW ☐ MW RS Remarks:
BEHAV-IOR OF ROCK MASS	BEHAVIOR DURING EXCAVATION: ☐ STABLE ☐ AFTERBREAKING ☐ FRIABLE ☐ SQUEEZING Remarks: ☐ LOOSE	SHAPE / LOCATION OF OVERBREAK:

GENERAL REMARKS:	SAMPLE:
	PHOTO:

NASHRI TUNNELWAY LIMITED ★ CHENANI

Annexure DII : ROAD TUNNELS - LIGHTING

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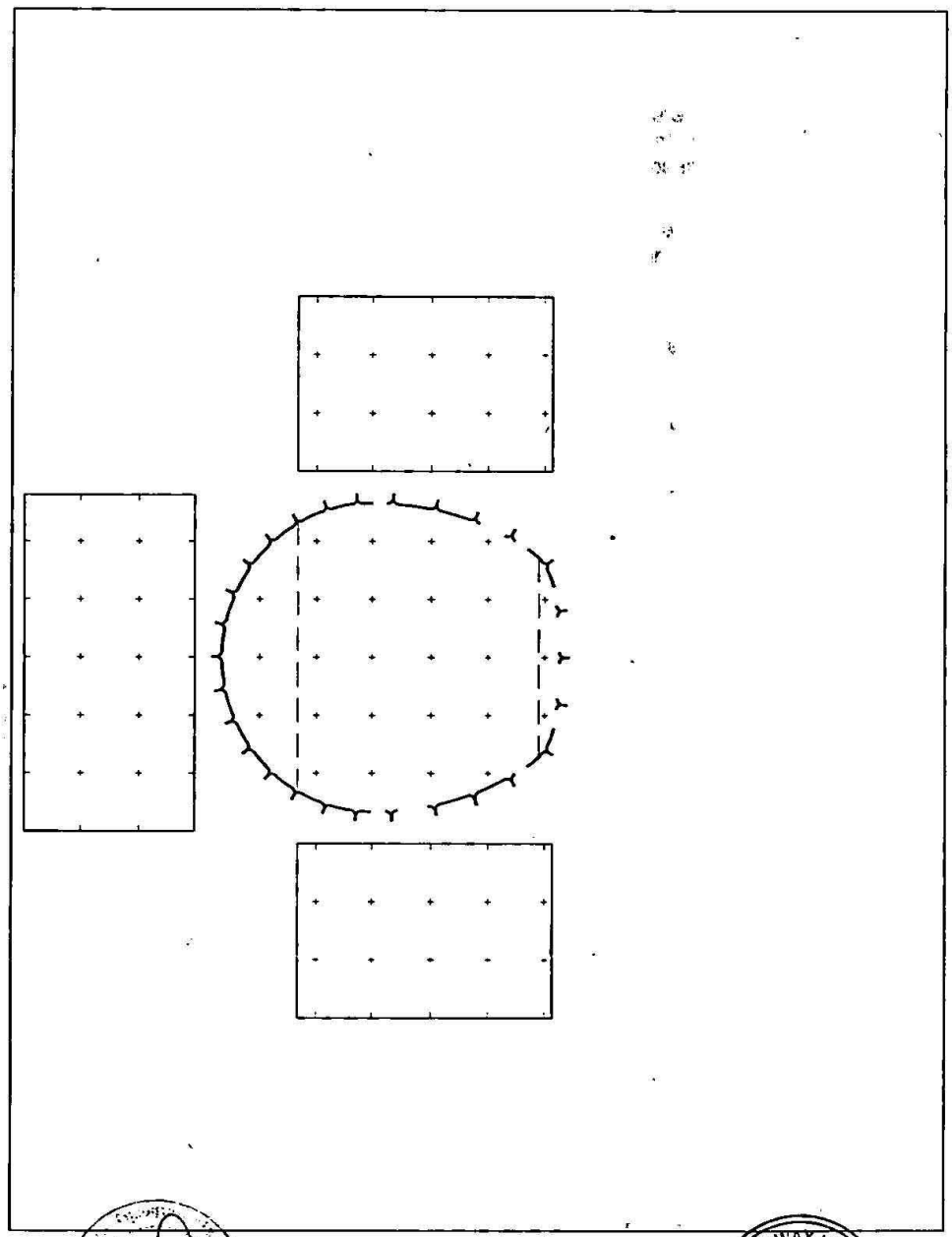


SHRI TUNNELWAY LIMITED
CHENANI - NASHRI

Distance between luminaries: 22.0 m
All luminance values are maintaining values. The maintenance factor shall be 0.7.

1.3.2.3 Emergency tunnel lighting

Interior lighting will serve as emergency tunnel lighting and is to be connected to the UPS-supply network. This will enable a secure tunnel lighting system, since the UPS-supplied luminaries will not extinguish in the event of power failure of the main supplying net (UPS.....uninterruptible power supply).

1.4 TECHNICAL SPECIFICATION

1.4.1 General

Luminaries (Lighting Fixture)

Luminaries should conform to IS 2149-1970 and 1913-1978 amended upto date and as per detailed specification of the item.

The luminaries should be complete with control gear suitable for operation on supplied voltage single phase 50 cycle/second supply. Acrylic cover is of high transparency clear, or glass with minimum percentage absorption of light. Fixing arrangements of acrylic cover should be with adequate quantity of stainless steel toggles. Gasket is of high quality neoprint rubber between acrylic cover or glass and main housing.

Control gear should consisting with of low-loss heavy duty polyester ballast, power factor improvement capacitor, external electronic ignitor etc. End mounting arrangements with sturdy 'U' clamps suitable for accommodating GI pipe of 50 mm Nominal Bore.

The rate of the item shall include all materials and labour for complete item. The contract rate shall be for unit of one number.

The sample of item should be got approved by the engineer in-charge prior to use of item.

Luminaries shall be symmetrically fed by all three phases.

In case of fire, the luminaries should have the capacity to operate at a temperature of 250 °C for a period of 60 minutes.

The support of the luminaries shall be fixed such that the luminaries do not extend into the clearance profile.

Housing for tunnel luminaries shall have:- Degree of protection: IP 66
Compressive strength: 6 bar

Housings shall consist of dust painted stainless steel, material no. 1.4571 according to DIN 17440.

The cable entrances shall be made with compressing cable glands suitable for the supply cables.

The housing shall be suitable for fixing both symmetrical and asymmetrical reflectors.

The mounting brackets shall be made from stainless steel according to DIN 17440 and have longitudinal slots for horizontal and vertical adjustment. The minimum numbers of mounting brackets are four per luminary.
The luminaire shall be removable without tools.

1. TUNNEL LIGHTING

1.1 GENERAL

This Specification covers the permanent interior lighting requirement for Short Tunnels. These structures only require emergency lighting levels during tunnel operation time. It covers all the necessary equipment, materials and accessories needed to complete the works. Power supply should be uninterruptible with alternative back up source, e.g. generator.

1.2 SCOPE OF WORK

- Interior lighting (luminaries)
- Luminary support
- Lamps
- Cabling
- Distribution Cabinet

1.3 VALUES AND DEFINITIONS

1.3.1 Basic Data

Permissible speed:	50 km/h in main tunnel
Gradient: (in direction of driving)	- 4.0 %
Stopping distance:	60 m
Road pavement:	concrete, R1 q(0) = 0,08
Maintenance factor:	0.7
Wall pavement:	concrete q(0) = 0,10
Height of luminary:	6.2 m interior lighting (one row of luminaries)

1.3.2 Interior Lighting

1.3.2.1 General

For the interior lighting one row of luminaries shall be provided.

The interior lighting of tunnels shall be with symmetrical luminaries equipped with high-pressure sodium lamps á 70 W.

1.3.2.2 Values:

Permissible speed:	50 km/h (main tunnel tubes)
Style of luminaries:	High pressure sodium (HPS) lamps 1 x 70 W with symmetrical light distribution

The luminaries shall have a plug connection between the optics (with the lamp holder/socket) and the pre-connection devices (to facilitate maintenance, so the optics can be changed without the need of tools). The latches shall be designed in such a way that the glass remains hanging on the latch after opening of the luminary and can not fall down.

The optics shall be rotate-able in 90° angles.

The glass has to withstand a pressure of spraying water of 6 bar.

The housing shall have loop-trough terminals inside (for the cabling/supply of the following luminaries), which shall be fitted with cage clamp springs (screw-less and vibration-proof). Phase selection shall be possible at the terminal blocks without any further modification of the wiring inside the housing/luminary.

The glass retaining frame, capable of been swung down on one side, is to be fitted with a non-light-scattering, thermal shock-resistant, at least 5 mm thick safety glass panel, it shall be fixed by four stainless steel quick-release safety catches. These catches shall be releasable without the need of any tools.

The glass retaining frame shall be fitted with two gaskets in stepped arrangement. The material, which is used for the gaskets, shall be of synthetic rubber, which has to be temperature/heat-resistant, damp-proof, non-ageing and resistant to the aggressive atmosphere in tunnels.

The housing shall be suitable for mechanical cleaning.

1.4.2 Optic

The optical reflector shall be symmetrical, consisting of chemical polished and anodised highest-grade aluminium (99.85 %).

The lamp holder / socket (E 27 or E 40) shall consist of porcelain and the internal wiring shall be made with heat resistant silicon wiring. The cut-off angle shall be approx. 80° for symmetrical reflectors.

Efficiency:
Luminaries with symmetrical optics: > 72 %

1.4.3 Lamps

High-pressure sodium lamps with clear tubular glass and socket E27 or E 40 (belongs to the lamp power).

Life rated:	15,000 hours (minimum)
Flux for HPS 70 W lamps:	6,500 lm (minimum)

Note: The luminaries shall be placed horizontal (related to the roadway) in a right angle to the tunnel axis.

1.4.4 Chassis

It shall be a plug-in module to be fixed without tools. Upon untying, the chassis must not fall off.

All equipment must be properly secured in accordance with manufacturers instructions

All internal wiring shall be heat-resistant silicon wiring.

1.4.5 Capacitor

All luminaries shall have an individual power factor corrector achieving a power factor (cos φ) of at least 0.92 for each luminary.

1.4.6 Ballasts

The ballasts shall be low power-loss ballasts with following maximum lamp losses:

High-pressure sodium lamp 70 W: 13 W

1.4.7 Luminary support

The luminary support shall consist of stainless steel material No. 1.4571 according to DIN 17440 or equivalent, and shall be resistant to all environmental conditions which exist in road tunnels.

The support shall consist of four C-formed angles of appropriate length and be adjustable in height.

The luminaries shall be mounted on the luminary supports in such a way, that the luminaries can be aligned in every direction.

Luminaries shall also be fixed in such a way, that the luminary cannot fall down.

The (screw) nut shall have a split-pin, lock nut or similar.

The luminary support shall be mounted on the final lining with drilled plugs. All screws, nuts, pins, plugs and cover plates shall be of stainless steel material No. 1.4571 according to DIN 17440 or equivalent.

1.4.8 Lighting control

1.4.8.1 Required control functions

One "Automatic - Local - Off" selector switch (for lighting control) at the distribution cabinet at the distribution building for following functions shall be provided. The orders are given via push buttons which are also mounted on the door of the distribution cabinets (on the outside surface). The feedbacks are visualized via pilot lamps, which are also mounted on the door of the distribution cabinets (on the outside surface).

Interior Lighting:

- Automatic:
  The interior lighting has to be automatically remote controlled.

- Local:
  The local orders shall only be executed if the selector switch stands on the "Local"-position. If the selector switch is controlled to "Local", the standing order shall continue until a manual order from the push buttons is ordered. If the selector switch is switched back from "Local" to "Automatic" the automatic orders shall be executed immediately.

1.4.9 Cabling

Wiring is not allowed. Each electrical circuit shall have a separate cable.

For cabling of the interior lighting, the cable shall be NHXH E30/FE180, i.e. bare copper-wire with zero-halide polyethylene insulation and a outer sheath of flame-retardant, zero-halide polymer-compound. It shall have orange functional endurance:
30 minutes; and insulation endurance: 180 minutes.

Only cables with the same voltage shall be installed into one conduit/duct, if this is not possible, separation elements shall be used.

For energy cables, the cable dimensioning shall be in accordance with the relevant standards and (if the area of cross section is not indicated) shall have a diameter assuring voltage drop is not more than 4 % to the nominal voltage from the transformer to the most distant supplied electrical facility. The cables shall also have such diameters that, if there is a short circuit at the furthest point to the circuit breaker, the circuit breaker cuts off efficiently without exceeding the cable's rated temperature rise.

If due to the voltage drop, the cross section of the supply cable for the first lamp/luminary of the concerned section exceeds the capacity of the luminary cable entry (exceeding 5x6 mm^2), then a cable box must to be used. The cable with the larger cross section is then connected to the cable which is to be connected between the luminaries (max. cable cross section 5x6 mm^2). Cable boxes must be mounted inside the cable duct near the rising to the luminary (first luminary of each cabled section).

The current rating of the terminals shall not be lower than the current rating of any connected cables. Live metal shall be recessed or suitably protected to avoid accidental contact.

The cable box shall be equipped with compressing synthetic cable glands, suitable for the connected cables.

Specifications for Protection Works

CLAUSE A-1 CONSTRUCTION OF GABION WALL

Sub-Clause A-1.1 General

This work shall consist of providing and laying factory manufactured wire gabion of approved size, design and filled with approved rock fill, lids closed all as per approved design, drawings and Technical Specifications and as approved by the Engineer.

The Contractor shall be required to provide complete design including its foundation and detailed engineering with working drawings in required numbers. This shall be supported by certificate from the supplier of gabions that he has proven experience in supplying and placing gabions for major highway projects and providing technical backup using in-house facilities.

Gabion walling being a specialised work, the Contractor shall ensure expert supervision by specialist from the technology provider from time to time.

The Gabion wall shall be designed with the given specification using proven system design certified with ISO 9001 / 2 or equivalent as approved by the Engineer. The designer may adopt system design for Gabion wall following any proprietary patented technique.

No extra cost either for patent or any design or expert supervision shall be made to the Contractor.

Sub-Clause A-1.2 Glossary

a) Double Twisted Wire Mesh: A non-ravelling mesh made in mechanically twisting continuous pars of wires through three and half turn (commonly called double twisted) which are then interconnected in the adjacent wires to form hexagonal shaped openings.

b) Mesh Size: The average distance measured at right angles between twisted sides over meshes.

c) Selvedge wire: Terminal wire used to edge the wire mesh perpendicular to the double twist by mechanically wrapping the mesh wires around it at least 2.5 times.

d) Edge wire: Terminal wire used to edge the wire mesh parallel to the double twist by continuously weaving at mechanically into the wire mesh.

e) Lacing wire: The Zinc + PVC coated metallic wire which interconnects empty units, closes and secure stone filled units.

f) Stiffener: A length of Zinc Coated steel wire used for support of facing by connecting the front panel to the back or side panel of a gabion or across the corners of gabion cell. Stiffener formed at the project site is of wire having the same diameter as for the lacing wire.

g) Geosynthetic: Geosynthetic is a general classification for all synthetic material used in geotechnical engineering applications. It includes geotextile and geonets. The material shall be as per Section 700.

Sub-Clause A-1.3 Materials

a. Wires: All wires shall be galvanised and PVC coated. The following shall be

the diameter of different types of wires.

a. **Mesh Wire :-** Internal diameter 2.77 mm and external diameter 3.70 mm.

b. **Selvedge Wire :-** Internal diameter 2.2 mm and external diameter 3.20 mm.

c. **Lacing Wire :-** Internal diameter 2.2 mm and external diameter 3.20 mm.

b. **Mesh :-** The Mesh of the gabion box shall be hexagonal in shape with opening size 80 x 100 as shown in the drawings.

c. **Box :-** The box size shall not be larger than 3 m x 1.5 m x 1 m nor smaller than 1m x 1 m x 1 m. Wherever the length of the box is more than 1.5 m diaphragms are to be provided such that nowhere the continuous length of the box is more than 1.5 m. Diaphragms shall be manufactured of the same material as the parent gabion and have selvedge wire through out their perimeter.

Sub-Clause A-1.4 **Fabrication**

Wire mesh unit shall be manufactured with all components mechanically connected at the production facility. The external face, reinforcing panel, and lid of the Wire mesh shall be woven into a single unit. The ends, back, and diaphragm shall be factory connected to the base. All perimeter edges of the mesh forming the basket shall be selvedged with wire having larger diameter

The facing element of a unit is divided into two cells by means of a diaphragm positioned at approximately 1 m centres. The diaphragm shall be secured in position to the base so that no additional lacing is necessary at the job-site.

The procedure for using lacing wire consists of cutting a sufficient length of wire (+ / - 1.0m), and first looping and / or twisting the lacing wire to the wire mesh. Proceed to lace with alternating double and single loops through every mesh opening approximately every 150 mm, pulling each loop tight and finally securing the end of the lacing wire to the wire mesh by looping and / or twisting.

Sub-Clause A-1.5 **Rock Fill**

Rock for gabion unit filling shall be angular to round, durable and of such quality that it shall not disintegrate on exposure to water or weathering during the life of the structure. The size of rock shall range between 250 mm and 400 mm. The range in sizes shall allow variation of 5% oversize and / or 5% undersize rock provided that it is not placed on the exposed surface.

Sub-Clause A-1.6 **Backfill Material**

Backfill Material shall be made of a good quality free draining, granular and / or selected fill. The recommended soil gradation is in the range of 0.02 mm to 6 mm or as indicated by AASHTO T-27 and FHWA Demo 82. Soils outside of this range may be suitable subject to the approval of the Engineer.

Sub-Clause A-1.7 **Tests**

All following tests on the mesh and lacing wire must be performed prior to manufacturing the mesh:

i. **Wire**

a) Tensile Strength: The wire used for manufacturing of Gabion or equivalent System and the lacing wire shall have a tensile strength of (38-48 kg / mm²) in accordance with ASTM A 641-97.

b) Elongation: The test must be carried out on a sample at least 30 cm long.

Elongation shall be less than 10% in accordance with ASTM A 370-92.

c) Zinc coating: Minimum quantities of zinc according to ASTM A 641-97 Class III soft temper coating.

d) Adhesion of Zinc coating: The adhesion of the zinc coating to the wire shall be such that, when the wire is wrapped six turns around a mandrel having four times the diameter of the wire, it does not flake or crack when rubbing it with the bare fingers, in accordance with ASTM A 641-97.

ii. **PVC (Polyvinyl Chloride) coating**

a) Specific gravity: 1.30-1.35 kg / m3 in accordance with ASTMD 792 Table 1.

b) Hardness: Between 50 and 60 shore D, according to ASTM D 2240.

c) Tensile strength: not less than 20.6 Mpa according ASTMD 412-92.

d) Modulus of elasticity: Not less than 18.6 Mpa according to ASTM D 412-92.

e) Abrasion resistance: The percentage of the weight loss shall not be less than 12%, according to ASTM D1242-92.

f) Creeping corrosion: The percentage of corrosion of the wire from a square cut end shall be less than 25 mm when the specimen has been measured for 2000 hrs in a 5% solution of HCl (hydrochloric acid 12 Be)

iii. **Accelerated aging test**

a) Salt spray test: Test period 3,000 hours, test method ASTM B117-94.

b) Exposure of UV rays: Test period 3,000 hours at 63°C, test method ASTM D1499-92a and ASTM G 23-93 apparatus Type E.

c) Brittleness temperature: No higher than -9°C, when tested accordance with ASTM D746.

The properties after aging test shall be as follows:

d) Appearance of coated mesh: no cracking, stripping or air bubbles, and no appreciable variation in colour.

e) Specific Gravity: variation shall not exceed 6%.

f) Hardness: variations shall not exceed 10%.

g) Tensile strength: variations shall not exceed 25%.

h) Modulus of elasticity: variation shall not exceed 25%.

i) Abrasion resistance: variation shall not exceed 10%.

j) Brittleness temperature shall not exceed 18°C.

iv. **Galvanized and PVC coated wire mesh (8 x 10 mesh type)**

a) PVC coating thickness: Nominal 0.5 mm, minimum 0.38 mm

b) Mesh Wire: Diameter 2.77 mm internal, 3.70 mm external

c) Selvedge Wire: Diameter 3.40 mm internal, 4.40 mm external

d) Mesh Opening: Nominal Dimension D = 80 mm

v. **Galvanized and PVC coated lacing wire and internal stiffeners**

a) PVC coating thickness: Nominal 0.5 mm, minimum 0.38 mm

b) Lacing wire: Diameter 2.20 mm internal, 3.20 mm external

c) Stiffener Wire: Diameter 2.20 mm internal, 3.20 mm external

The procedure for using lacing wire consists of cutting a sufficient length of wire (+ / - 1.0m), and first looping and / or twisting the lacing wire to the wire mesh. Proceed to lace with alternating double and single loops through every mesh opening approximately every 150 mm, pulling each loop tight and finally securing the end of the lacing wire to the wire mesh by looping and / or twisting.

Sub-Clause A-1.7.1 **Tolerances**

Wire Zinc coating in accordance with ASTM A641-97 Class III soft temper coating.

Gabion unit: ± 5% on the length, width, and height Mesh opening Tolerances on the hexagonal, double twisted wire mesh opening shall not exceed 16% and 4% on the nominal dimension D values.

Sub-Clause A-1.8 **Standard Codes**

ASTM A 641-97 Specification for Zinc Coated (Galvanized) Carbon Steel Wire.

ASTM A 370-92 Test Methods and definitions for Mechanical Testing of Steel Products

ASTM A 90-93 Test Method for Weight (Mass) of Coating on Iron and Steel Articles with Zinc or Zinc Alloy Coating

ASTM A 313-92 Specification for Chromium- Nickel stainless and Heat resisting steel springs wire

ASTM A 764-93 Specification for Steel Wire, Carbon, Drawn Galvanized and Galvanized at size for Mechanical springs

Sub-Clause A-1.9 **Construction Technique**

Sub-Clause A-1.9.1 **Assembly**

The Gabion units are supplied folded flat and packed in bundles. The facing section of the units are assembled individually by erecting the sides, back, ends, and diaphragm, ensuring that all panels are in the correct position, and the tops of all sides are satisfactorily aligned. The four corners of the basket shall be connected first, followed by the internal diaphragm to the outside walls. All connections shall be made using lacing wire or ring fasteners.

The use of ring fasteners shall be done in accordance with the manufacturer's recommendations.

Sub-Clause A-1.9.2 **Installation**

Prior to installing the assembled gabion unit system, the foundation on which the units are to be placed shall be cut or filled and graded to the lines and grades shown in the drawings. Surface irregularities, loose material, and vegetation shall be removed during the preparation of the foundation.

Sub-Clause A-1.9.3 **Filling of Gabion Units**

The gabion units or boxes shall be assembled individually by erecting sides, back, ends and diaphragms, ensuring that all panels are in the correct position, and the tops of all sides are satisfactorily aligned. The four corners of the box shall be connected first, followed by the internal diaphragm to the out side walls. All connections shall be made using lacing wire.

Prior to installing the assembled units, the foundation on which the Gabion wall is to be placed shall be cut or filled, compacted and graded to the lines and grades

shown in drawings as per Section 300. Surface irregularities, loose material and vegetation shall be removed during the preparation of the foundation.

The gabion units shall be carried to their final position and connected with adjoining empty units, along the vertical and top edges of their contact surfaces as per manufacturers recommendations or as directed by the Engineer. When a structure requires more than one layer of units, the upper layer shall be connected to the top of the lower layer along the front and back edges as per manufacturer's recommendations or as directed by the Engineer.

Then boxes shall be filled with rock as specified in Clause A-8.3.3 During the filling operation some manual stone placement is required to minimize voids. For vertical or near vertical structures the exterior of the box shall be carefully hand placed to give a neat, flat and compact appearance. Care shall be taken when placing fill material to assure that the sheathing of the PVC coated box will not be damaged.

The boxes shall be filled in stages so that local deformation may be avoided. That is, at no time shall any box be filled to a depth exceeding 300 mm higher than that of the adjoining cell. It is also recommended to slightly overfill the boxes to allow for settlement of the rock.

Sub-Clause A-1.9.4 **Internal Connecting Wires**

Internal connecting wires shall be used when a structure requires gabion unit layers to be stacked on top of each other. Internal Connecting Wires shall connect the exposed face of a unit to the opposite side of the unit. An exposed face is any side of a unit that will be exposed or unsupported after the structure is completed. In this respect, lacing wire shall be used.

Connecting wire shall be installed after filling of each layer of 300 mm or 250 mm as the case may be.

Sub-Clause A-1.9.5 **Placement of the backfill**

Prior to starting this operation a non-woven geotextile filter shall be placed at the facing section and backfill interface. The characteristics of the non-woven geotextile shall be as specified by the Engineer. The geotextile should have a 500 mm return at both top and bottom.

The granular backfill shall be done in lifts of approximately 300 mm. Compacting is to proceed parallel to the wall, ensuring that the compacting machine does not within 1000 mm of the rear of the face section. The homogeneity of the backfill and the level of compaction required shall be ensured.

Sub-Clause A-1.9.6 **Lid Closing**

Once the boxes are completely full, the lids shall be pulled tight until the lid meets the parameter edges of the box. The lid must then be tightly laced and / or fastened along all edge ends, and tops as shown in approved drawings.

CLAUSE A-2 **CONSTRUCTION OF GABION WIRE MESH SYSTEM**

This work shall consist of providing and laying factory manufactured gabion with wire mesh of approved design, filled with approved rock fill, structural backfill with lids closed all as per design, drawings and Technical Specifications and as approved by the Engineer.

Sub-Clause A-2.1 **General**

The Contractor shall be required to provide complete design including its foundation and details engineering with working drawing in required numbers. This shall be supported by certificate from the supplier of gabions that he has proven experience in supplying and placing gabions for major highway projects and providing technical backup using in house facilities.

Gabion Wire Mesh System being a specialised work, the Contractor shall ensure expert supervision by specialist from the technology provider time to time.

The Gabion wall shall be designed with the given specification using proven system design certified with ISO 9001 / 2 or equivalent as approved by the Engineer. The designer may adopt system design for Gabion wall following any proprietary patented technique.

No extra cost either for patent or any design or expert supervision shall be made to the Contractor.

Sub-Clause A-2.2 **Glossary**

a) Double Twisted Wire Mesh: A non-ravelling mesh made in mechanically twisting continuous pars of wires through three and half turn (commonly called double twisted) which are then interconnected in the adjacent wires to form hexagonal shaped openings.

b) Mesh Size: The average distance measured at right angles between twisted sides over meshes.

c) Selvedge wire: Terminal wire used to edge the wire mesh perpendicular to the double twist by mechanically wrapping the mesh wires around it at least 2.5 times.

d) Edge wire: Terminal wire used to edge the wire mesh parallel to the double twist by continuously weaving at mechanically into the wire mesh.

e) Lacing wire: The Zinc + PVC coated metallic wire which interconnects empty units, closes and secure stone filled units.

f) Stiffener: A length of Zinc Coated steel wire used for support of facing by connecting the front panel to the back or side panel of a gabion or across the corners of gabion cell. Stiffener formed at the project site is of wire having the same diameter as for the lacing wire.

g) Geosynthetic: Geosynthetic is a general classification for all synthetic material used in geotechnical engineering applications. It includes geotextiles and geonets. The material shall be as per Section 700.

Sub-Clause A-2.3 **Materials**

Sub-Clause A-2.3.1 **Wires:** - All wires shall be galvanised and PVC coated. The following shall be the diameter of different types of wires.

a. **Mesh Wire:** - Internal diameter 2.77 mm and external diameter 3.70 mm.

b. **Selvedge Wire:** - Internal diameter 3.20 mm and external diameter 4.20 mm.

c. **Lacing Wire:** Internal diameter 2.2 mm and external diameter 3.20 mm.

d. **Stiffener Wire:** - Internal diameter 2.2 mm and external diameter 3.20 mm.

Sub-Clause A-2.3.2 **Mesh:** - The Mesh of the box and reinforcing wire mesh panel shall be hexagonal in shape with opening size 80 x 100 as shown in the drawings.

Sub-Clause A-2.3.3 **Box:** - The box size shall not be larger than 3 m x 1.5 m x 1 m nor smaller than

x 1 m x 1 m. Wherever the length of the box is more than 1.5 m diaphragms are to be provided such that nowhere the continuous length of the box is more than 1.5 m. Diaphragms shall be manufactured of the same material as the parent gabion and have selvedge wire through out their perimeter.

Sub-Clause A-2.4 **Fabrication**

Wire mesh unit similar to Gabion unit shall be manufactured with all components mechanically connected at the production facility. The external face, reinforcing panel, and lid of the Wire mesh shall be woven into a single unit. The ends, back, and diaphragm shall be factory connected to the base. All perimeter edges of the mesh forming the basket shall be selvedged with wire having larger diameter

The facing element of a unit is divided into two cells by means of a diaphragm positioned at approximately 1 m centres. The diaphragm shall be secured in position to the base so that no additional lacing is necessary at the job-site.

The procedure for using lacing wire consists of cutting a sufficient length of wire (+ / - 1.0m), and first looping and / or twisting the lacing wire to the wire mesh. Proceed to lace with alternating double and single loops through every mesh opening approximately every 150 mm, pulling each loop tight and finally securing the end of the lacing wire to the wire mesh by looping and / or twisting.

Sub-Clause A-2.5 **Rock Fill**

Rock for the facing section of a Wire Mesh unit shall be hard, angular to round, durable and of such quality that it shall not disintegrate on exposure to water or weathering during the life of the structure. The rocks shall range between 150 mm and 300 mm. The range in sizes shall allow for a variation of 5% oversize and/or 5% undersize rock, provided that it is not placed on the exposed surface. The size shall be such that a minimum of three layers of rock must be achieved when filling the 1 m high unit and a minimum of two layers for the 0.6 m high units

Sub-Clause A-2.6 **Backfill Material**

Backfill Material shall be made of a good quality free draining, granular and / or selected fill and shall be Mechanically Stabilised. The recommended soil gradation is in the range of 0.02 mm to 6 mm or as indicated by AASHTO T-27 and FHWA Demo 82. Soils outside of this range may be suitable subject to the approval of the Engineer.

Sub-Clause A-2.7 **Tests**

All following tests on the mesh and lacing wire must be performed prior to manufacturing the mesh:

i. **Wire**

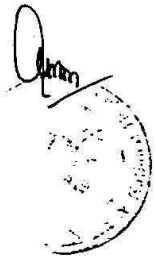
a) Tensile Strength: The wire used for manufacturing of Gabion or equivalent System and the lacing wire shall have a tensile strength of (38-48 kg / mm2), in accordance with ASTM A 641-97.

b) Elongation: The test must be carried out on a sample at least 30 cm long. Elongation shall be less than 10% in accordance with ASTM A 370-92.

c) Zinc coating: Minimum quantities of zinc according to ASTM A 641-97 Class III soft temper coating.

d) Adhesion of Zinc coating: The adhesion of the zinc coating to the wire shall be such that, when the wire is wrapped six turns around a mandrel having four times the diameter of the wire, it does not flake or crack when rubbing it with

the bare fingers, in accordance with ASTM A 641-97.



ii. **PVC (Polyvinyl Chloride) coating**

a) Specific gravity: 1.30-1.35 kg / m3 in accordance with ASTMD 792 Table 1.

b) Hardness: Between 50 and 60 shore D, according to ASTM D 2240.

c) Tensile strength: not less than 20.6 Mpa according ASTMD 412-92.

d) Modulus of elasticity: Not less than 18.6 Mpa according to ASTM D 412-92.

e) Abrasion resistance: The percentage of the weight loss shall not be less than 12%, according to ASTM D1242-92.

f) Creeping corrosion: The percentage of corrosion of the wire from a square cut end shall be less than 25 mm when the specimen has been measured for 2000 hrs in a 5% solution of HCl (hydrochloric acid 12 Be)

iii. **Accelerated aging test**

a) Salt spray test: Test period 3,000 hours, test method ASTM B117-94.

b) Exposure of UV rays: Test period 3,000 hours at 630C, test method ASTM D1499-92a and ASTM G 23-93 apparatus Type E.

c) Brittleness temperature: No higher than -9oC, when tested accordance with ASTM D746.

The properties after aging test shall be as follows:

a) Appearance of coated mesh: no cracking, stripping or air bubbles, and no appreciable variation in colour.

b) Specific Gravity: variation shall not exceed 6%.

c) Hardness: variations shall not exceed 10%.

d) Tensile strength: variations shall not exceed 25%.

e) Modulus of elasticity: variation shall not exceed 25%.

f) Abrasion resistance: variation shall not exceed 10%.

g) Brittleness temperature shall not exceed 18^0C.

iv. **Galvanized and PVC coated wire mesh (8 x 10 mesh type)**

a) PVC coating thickness: Nominal 0.5 mm , minimum 0.38 mm

b) Mesh Wire: Diameter 2.77 mm internal, 3.70 mm external

c) Selvedge Wire: Diameter 3.40 mm internal, 4.40 mm external

d) Mesh Opening: Nominal Dimension D = 80 mm

v. **Galvanized and PVC coated lacing wire and internal stiffeners**

a) PVC coating thickness: Nominal 0.5 mm, minimum 0.38 mm

b) Lacing wire: Diameter 2.20 mm internal, 3.20 mm external

c) Stiffener Wire: Diameter 2.20 mm internal, 3.20 mm external

The procedure for using lacing wire consists of cutting a sufficient length of wire (+ / - 1.0m), and first looping and / or twisting the lacing wire to the wire mesh. Proceed to lace with alternating double and single loops through every mesh opening approximately every 150 mm, pulling each loop tight and finally securing the end of the lacing wire to the wire mesh by looping and / or twisting.

Sub-Clause A-9.7.1 **Tolerances**

Wire Zinc coating in accordance with ASTM A641-97 Class III soft temper coating.

Gabion unit: ± 5% on the length, width, and height Mesh opening Tolerances on the hexagonal, double twisted wire mesh opening shall not exceed 16% and 4% on the nominal dimension D values.

Sub-Clause A-2.8 **Standard Codes**

ASTM A 641-97 Specification for Zinc Coated (Galvanized) Carbon Steel Wire.

ASTM A 370-92 Test Methods and definitions for Mechanical Testing of Steel Products

ASTM A 90-93 Test Method for Weight (Mass) of Coating on Iron and Steel Articles with Zinc or Zinc Alloy Coating

ASTM A 313-92 Specification for Chromium- Nickel stainless and Heat resisting steel springs wire

ASTM A 764-93 Specification for Steel Wire, Carbon, Drawn Galvanized and Galvanized at size for Mechanical springs

Sub-Clause A-2.9 **Construction Technique**

Sub-Clause A-2.9.1 **Assembly**

Wire mesh units are supplied folded flat and packed in bundles. The facing section of the units are assembled individually by erecting the sides, back, ends, and diaphragm, ensuring that all panels are in the correct position, and the tops of all sides are satisfactorily aligned. The four corners of the basket shall be connected first, followed by the internal diaphragm to the outside walls. All connections shall be made using lacing wire or ring fasteners.

The use of ring fasteners shall be done in accordance with the manufacturer's recommendations.

Following assembly of the facing section the reinforcing panel shall be unfolded to the required length behind the facing section and the shipping folds removed. They can be removed by placing the fold over a 2" x 4" (5 cm x 10 cm) steel board and walking along the sides.

Sub-Clause A-2.9.2 **Installation**

Prior to installing the assembled Wire mesh system units, the foundation on which the units are to be placed shall be cut or filled and graded to the lines and grades shown in the drawings. Surface irregularities, loose material, and vegetation shall be removed during the preparation of the foundation.

The Wire mesh system units are carried to their final position and connected with the adjoining empty units along the vertical and top edges of their contact surfaces using the same connecting procedure(s) described before. Whenever a structure requires more than one layer of units, the upper layer shall be connected to the top of the lower layer along the front and back edges of the contact surface using the same connecting procedure(s) described before.

Sub-Clause A-2.9.3 **Filling of Facing Section**

The facing section shall be filled with rock as specified. During the filling operation manual stone placement is required to minimize voids. For vertical or near vertical structures the exterior of the basket may be carefully hand placed to

give a neat, flat, and compact appearance. Care shall be taken when placing fill material to ensure that the sheathing on the PVC coated baskets will not be damaged. The cells shall be filled in stages so that local deformation may be avoided. That is, at no time shall any cell be filled to a depth exceeding 1-foot (0.30 m) higher than the adjoining cell. It is also recommended to slightly overfill the baskets to allow for settlement of the rock.

Sub-Clause A-2.9.4 **Internal Connecting Wires**

Internal connecting wires shall be used when a structure requires layers to be stacked on top of each other. Internal Connecting Wires shall connect the exposed face of a unit to the opposite side of the unit. An exposed face is any side of a unit that will be exposed or unsupported after the structure is completed. In this respect, lacing wire shall be used.

Connecting wire shall be installed after filling of each layer of 300 mm or 250 mm as the case may be.

Sub-Clause A-2.9.5 **Placement of the Structural backfill**

Prior to starting this operation a geotextile filter shall be placed at the facing section and backfill interface. The characteristics of the geotextile shall be as specified by the Engineer. The geotextile should have a 300 mm return at both top and bottom.

The granular backfill shall be installed in lifts of approximately 300 mm and dumped in the middle section of the anchor mesh panel Compacting is to proceed parallel to the wall, ensuring that the compacting machine does not come in contact with the mesh panel or within 1000 mm of the rear of the face section. The homogeneity of the backfill and the level of compaction required shall be ensured.

Sub-Clause A-2.9.6 **Lid Closing**

Once the boxes are completely full, the lids shall be pulled tight until the lid meets the parameter edges of the box. The lid must then be tightly laced and / or fastened along all edge ends, and tops as shown in approved drawings.

Sub-Clause A-2.9.7 **Mesh Cutting and Folding**

Where shown on the drawings or otherwise directed by the engineer, the Wire Mesh System may be cut, folded and fastened together to suit existing site conditions. The mesh must be cleanly cut and surplus mesh either folded back or overlapped so that it can be securely fastened together with lacing wire or fasteners. Any reshaped Wire Mesh System shall be assembled, installed, filled and closed as specified in the previous sections.

CLAUSE A-3 GROUTED DOWELS FOR SLOPE STABILITY AND PROTECTION WORKS

Sub-Clause A-3.1 **Scope**

This work shall consist of furnishing, drilling, installing and grouting of dowels in conformity with the dimensions, lines and grades shown on the plans, or as determined by the engineer. The work shall generally be done in conformity to BS: 8006 Specifications.

Sub-Clause A-3.2 **Material Property Requirements**

Sub-Clause A-3.2.1 **Dowel Rod**

It shall be essentially a steel bar of 32 mm diameter and of required length inserted into a predrilled hole and then grouted so that there is no empty space between t

hole wall and the dowel surface. The metal used for the production of the dowel shall conform to (BS4449:1997) High Yield Deformed - Steel having a Yield strength of 460 MPa to 500 MPa, and a Rupture strength of 600 MPa.

Sub-Clause A-3.2.2 **Water**

As per Appendix – 1800/III **(All appendices have references to MORT&H Specifications for Road and Bridge Works)**

Sub-Clause A-3.2.3 **Cement**

As per Appendix – 1800/III

Sub-Clause A-3.2.4 **Sand**

As per Appendix – 1800/III

Sub-Clause A-3.2.5 **Admixtures**

As per Appendix – 1800/III

Sub-Clause A-3.2.6 **Grout**

As per Appendix – 1800/III

Sub-Clause A-3.3 **Equipment**

The following equipment shall be used for the purposes of drilling and grouting dowels.

Sub-Clause A-3.3.1 **Drilling Equipment**

Drilling of holes is commonly done by a rotary or rotary percussion handheld or remotely operated drill equipment. It must be capable of providing a stable drill hole having dimensions within the permitted tolerance and which is free of obstructions or major protrusions so that the bar can be inserted without undue resistance.

Sub-Clause A-3.3.2 **Grout Mixer and Agitator**

As per Appendix – 1800/III

Sub-Clause A-3.3.3 **Grout Pump**

As per Appendix – 1800/III

Sub-Clause A-3.3.4 **Water Pump**

As per Appendix – 1800/III

Sub-Clause A-3.3.5 **Grout Screen**

As per Appendix – 1800/III

Sub-Clause A-3.3.6 **Connections and Air Vents**

As per Appendix – 1800/III

Sub-Clause A-3.4 **Construction and Installation Requirements**

Sub-Clause A-3.4.1 **Drilling**

The drill holes for rock dowels are commonly produced by a rotary or rotary percussion mechanism with air or water used as flushing medium. The drilling machine or technology employed may be handheld or remotely operated drill rigs. The diameter of drill hole shall be minimum 25 mm larger than dowel diameter.

Sub-Clause A-3.4.2 **Installation of Dowel**

The boreholes are cleaned by flushing with compressed air or water. The dowel is inspected for damages or corrosion, immediately prior to installation. The dowels of required lengths are inserted into the hole till it touches the hole end.

Sub-Clause A-3.4.3 **Grouting**

Grout shall be injected to fill the hole completely. This will be ensured when the grout of the same consistency comes out of the hole. In case the length of dowel protrudes from the hole, it shall be covered by concrete by hand packing.

CLAUSE A-4 GROUTED ROCK BOLTS FOR SLOPE STABILITY AND PROTECTION WORKS

Sub-Clause A-4.1 **Scope**

This work shall consist of furnishing, drilling, installing and grouting of rock bolts, in conformity with the dimensions, lines and grades shown on the plans, or as determined by the engineer. The work shall generally be done in conformity to the BS: 8006 Specifications.

Sub-Clause A-4.2 **Material Property Requirements**

Sub-Clause A-4.2.1 **Mechanical Shell Anchor**

It is a mechanically anchored bar 32 mm nominal diameter and 12 m long. With an expansion shell anchor, a wedge attached to the shank is pulled into a conical shell forcing it to expand against the walls of the drill hole.

The metal used for the production of the rock bolts shall conform to BS 4449:1997 High Yield - Steel having Rupture Strength of 600 MPa.

The bar must be threaded at the proximal end to allow tensioning of the bolt and for a nut and faceplate to be attached.

Sub-Clause A-4.2.2 **Water**

As per Appendix – 1800/III

Sub-Clause A-4.2.3 **Cement**

As per Appendix – 1800/III

Sub-Clause A-4.2.4 **Sand**

As per Appendix – 1800/III

Sub-Clause A-4.2.5 **Admixtures**

As per Appendix – 1800/III

Sub-Clause A-4.2.6 **Grout**

As per Appendix – 1800/III

Sub-Clause A-4.3 **Equipment**

The following equipment shall be used for the purposes of drilling and grouting anchored bolts.

Sub-Clause A-4.3.1 **Drilling Equipment**

Drilling of holes is commonly done by a rotary or rotary percussion handheld or remotely operated drill equipment. It must be capable of providing a stable drill hole having dimensions within the permitted tolerance and which is free of

obstructions or major protrusions so that the bar can be inserted without undue resistance.

Sub-Clause A-4.3.2 **Grout Mixture And Agitator**

As per Appendix – 1800/III

Sub-Clause A-4.3.3 **Grout Pump**

As per Appendix – 1800/III

Sub-Clause A-4.3.4 **Water Pump**

As per Appendix – 1800/III

Sub-Clause A-4.3.5 **Grout Screen**

As per Appendix – 1800/III

Sub-Clause A-4.3.6 **Connections and Air Vents**

As per Appendix – 1800/III

Sub-Clause A-4.4 **Construction and Installation Requirements**

Sub-Clause A-4.4.1 **Drilling**

The drill holes for rock bolts are commonly produced by a rotary or rotary percussion mechanism with air or water being used as flushing medium. The drilling machine or technology employed may be handheld or remotely operated drill rigs.

Sub-Clause A-4.4.2 **Installation of Rock bolt**

The boreholes are cleaned by flushing with compressed air or water. The rock bolt is inspected for damages or corrosion, immediately prior to installation.

The rock bolts are driven into the hole until the expansion shell reaches the hole end and an initial tension is applied by tightening the bolt so that the wedge shaped blades are held stationary against the hole wall. A steel plate 250 x 250 x 10 mm thick with a conical washer shall be inserted on to the bolt on the face of the rock. Rock bolts shall be tensioned either directly, using hydraulic jacks or indirectly by applying a measured torque to the locking nut. The load is transferred from the rock bolt via threaded nuts onto the face plate.

Sub-Clause A-4.4.3 **Grouting**

Grouting shall be injected through the grout inlet tube to fill the hole completely. This will be ensured when the grout of the same consistency comes out the grout return tube.

Sub-Clause A-4.4.4 **Stressing and Testing**

The hydraulic jacks and pumping unit should be capable of tensioning the rock bolt tendon to not less than 80% of characteristics of the shank. Typically between 1% to 5% of the bolts should be checked with hydraulic jack. The method of tensioning, the sequence of stressing and procedures to be adopted for each stressing operation is as per specified or according to the Engineer.

CLAUSE A-5 **CONTROL BLASTING**

Sub-Clause A-5.1 **General**

The specifications for excavation in rock are covered by MORT&H "Specifications for Road & Bridge Works" vide Section 300. The following specifications are additional and supplementary to the same.

Sub-Clause A-5.2 **Control Blasting**

Whenever required by the Engineer, the rock blasting shall be controlled so that vibration generated during the blasting do not cause damage to the building and installation around built up areas. Similarly, the rock pieces should not fly off the pits and thus damage the buildings and installation and life and limb of people around. Apart from the general precautions mentioned in the MORT&H Specifications, following protective measures and limits for use of explosives are suggested as guidelines.

Sub-Clause A-5.3 **Protective Measures**

(a) Short delay blasting with light charges shall be used.

(b) The blast hole shall be covered with 0.6 to 1.0 sqm. Mild steel plate of minimum 6 mm thickness.

(c) Reinforcement rod mesh not less than 20 mm dia at 150 mm centers in both directions shall be placed over the steel plates.

(d) Steel plate and reinforcements shall be inspected after every blasting operation and all twists shall be removed before reuse to the satisfaction of the Engineer.

(e) The thickness of the covering plate and the kind of dead weight is to be duly approved by the Engineer.

When blasting is necessary adjacent in partially of completely built structures the contractor shall take all precautions necessary to prevent flying rock from causing damage to the structures.

Sub-Clause A-5.4 **Blasting Within Certain Limits**

No blasting shall be allowed for any of the excavation until freshly placed concrete of nearby structures has reached a minimum strength of 7 MPa.

Normally, blasting shall be resorted to only after 7 days of concreting work in case of OPC (10 days in case of PPC) in adjacent structures.

In no case shall blasting be allowed closer than 15m to any structure after concrete placing has started.

When minor blasting is necessary after concrete placing has started in any structure, the maximum size of charge for distance from 100m and above shall be limited to the following:

Distance in m	Safe particle velocity 10 mm/sec Charge in kg per delay	Safe particle velocity 3 mm/sec Charge in kg per delay.
100	10.7	2.6
150	24.2	5.8
200	43.0	10.3
250	67.3	16.7
300	96.9	23.2
350	131.9	31.6
400	172.3	41.2
450	218.2	52.2
500	269.3	64.5

Any deviation in the above-recommended limits will be adopted only after the specific approval of the Engineer. The contractor shall submit the scheme with charges and delays he proposed to use for blasting, for approval of the Engineer.

It is generally recommended that where the blasting is to be done, within 20 m of the nearest point of permanent building, the area shall be line drilled on periphery before blasting.

The Contractor shall be responsible for all damage caused by blasting whether to permanent or temporary structures and shall replace or repair the structures at his own cost.

Sub-Clause A-5.5 **Precautions after Blasting**

After the blast, the supervisor must carefully inspect the work and satisfy himself that all the charges have exploded. After the blast takes place in underground works, the workmen shall not be allowed to go to the face till toxic gases have disappeared from the face.

If it is suspected that part of the blast has failed to fire or is delayed, sufficient time shall be allowed to elapse before entering the danger zone. When fuse and blasting caps are used, a safe time should be allowed and then the supervisor alone shall leave the shelter to inspect the blasting zone.

None of the drillers are to work near the misfired hole until one of the two following operations have been carried out by the Supervisor:

Either (i) the Supervisor should very carefully (when the tamping is of damp clay) extract the tamping with a wooden scraper or jet of water or compressed air (using a pipe of soft material) and withdraw the fuse with the primer and a fresh detonator with fuse should be placed in these holes and fired out, or (ii) the hole may be cleared of 30 cm of tamping and its direction then be ascertained by placing a stick in the hole. Another hole may then be drilled at least 60 centimeters away and parallel to it and about 30 cm less in depth, this hole shall them be charged and fired. The balance of the cartridges and detonators found in the muck shall be removed.

Before leaving his work, the Supervisor of the concluding shift shall inform the Supervisor of the relieving shift of any case of misfires and should point out the position with a red cross denoting the same and also stating what action, if any, he has taken in the matter.

The Supervisor should also at once report at the office of the Contractor and the Engineer all cases of misfire, the cause of the same and what steps were taken in connection with these.

The names of the day and night shift Supervisors must be noted daily in the Contractor's office.

If a misfire has been found to be due to a defective detonator of dynamite the whole quantity or box from which the defective article was taken, must be thoroughly inspected by the Contractor.

Drilling in holes not completely exploded by blasting shall not be permitted.

Sub-Clause A-5.6 **Personnel**

Excavation by blasting will be permitted only under the personal supervision of competent and licensed blasters and trained workmen.

All supervisors and workmen in-charge of preparation, handling, storage and blasting work shall be adequately insured by the Contractor.

Storage shall be in charge of a very reliable person approved by the Engineer, who may, if necessary conduct police enquiries as to his reliability, antecedents etc. The contractor shall have to produce a security for the person in-charge of the explosives, if and when required by the Engineer, of the civil authorities of the district.

The Contractor shall make sure that his supervisors and workmen are fully conversant with all the rules to be observed in storing, handling and use of the explosives. It shall be ensured that the supervisors in charge are thoroughly acquainted with the details of the handling of explosives and blasting operations.

CLAUSE A-6 TEMPORARY BARRICADING FOR STOPPAGE OF CUT MATERIAL FROM SPREADING ON THE ROAD

Sub-Clause A-6.1 Description

The work shall consist of fabricating, supplying and erecting at site the Mild Steel Barricading, including painting a coat of steel primer and two coat of synthetic enamel paint conforming to Additional Technical Specifications Clause A-7, removing, carriage and re-erecting at other desired locations the Mild Steel Barricades complete as per Drawings and as directed by the Engineer. The units shall be kept always in working conditions. The repair/ replacement of any member shall be the responsibility of the contractor. The payment shall be made for quantity executed upto 1050 m. In case more quantity is required or provided over the quantity taken in the BOQ the same shall be incidental to the work.

During construction activities for widening of road on hillside, the contractor shall provide rock fall fencing and deepen and widen the existing hillside drain to arrest the falling materials from coming to road surface. The fencing shall be of type as shown in the drawing or as directed by the Engineer for safety of road users and workers. After the completion of the work, the temporary fencing shall be shifted or removed according to necessity. All works towards clearing accumulated debris arrested by fencing regularly, deepening and widening of existing drain etc. shall be considered incidental to the work.

Sub-Clause A-6.2 Materials

The barricading shall be made of M.S. Structural Steel as per the drawing and approved by the Engineer.

Sub-Clause A-6.3 Fabrication

The temporary barricading shall be factory manufactured as per the drawings.

The work shall conform to the following sections of MORT&H Specifications.

Excavation in foundations Section 300

Structural concrete Section 1700

Structural Steel Section 1900

Sub-Clause A-6.4 Fixing at Site

Sub-Clause A6.4.1 Erection

The Temporary Barricading units shall be erected true to the levels, grades and verticality. They shall be secured to the foundation by mean of foundation bolts.

cement concrete. The lateral support shall be provided by the steel anchor stay wires (wherever required) which shall be fixed to the rock / ground by means of spikes and nails. Various units shall be jointed together by means of bolts and nuts as shown on the drawing.

Sub-Clause A6.4.2 **Reuse**

The temporary barricades shall be put to reuse wherever required. To do so, the foundation nuts and spikes of stay wire shall be removed and the units fixed at the desired location as per Sub-Clause A-15.4.1 above.

Sub-Clause A-6.5 **Measurements for Payment**

The temporary barricades shall be measured in numbers for the new supply and erection.

The re-erection shall be measured in linear meters.

Sub-Clause A-6.5.1 **Salvage Value**

The contractor shall take back these temporary barricades in full quantities after the completion of the project or earlier as per direction of the Engineer by paying at the rate of 50% of his quoted rate or Rs. 8,500/- per number, whichever is more as salvage value to the Employer. Recovery for the salvage value shall be made in Final Payment certificate. These temporary units shall not be used in any permanent work in the project."

Sub-Clause A-6.6 **Rate**

The contract unit rate for supplying the complete barricading unit as per drawing will include the fabrication, applying a coat of approved steel primer, two coats of synthetic enamel as per Additional Technical Specifications Clause A-7, supplying steel stay wires, spikes, nails and foundations bolts etc; as per item no. 2.10 of BOQ.

The contract unit rate for erecting the temporary barricades will include initial erection, including founding and fixing stay wire etc, removal of barricading units, spikes and nails, stay wire and cutting foundation bolts and re-erecting at desired locations in proper foundations with foundation bolts and stay wires etc. including maintenance and replacement of damaged parts and bringing the unit to working conditions to the satisfaction of the Engineer, as per item no 2.11 of BOQ.

CLAUSE A-7 **TEMPORARY BARRICADING STRUCTURAL SHED FOR TRAFFIC PROTECTION DURING HILL CUTTING**

Sub-Clause A-7.1 **Description**

The work shall consist of fabricating, supplying and erecting at site the Mild Steel Temporary Barricading Structural Shed for the protection of traffic during hill cutting, including painting a coat of steel primer and two coat of synthetic enamel paint conforming to Additional Technical Specifications Clause A-7, removing, carriage and re-erecting at other desired locations the Mild Steel Temporary Barricading Structural Shed complete as per Drawings and as directed by the Engineer. The units shall be kept always in working conditions. The repair/ replacement of any member shall be the responsibility of the contractor. The payment shall be made for quantity executed upto 400 m. In case more quantity is required or provided over the quantity taken in the BOQ the same shall be incidental to the work.

During construction activities for widening of road on hillside, the contractor shall provide Mild Steel Temporary Barricading Structural Shed to protect the traffic

plying on existing road at the location where hill cutting is in progress from the falling stones. The Mild Steel Temporary Barricading Structural Shed shall be of type as shown in the drawing or as directed by the Engineer for safety of road users and workers. After the completion of the work, the Mild Steel Temporary Barricading Structural Shed shall be shifted or removed according to necessity. All works towards clearing accumulated debris arrested by shed or accumulated by road side regularly, deepening and widening of existing drain etc. shall be considered incidental to the work.

Sub-Clause A-7.2 **Materials**

The barricading shall be made of M.S. Structural Steel as per the drawing and approved by the Engineer.

Sub-Clause A-7.3 **Fabrication**

The temporary barricading shall be factory manufactured as per the drawings.

The work shall conform to the following sections of MORT&H Specifications.

Excavation in foundations Section 300

Structural concrete Section 1700

Structural Steel Section 1900

Sub-Clause A-7.4 **Fixing at Site**

Sub-Clause A-7.4.1 **Erection**

The Temporary Barricading units shall be erected true to the levels, grades and verticality. They shall be secured to the foundation by mean of foundation bolts in cement concrete..

Sub-Clause A-7.4.2 **Reuse**

The temporary barricades shall be put to reuse wherever required. To do so, the foundation concrete, nuts and bolts shall be removed and the units fixed at the desired location as per Sub-Clause A-16.4.1 above.

Sub-Clause A-7.5 **Measurements for Payment**

The temporary barricades shall be measured in numbers for the new supply and erection.

The re-erection shall be measured in linear meters.

Sub-Clause A-7.5.1 **Salvage Value**

The contractor shall take back these temporary barricades in full quantities after the completion of the project or earlier as per direction of the Engineer by paying at the rate of 50% of his quoted rate or Rs. 1,78,500/- per number, whichever is more as salvage value to the Employer. Recovery for the salvage value shall be made in Final Payment certificate. These temporary units shall not be used in any permanent work in the project."

CLAUSE A-8 **ROCK NET**

Sub-Clause A-8.1 **General**

This work shall consist of providing and fixing factory manufactured wire mesh of approved size, design nailed to rock surface as per approved design, drawings and Technical Specifications and as approved by the Engineer.

SHRI TUNNELWAY LIMITED CHENNAI NASHRI

The Contractor shall be required to provide complete design including its nailing and detailed engineering with working drawings in required locations. This shall be supported by certificate from the supplier of rock net that he has proven experience in supplying and fixing rock net for major highway projects and providing technical backup using in-house facilities.

Rock netting being a specialised work, the Contractor shall ensure expert supervision by specialist from the technology provider from time to time.

The rock net shall be designed with the given specification using proven system design certified with ISO 9001 / 2 or equivalent as approved by the Engineer. The designer may adopt system design for rock netting following any proprietary patented technique.

No extra cost either for patent or any design or expert supervision shall be made to the Contractor.

Sub-Clause A-8.2 **Glossary**

a) Double Twisted Wire Mesh: A non-ravelling mesh made in mechanically twisting continuous pars of wires through three and half turn (commonly called double twisted) which are then interconnected in the adjacent wires to form hexagonal shaped openings.

b) Mesh Size: The average distance measured at right angles between twisted sides over meshes.

c) Selvedge wire: Terminal wire used to edge the wire mesh perpendicular to the double twist by mechanically wrapping the mesh wires around it at least 2.5 times.

d) Edge wire: Terminal wire used to edge the wire mesh parallel to the double twist by continuously weaving at mechanically into the wire mesh.

e) Lacing wire: The Zinc + PVC coated metallic wire which interconnects adjacent nets, sealing the joint between the nets.

Sub-Clause A-8.3 **Materials**

a. Wires: - All wires shall be galvanised and PVC coated. The following shall be the diameter of different types of wires.

a. **Mesh Wire:** - Internal diameter 2.2 mm and external diameter 3.70 mm.

b. **Selvedge Wire:** - Internal diameter 2.2 mm and external diameter 3.20 mm.

c. **Lacing Wire:** - Internal diameter 2.2 mm and external diameter 3.20 mm.

d. **Edge Wire:** - Internal diameter 2.2 mm and external diameter 3.20 mm.

b. Mesh: - The Mesh of the gabion box shall be hexagonal in shape with opening size 60 x 80 as shown in the drawings.

c. Anchors: - The Anchors shall be 300 mm long hooks made of 16 mm diameter High Yield Steel.

d. Water

As per Appendix – 1800/III

(All appendices have references to MORT&H Specifications for Road and Bridge W

e. Cement

As per Appendix – 1800/III

f. Sand

As per Appendix – 1800/III

g. Admixtures

As per Appendix – 1800/III

h. Grout

As per Appendix – 1800/III

Sub-Clause A-8.4 **Fabrication**

Wire mesh unit shall be manufactured with all components mechanically connected at the production facility

The procedure for using lacing wire consists of cutting a sufficient length of wire (+ / - 1.0m), and first looping and / or twisting the lacing wire to the wire mesh. Proceed to lace with alternating double and single loops through every mesh opening approximately every 150 mm, pulling each loop tight and finally securing the end of the lacing wire to the wire mesh by looping and / or twisting.

Sub-Clause A-8.5 **Tests**

All following tests on the mesh and lacing wire must be performed prior to manufacturing the mesh:

vi. **Wire**

a) Tensile Strength: The wire used for manufacturing of Gabion or equivalent System and the lacing wire shall have a tensile strength of (38-48 kg / mm^2), in accordance with ASTM A 641-97.

b) Elongation: The test must be carried out on a sample at least 30 cm long. Elongation shall be less than 10% in accordance with ASTM A 370-92.

c) Zinc coating: Minimum quantities of zinc according to ASTM A 641-97 Class III soft temper coating.

d) Adhesion of Zinc coating: The adhesion of the zinc coating to the wire shall be such that, when the wire is wrapped six turns around a mandrel having four times the diameter of the wire, it does not flake or crack when rubbing it with the bare fingers, in accordance with ASTM A 641-97.

vii. **PVC (Polyvinyl Chloride) coating**

a) Specific gravity: 1.30-1.35 kg / m3 in accordance with ASTMD 792 Table 1.

b) Hardness: Between 50 and 60 shore D, according to ASTM D 2240.

c) Tensile strength: not less than 20.6 MPa according ASTMD 412-92.

d) Modulus of elasticity: Not less than 18.6 MPa according to ASTM D 412-92.

e) Abrasion resistance: The percentage of the weight loss shall not be less than 12%, according to ASTM D1242-92.

f) Creeping corrosion: The percentage of corrosion of the wire from a square cut end shall be less than 25 mm when the specimen has been measured for 2000 hrs in a 5% solution of HCl (hydrochloric acid 12 B

viii. **Accelerated aging test**

a) Salt spray test: Test period 3,000 hours, test method ASTM B117-94.

b) Exposure of UV rays: Test period 3,000 hours at 63°C, test method ASTM D1499-92a and ASTM G 23-93 apparatus Type E.

c) Brittleness temperature: No higher than -9°C, when tested accordance with ASTM D746.

The properties after aging test shall be as follows:

d) Appearance of coated mesh: no cracking, stripping or air bubbles, and no appreciable variation in colour.

e) Specific Gravity: variation shall not exceed 6%.

f) Hardness: variations shall not exceed 10%.

g) Tensile strength: variations shall not exceed 25%.

h) Modulus of elasticity: variation shall not exceed 25%.

i) Abrasion resistance: variation shall not exceed 10%.

j) Brittleness temperature shall not exceed 180C.

ix. **Galvanized and PVC coated wire mesh (6 x 8 mesh type)**

a) PVC coating thickness: Nominal 0.5 mm, minimum 0.38 mm

b) Mesh Wire: Diameter 2.77 mm internal, 3.70 mm external

c) Selvedge Wire: Diameter 3.40 mm internal, 4.40 mm external

d) Mesh Opening: Nominal Dimension D = 80 mm

Sub-Clause A-8.6 **Tolerances**

Wire Zinc coating in accordance with ASTM A641-97 Class III soft temper coating.

Gabion unit: ± 5% on the length, width, and height Mesh opening Tolerances on the hexagonal, double twisted wire mesh opening shall not exceed 16% and 4% on the nominal dimension D values.

Sub-Clause A-8.7 **Standard Codes**

ASTM A 641-97 Specification for Zinc Coated (Galvanized) Carbon Steel Wire.

ASTM A 370-92 Test Methods and definitions for Mechanical Testing of Steel Products

ASTM A 90-93 Test Method for Weight (Mass) of Coating on Iron and Steel Articles with Zinc or Zinc Alloy Coating

ASTM A 313-92 Specification for Chromium- Nickel stainless and Heat resisting steel springs wire

ASTM A 764-93 Specification for Steel Wire, Carbon, Drawn Galvanized and Galvanized at size for Mechanical springs.

Sub-Clause A-8.8 **Construction Technique**

1. Surface preparation

The loose material shall be scrapped from the rock surface to be netted.

Sub-Clause A-8.9 **Fixing of rock net**

The roll of wire mesh shall first be anchored at top and the net then rolled over the rock face. The rock net shall be well stretched before anchoring. The jointing of adjacent nets shall be done with lacing wire. Holes shall be drilled at a minimum angle of 15^0 angles for anchors, at least 50 mm longer than the anchor lengths. The holes then should be filled with the grout. The Anchors than shall be hammered in to the holes

CLAUSE A-9 **FENCE**

Sub-Clause A-9.1 **General**

This work shall consist of providing and fixing welded wire fabric of approved size, design fixed with posts @ 2 m per approved design, drawings and Technical Specifications and as approved by the Engineer.

Sub-Clause A-9.2 **Materials**

a. **Net:** - The net shall be welded wire fabric of size 25 x 25 x 2.3 mm. the net shall be painted with epoxy paint as per Technical Specification Clause No. 1400

b. **Posts:** - The post shall be mild steel standard rolled angle of size 50 x 50 x 6 mm. the alternate post shall be anchored with standard angle of size 50 x 50 x 6 mm at an angle not less than 40^0. the post shall be painted with epoxy paint.

Sub-Clause A-9.3 **Fixing**

i. **Post**

The post shall be standard angle of size 50 x 50 x 6 placed at 2 m spacing. The post shall be 1.8 m long out of which 300 mm shall be embedded in the foundation and 1500 mm height above ground. The post shall have holes for fixing the net. The post shall be fixed with foundation as shown in the drawing.

ii. **Net**

The Net shall be fixed to the post with the help of lacing wire. The two adjacent nets shall be overlapped for 300 mm. The nets shall be joined properly with lacing wire at overlap.

CLAUSE A-10 **HYDRO SEEDING**

1. General

This work shall consist of providing and spraying a mixture of water, seed and fertiliser on the surface requiring hydroseeding as drawings and Technical Specifications and as approved by the Engineer. The spraying is to be done repeatedly at an interval till vigorous healthy sward of grass is achieved.

2. Materials

Sub-Clause A-10.2.1 **Water**

Water shall be as per Technical Specification Sub Clause No. 1010.

Sub-Clause A-10.2.2 **Seed**

The seeds will of the following or similar types of medium sized clump grass suitable to the local climate.

1.	Cymbopogon microtheca	-	Khar
2.	Arunduella nepalensis	-	Phurke

3: Eulaliopris binata - Babiyo

Sub-Clause A-10.2.3 **Fertilizer / Manure**

The fertilizer shall be commercial fertilizer and / or approved manure available in local market and suitable for the prevailing conditions and approved by the Engineer. The fertilizer shall not be of acidic property.

Sub-Clause A-10.2.4 **Fibres**

Fibres shall be of shredded untreated jute bag, jute rope or coconut fibres or wood fibres, shredded re-cycled paper or similar types of biodegradable fibrous material which can hold moisture for a longer duration. The maximum length of fibrous material will be less than 3 cm.

Sub-Clause A-10.2.5 **Soil**

The soil shall be agricultural soil of sandy-loam texture, free from kankar, moorum, shingle, stone, brickbats, building rubbish and any other foreign matter. The earth shall be free from clods or lumps of sizes bigger than 75mm in any direction. It shall also be free from coarse sand and any other material which in the opinion of the Engineer can damage the wire mesh during spraying. It shall have Ph value ranging between 6.0 to 8.5.

Sub-Clause A-10.2.6 **Equipment**

Equipment shall have a built in agitation system and operating capacity sufficient to agitate, suspend and homogeneously mix slurry containing not less than 20 kilos (44 lbs.) of organic mulching amendment plus fertilizer, chemical additives and solids for each 100 gallons of water.

Sub-Clause A-10.2.7 **Preparation of Mix**

Seed, fertiliser, fibres, soil and water shall be thoroughly mixed together in the truck mounted tank. The proportion of the ingredients shall be fixed on trail and error basis.

Sub-Clause A-10.2.8 **Spraying**

Seed, fertilizer, fibres, soil and water shall be thoroughly mixed together and then applied under pressure to the area to be treated, by means of Hydroseeding equipment specifically designed for this purpose and by operators trained in the use of this equipment. The constantly agitated mixture shall be applied on a calm day, operating on a front so that the mixture is evenly distributed over the area at the specified rate. Complete each front before commencing the next.

Hydroseeding will be repeated onto the surface until at least 25% of the area is covered by successful seeding.

While spraying the following things shall be observed.

- The mix sprayed over the surface shall provide an even distribution of seed, fibres, soil and fertiliser.
- Hydroseeding slurry components should not be in the Hydroseeding machine for more than two (2) hours because of possible seed destruction. If slurry components are left for more than two hours in the machine, 50% more of the originally specified seed mix should be added to any slurry mixture which has not been applied within the two hours after mixing. Add 75% more of the original seed mix to any slurry mixture which has not been applied eight (8) hours after mixing. All mixtures more than eight (8) hours old must be disposed, off-site, at the contractor's expense.

- Special care shall be exercised prevent any of the slurry from being sprayed onto other areas including buildings, footpath, carriageway etc. All slurry sprayed onto these surfaces shall be removed by the contractor at his own expense.
- All seeded areas shall be inspected for failures and re-sprayed, using not less than half the original application rates. The re-spraying shall be done at least 10 days and not more than 15 days after the previous spray. water shall be applied to the hydroseeded surface for at least 3 months after successful seeding.

Sub-Clause A-10.2.9 **Minimum Coverage:**

Final approval and acceptance shall be based on the minimum coverage of the area of application by successful hydroseeding. The minimum area of coverage acceptable shall be not less than 40 % of the area of application as determined by the Engineer.

SCHEDULE - E
(See Clause 4.1.3)

APPLICABLE PERMITS

1 Applicable Permits

1.1 The Concessionaire shall obtain, as required under the Applicable Laws, the following Applicable Permits on or before the Appointed Date, save and except to the extent of a waiver granted by the Authority in accordance with Clause 4.1.3 of the Agreement:

(a) Permission of the State Government for extraction of boulders from quarry;

(b) Permission of Village Panchayat 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 Asphalt Plant;

(h) Permission of Village Panchayat and State Government for borrow earth;

(i) Permission of State Government for cutting of trees; and

(j) Any other permits or clearances required under Applicable Laws.

1.2 Applicable Permits, as required, relating to environmental protection and conservation shall have been procured by the Authority as a Condition Precedent.

Chenani Nashri Tunnelway Limited

SCHEDULE –F
(See Clause 9.1)

PERFORMANCE SECURITY

The Chairman,
National Highways Authority of India
New Delhi

WHEREAS:

(A) **CHENANI NASHRI TUNNELWAY LIMITED** (the "Concessionaire") and the Chairman, National Highways Authority of India (the "Authority") have entered into a Concession Agreement dated *** (the "Agreement") whereby the Authority has agreed to the Concessionaire undertaking and Two/Four-Laning of the Chenani - Nashri section of National Highway No. 1A on Design build, Finance, operate and transfer on Annuity ("DBFOT Annuity") basis, subject to and in accordance with the provisions of the Agreement.

(B) The Agreement requires the Concessionaire to furnish a Performance Security to the Authority in a sum of **Rs.125.95 crores (Rupees One Hundred and Twenty Five Crores and Ninety Five Lakhs only)** (the "Guarantee Amount") as security for due and faithful performance of its obligations, under and in accordance with the Agreement, during the Construction Period (as defined in the Agreement).

(C) We, ***** through our Branch at ***** (the "Bank") have agreed to furnish this Bank 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 Concessionaire's obligations during the Construction 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 Concessionaire, such sum or sums upto 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 Concessionaire 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 Concessionaire is in default in due and faithful performance of its obligations during the Construction Period under the Agreement and its decision that the Concessionaire is in default shall be final, and binding on the Bank, notwithstanding any differences between the

Authority and the Concessionaire, or any dispute between them pending before any court, tribunal, arbitrators or any other authority or body, or by the discharge of the Concessionaire 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 Concessionaire 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 Concessionaire 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 Concessionaire 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 Concessionaire, 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 Concessionaire 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 Concessionaire 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, not later than 6 (six) months from the date of expiry of 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 Performance Security shall cease to be in force and effect when the Concessionaire shall have expended on Project construction an aggregate sum not less than 20% (twenty per cent) of the Total Project Cost which is deemed to be Rs. 503.80 cr. for the purposes of this Guarantee, and provided the Concessionaire is not in breach of this Agreement. Upon request made by the Concessionaire for release of the Performance Security alongwith the particulars required hereunder,

duly certified by a statutory auditor of the Concessionaire, the Authority shall release the Performance Security forthwith.

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 that it has the power to issue this Guarantee and the undersigned has full powers to do so on behalf of the Bank.

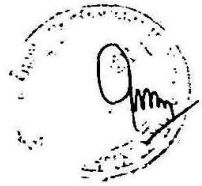
10. Any notice by way of request, demand or otherwise hereunder may be sent by post addressed to the Bank at its above referred Branch, which shall be deemed to have been duly authorised to receive such notice and to effect payment thereof forthwith, and if sent by post it shall be deemed to have been 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.

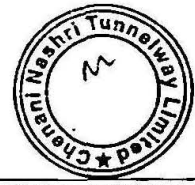
11. This Guarantee shall come into force with immediate effect and shall remain in force and effect for a period of one year or until it is released earlier by the Authority pursuant to the provisions of the Agreement.

Signed and sealed this ** day of ***, 20** at ***.

SIGNED, SEALED AND DELIVERED
For and on behalf of the BANK by:

(Signature)
(Name)
(Designation)
(Address)





SCHEDULE –G
(See Clause 12.1)

PROJECT COMPLETION SCHEDULE

1 Project Completion Schedule

During Construction Period, the Concessionaire shall comply with the requirements set forth in this Schedule-G for each of the Project Milestones and the Scheduled Four-Laning Date (the "**Project Completion Schedule**"). Within 15 (fifteen) days of the date of each Project Milestone, the Concessionaire shall notify the Authority of such compliance alongwith necessary particulars thereof.

2 Project Milestone-I

2.1 Project Milestone-I shall occur on the date falling on the 180th (one hundred and eightieth) day from the Appointed Date (the "**Project Milestone-I**").

2.2 Prior to the occurrence of Project Milestone-I, the Concessionaire shall have commenced construction of the Project Highway and expended not less than 10% (ten per cent) of the total capital cost set forth in the Financial Package.

3 Project Milestone-II

3.1 Project Milestone-II shall occur on the date falling on the 365th (three hundred and sixty fifth) day from the Appointed Date (the "**Project Milestone-II**").

3.2 Prior to the occurrence of Project Milestone-II, the Concessionaire shall have commenced construction of all bridges and expended not less than 20% (twenty per cent) of the total capital cost set forth in the Financial Package.

4 Project Milestone-III

4.1 Project Milestone-III shall occur on the date falling on the 550th (five hundred and fiftieth) day from the Appointed Date (the "**Project Milestone-III**").

4.2 Prior to the occurrence of Project Milestone-III, the Concessionaire shall have commenced construction of all Project Facilities and expended not less than 30% (thirty per cent) of the total capital cost set forth in the Financial Package.

5. Project Milestone-IV

5.1 Project Milestone-IV shall occur on the date falling on the 730th (seven hundred and thirtieth) day from the Appointed Date (the "**Project Milestone-IV**").

5.2 Prior to the occurrence of Project Milestone-IV, the Concessionaire shall have commenced construction of all Project Facilities and expended not less than 40% (forty per cent) of the total capital cost set forth in the Financial Package.

6. Project Milestone-V

6.1 Project Milestone-V shall occur on the date falling on the 925th (Nine hundred and twenty fifth) day from the Appointed Date (the **"Project Milestone-V"**).

6.2 Prior to the occurrence of Project Milestone-V, the Concessionaire shall have commenced construction of all Project Facilities and expended not less than 50% (fifty per cent) of the total capital cost set forth in the Financial Package.

7. Project Milestone-VI

7.1 Project Milestone-VI shall occur on the date falling on the 1105th (One thousand One hundred and fifth) day from the Appointed Date (the **"Project Milestone-VI"**).

7.2 Prior to the occurrence of Project Milestone-VI, the Concessionaire shall have commenced construction of all Project Facilities and expended not less than 60% (sixty per cent) of the total capital cost set forth in the Financial Package.

8. Project Milestone-VII

8.1 Project Milestone-VII shall occur on the date falling on the 1285th (One thousand two hundred and eighty fifth) day from the Appointed Date (the **"Project Milestone-VII"**).

8.2 Prior to the occurrence of Project Milestone-VII, the Concessionaire shall have commenced construction of all Project Facilities and expended not less than 70% (seventy per cent) of the total capital cost set forth in the Financial Package.

9. Project Milestone-VIII

9.1 Project Milestone-VIII shall occur on the date falling on the 1465th (One thousand Four hundred and sixty fifth) day from the Appointed Date (the **"Project Milestone-VIII"**).

9.2 Prior to the occurrence of Project Milestone-VIII, the Concessionaire shall have commenced construction of all Project Facilities and expended not less than 80% (eighty per cent) of the total capital cost set forth in the Financial Package.

10. Project Milestone-IX

10.1 Project Milestone-IX shall occur on the date falling on the 1645th (One thousand six hundred and forty fifth) day from the Appointed Date (the **"Project Milestone-IX"**).

10.2 Prior to the occurrence of Project Milestone-IX, the Concessionaire shall have commenced construction of all Project Facilities and expended not less than 90% (ninety per cent) of the total capital cost set forth in the Financial Package.

11. Project Milestone-X

11.1 Project Milestone-X shall occur on the date falling on the 1825th (One thousand eight hundred and twenty fifth) day from the Appointed Date (the **"Project Milestone-X"**).

11.2 Prior to the occurrence of Project Milestone-X, the Concessionaire shall have commenced construction of all Project Facilities and expended not less than 100% (hundred per cent) of the total capital cost set forth in the Financial Package.

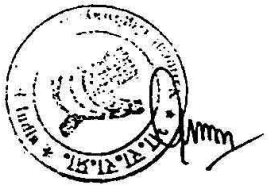
12. Scheduled Four-Laning/Tunnel Completion Date

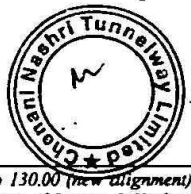
12.1 Scheduled Date for Four Laning and Tunnel Completion shall occur on the 1825th (One thousand eight hundred and twenty fifth) day from the Appointed Date.

12.2 On or before the Scheduled Project Completion Date, the Concessionaire shall have completed the Four Laning Project Highway and Tunnel in accordance with this Agreement.

13. Extension of period

Upon extension of any or all of the aforesaid Project Milestones or the Scheduled Four Laning/Tunnel 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 –H
(See Clause 12.3)

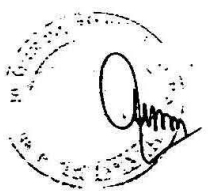
DRAWINGS

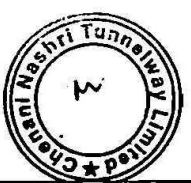
1 Drawings

In compliance of the obligations set forth in Clause 12.3 of this Agreement, the Concessionaire shall furnish to the Independent Engineer, free of cost, all Drawings listed in Annex-I of this Schedule-H.

2 Additional drawings

If the Independent 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 Concessionaire to prepare and furnish such drawings forthwith. Upon receiving a requisition to this effect, the Concessionaire shall promptly prepare and furnish such drawings to the Independent Engineer, as if such drawings formed part of Annex-I of this Schedule-H.





Annex - I
(Schedule-H)

List of Drawings

1. The Project Highway drawings, as defined in Clause 1.1, Definitions, Article 1, Definitions and Interpretation, Part-I: Preliminary, of the Concession Agreement shall consist:

   (a) Working Drawings of all the components/elements of the Project Highway as determined by Independent Engineer/NHAI, and
   (b) As-built drawings for the Project Highway components/elements as determined by IE/NHAI. As-built drawings shall be duly certified by Independent Engineer.

2. A minimum list of the drawings of the various components/elements of the Project Highway and project facilities required to be submitted by the Concessionaire is given below:

   (a) Drawings of horizontal alignment, vertical profile and cross sections
   (b) Drawings of cross drainage works
   (c) Drawings of interchanges, major intersections, grade separators, underpasses and ROB's
   (d) Drawings of toll plaza layout, toll collection systems and roadway near toll plaza
   (e) Drawings of Control Centre
   (f) Drawings of bus-bay and bus shelters with furniture and drainage system
   (g) Drawing of a truck parking lay bye with furniture and drainage system
   (h) Drawings of road furniture items including traffic signage, markings, safety barriers, etc.
   (i) Drawings of traffic diversion plans and traffic control measures
   (j) Drawings of road drainage measures
   (k) Drawings of typical details slope protection measures
   (l) Drawings of landscaping and horticulture
   (m) Drawings of pedestrian crossings
   (n) Drawings of street lighting
   (o) Layout/Configuration of HTMS
   (p) General arrangement showing area of Base camp and Administrative Block

SCHEDULE –I
(See Clause 14.1.2)

TESTS

1 Schedule for Tests

1.1 The Concessionaire shall, not later than 30 (thirty) days prior to the likely completion of Two/Four-Laning, notify the Independent Engineer and the Authority of its intent to subject the Project Highway to Tests, and not later than 7 (seven) days prior to the actual date of Tests, furnish to the Independent Engineer and the Authority detailed inventory and particulars of all works and equipment forming part of Two/Four-Laning.

1.2 The Concessionaire shall notify the Independent Engineer of its readiness to subject the Project Highway to Tests at any time after 7 (seven) days from the date of such notice, and upon receipt of such notice, the Independent Engineer shall, in consultation with the Concessionaire, 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 Independent Engineer shall thereupon conduct the Tests itself or cause any of the Tests to be conducted in accordance with Article 14 and this Schedule-I.

2 Tests

2.1 Visual and physical Test: The Independent Engineer shall conduct a visual and physical check of Two/Four-Laning to determine that all works and equipment forming part thereof conform to the provisions of this Agreement.

2.2 Test drive: The Independent Engineer shall undertake a test drive of the Project Highway by a Car and by a fully loaded Truck to determine that the quality of service conforms to the provisions of the Agreement.

2.3 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 1,800 (one thousand and eight hundred) mm for each kilometre.

2.4 Pavement Composition Test: The thickness and composition of the pavement structure shall be checked on a sample basis by digging pits to determine conformity of such pavement structure with Specifications and Standards. The sample shall consist of one pit in each direction of travel to be chosen at random in each stretch of 5 (five) kilometres of the Project Highway. The first pit for the sample shall be selected by the Independent Engineer through an open draw of lots and every fifth kilometre from such first pit shall form part of the sample for this pavement quality Test.

2.5 Cross-section Test: The cross-sections of the Project Highway shall be checked on a sample basis through physical measurement of their dimensions for determining the conformity thereof with Specifications and Standards. For the

road portion, the sample shall consist of one spot to be selected at random in each stretch of 1 (one) kilometre of the Project Highway. The first spot for the sample shall be selected by the Independent Engineer through an open draw of lots and the spots located at every one kilometre from such first spot shall form part of the sample. For the bridge portion, one spot shall be selected at random by the Independent Engineer in each span of the bridge.

2.6 Structural Test for bridges: All major and minor bridges constructed by the Concessionaire 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 Nondestructive Testing Techniques, at two spots in every span, to be chosen at random by the Independent Engineer. Bridges with a span of 15 (fifteen) metres or more shall also be subjected to load testing.

2.7 Other Tests: The Independent Engineer may require the Concessionaire 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.

2.8 Environmental audit: The Independent 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.

2.9 Safety review: Safety audit of the Project Highway shall have been undertaken by the Safety Consultant as set forth in Schedule-L, and on the basis of such audit, the Independent Engineer shall determine conformity of the Proj ect Highway with the provisions of this Agreement.

3 Agency for conducting Tests

All Tests set forth in this Schedule-I shall be conducted by the Independent Engineer or such other agency or person as it may specify in consultation with the Authority.

4 Completion/Provisional Certificate

Upon successful completion of Tests, the Independent Engineer shall issue the Completion Certificate or the Provisional Certificate, as the case may be, in accordance with the provisions of Article 14.

Chenani Nashri Tunnelway Limited

SCHEDULE –J
(See Clauses 14.2 & 14.3)

COMPLETION CERTIFICATE

1. I, **** (Name of the Independent Engineer), acting as Independent Engineer, under and in accordance with the Concession Agreement dated *** (the "Agreement"), for Two/Four-Laning of the Chenani - Nashri section (km 89.00 to km 130.00 (new alignment) including 9 Km long tunnel (2 lane) with parallel escape tunnel) of National Highway No. 1A (the "Project Highway") on Design build, Finance operate and transfer on annuity (DBFOT Annuity) basis, through **CHENANI NASHRI TUNNELWAY LIMITED**, hereby certify that the Tests specified in Article 14 and Schedule-I 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 commercial service of the Users thereof.

2. It is certified that, in terms of the aforesaid Agreement, all works forming part of Two/Four-Laning have been completed, and the Project Highway is hereby declared fit for entry into commercial operation on this the *** day of *** 20**.

SIGNED, SEALED AND DELIVERED
For and on behalf of
the INDEPENDENT ENGINEER by:

(Signature)
(Name)
(Designation)
(Address)

PROVISIONAL CERTIFICATE

1 I, **** (Name of the Independent Engineer), acting as Independent Engineer, under and in accordance with the Concession Agreement dated *** (the "Agreement"), for Two/Four-Laning of the Chenani - Nashri section (km 89.00 to km 130.00 (new alignment) including 9 Km long tunnel (2 lane) with parallel escape tunnel) of National Highway No. 1A (the "Project Highway") on Design, build, Finance, operate and transfer on annuity (DBFOT Annuity) basis through **CHENANI NASHRI TUNNELWAY LIMITED** , hereby certify that the Tests specified in Article 14 and Schedule-I of the Agreement have been undertaken to determine compliance of the Project Highway with the provisions of the Agreement.

2 Construction Works that were found to be incomplete and/or deficient have been specified in the Punch List appended hereto, and the Concessionaire has agreed and accepted that it shall complete and/or rectify all such works in the time and manner set forth in the Agreement. Some of the incomplete works have been delayed as a result of reasons attributable to the Authority or due to Force Majeure and the Provisional Certificate cannot be withheld on this account. Though the remaining incomplete works have been delayed as a result of reasons attributable to the Concessionaire, I am satisfied that having regard to the nature and extent of such incomplete works, it would not be prudent to withhold commercial operation of the Project Highway, pending completion thereof.

3 In view of the foregoing, I am satisfied that the Project Highway can be safely and reliably placed in commercial service of the Users thereof, and in terms of the Agreement, the Project Highway is hereby provisionally declared fit for entry into commercial operation on this the *** day of *** 20**.

ACCEPTED, SIGNED, SEALED AND DELIVERED For and on behalf of CONCESSIONAIRE by:	SIGNED, SEALED AND DELIVERED For and on behalf of INDEPENDENT ENGINEER by:
(Signature) (Name and Designation) (Address)	(Signature) (Name and Designation) (Address)

SCHEDULE –K
(See Clause 17.2)

MAINTENANCE REQUIREMENTS

1 Maintenance Requirements

1.1 The Concessionaire shall, at all times, operate and maintain the Project Highway in accordance with the provisions of the Agreement, Applicable Laws and Applicable Permits. In particular, the Concessionaire shall, at all times during the Operation Period, conform to the maintenance requirements set forth in this Schedule-K (the "Maintenance Requirements").

1.2 The Concessionaire shall repair or rectify any defect or deficiency set forth in Paragraph 2 of this Schedule-K within the time limit specified therein and any failure in this behalf shall constitute a breach of the Agreement. Upon occurrence of any breach hereunder, the Authority shall be entitled to recover Damages as set forth in Clause 17.8 of the Agreement, without prejudice to the rights of the Authority under the Agreement, including Termination thereof.

2 Repair/rectification of defects and deficiencies

The obligations of the Concessionaire in respect of Maintenance Requirements shall include repair and rectification of the defects and deficiencies specified in Annex - I of this Schedule - K within the time limit set forth therein.

3 Other defects and deficiencies

3.1 In respect of any defect or deficiency not specified in Annex - I of this Schedule-K, the Concessionaire shall undertake repair or rectification in accordance with Good Industry Practice.

3.2 In respect of any defect or deficiency not specified in Annex - I of this Schedule-K, the Independent 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 Concessionaire within the time limit specified by the Independent Engineer.

4 Extension of time limit

Notwithstanding anything to the contrary specified in this Schedule-K, if the nature and extent of any defect or deficiency justifies more time for its repair or rectification than the time specified herein, the Concessionaire shall be entitled to additional time in conformity with Good Industry Practice. Such additional time shall be determined by the Independent Engineer and conveyed to the Concessionaire and the Authority with reasons thereof.

5 Emergency repairs/restoration

Notwithstanding anything to the contrary contained in this Schedule-K, if any

defect, deficiency or deterioration in the Project Highway poses danger to the life or property of the Users thereof, the Concessionaire shall promptly take all reasonable measures for eliminating or minimizing such danger.

6 Daily Inspection by the Concessionaire

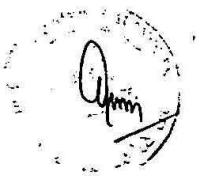
The Concessionaire shall, through its engineer, undertake a daily visual inspection of the Project Highway and maintain a record thereof in a register to be kept in such form and manner as the Independent Engineer may specify. Such record shall be kept in safe custody of the Concessionaire and shall be open to inspection by the Authority and the Independent Engineer at any time during office hours.

7 Divestment Requirements

All defects and deficiencies specified in this Schedule-K shall be repaired and rectified by the Concessionaire so that the Project Highway conforms to the Maintenance Requirements on the Transfer Date.

8 Display of Schedule - K

The Concessionaire shall display a copy of this Schedule - K at the Toll Plaza along with the Complaint Register stipulated in Article 46.



Annex - I
(Schedule-K)

Repair/Rectification of Defects and Deficiencies

The Concessionaire shall repair and rectify the defects and deficiencies specified in this Annex-I of Schedule-K within the time limit set forth herein.

	Nature of defect or deficiency		**Time limit for repair/ rectification**
ROADS			
(a)	**Carriageway and paved shoulders**		
(i)	Breach or blockade	-	Temporary restoration of traffic within 24 hours; permanent restoration within 15 days
(ii)	Roughness value exceeding 2,500 mm in a stretch of 1 km (as measured by a standardised roughometer/bump integrator)	-	180 days
(iii)	Pot holes	-	48 hours
(iv)	Cracking in more than 5% of road surface in a stretch of 1 km	-	30 days
(v)	Rutting exceeding 10 mm in more than 2% of road surface in a stretch of 1 km (measured with 3 m straight edge)	-	30 days
(vi)	Bleeding/skidding	-	7 days
(vii)	Ravelling/Stripping of bitumen surface exceeding 10 sq m	-	15 days
(viii)	Damage to pavement edges exceeding 10 cm	-	15 days
(ix)	Removal of debris	-	6 hours
(b)	**Hard/earth shoulders, side slopes, drains and culverts**		
(i)	Variation by more than 2% in	-	30 days

	the prescribed slope of camber/cross fall	
(ii)	Edge drop at shoulders exceeding 40 mm	- 7 days
(iii)	Variation by more than 15% in the prescribed side (embankment) slopes	- 30 days
(iv)	Rain cuts/gullies in slope	- 7 days
(v)	Damage to or silting of culverts and side drains during and immediately preceding the rainy season	- 7 days
(vi)	Desilting of drains in urban/semi-urban areas	- 48 hours
(c)	**Road side furniture including road signs and pavement marking**	
	Damage to shape or position; poor visibility or loss of retro-reflectivity	- 48 hours
(d)	**Street lighting and telecom (ATMS)**	
(i)	Any major failure of the system	- 24 hours
(ii)	Faults and minor failures	- 8 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 hours
(ii)	Deterioration in health of trees and bushes	- Timely watering and treatment
(iii)	Replacement of trees and bushes	- 90 days
(iv)	Removal of vegetation affecting sight line and road structures	- 15 days
(f)	**Rest areas**	
(i)	Cleaning of toilets	- Every 4 hours
(ii)	Defects in electrical, water and sanitary installations	- 24 hours

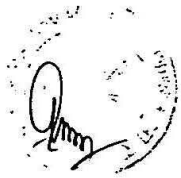
(g)	**Toll plazas**	
(i)	Failure of toll collection equipment or lighting	- 8 hours
(ii)	Damage to toll plaza	- 7 days
(h)	**Other Project Facilities and Approach roads**	
(i)	Damage or deterioration in Approach Roads, pedestrian facilities, truck lay-bys, bus-bays, bus-shelters, cattle crossings, Traffic Aid Posts, Medical Aid Posts and other works	- 15 days

BRIDGES

(a)	**Superstructure of bridges**	
(i)	Cracks Temporary measures Permanent measures	 - within 48 hours - within 45 days
(ii)	Spalling/scaling	- 15 days
(b)	**Foundations of bridges**	
(i)	Scouring and/or cavitation	- 15 days
(c)	**Piers, abutments, return walls and wing walls of bridges**	
(i)	Cracks and damages including settlement and tilting	- 30 days
(d)	**Bearings (metallic) of bridges**	
(i)	Deformation	- 15 days
(e)	**Joints in bridges**	
(i)	Loosening and malfunctioning of joints	- 15 days
(f)	**Other items relating to bridges**	
(i)	Deforming of pads in elastomeric bearings	- 7 days
(ii)	Gathering of dirt in bearings and joints; or clogging of spouts, weep holes and vent-holes	- 3 days
(iii)	Damage or deterioration in parapets and handrails	- 3 days

SHRI NASHRI TUNNELWAY LIMITED CHENANI

(iv)	Rain-cuts or erosion of banks of the side slopes of approaches	-	15 days
(v)	Damage to wearing coat	-	15 days
(vi)	Damage or deterioration in approach slabs, pitching, apron, toes, floor or guide bunds	-	30 days
(vii)	Growth of vegetation affecting the structure or obstructing the waterway	-	15 days



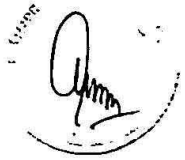
Annex II
(Schedule K)
SERVICE LEVEL REQUIREMENTS – (FRAMEWORK ONLY)

The Concessionaire shall operate and maintain the highway in a manner that provides the Users Assured Lane Availability as specified in this Annex -II of Schedule -K within the time limit set forth herein.

1. Lane Availability

Item	Number of total lane sections – hrs available	Assured availability – minimum time for which lane sections are available to Users – 98% of total lane section – hrs available in an Annuity Payment Period
Assured Lane Availability	Lane section = Project Highway length (m) x number of lanes / 250 (m) Hours available = days in an Annuity Payment Period x 24	Lane section - hrs

Item	Service Level	Measurement/ Detection
Assured Availability	The availability of Carriageway assured by the Concessionaire for each Annuity Payment Period, computed as under: Assured Lane Availability = Number of lanes X Lane sections X 24 (hours) X Actual number of days in the relevant Annuity Payment Period X 98% (Lane sections = Length of lane / 250m)	Monthly Report / IE Monthly Inspection Report / IE Routine inspection



SCHEDULE –L
(See Clause 18.1.1)

SAFETY REQUIREMENTS

1 Guiding principles

1.1 Safety Requirements aim at reduction in injuries, loss of life and damage to property resulting from accidents on the Project Highway, irrespective of the person(s) at fault.

1.2 Users of the Project Highway include motorised and non-motorised vehicles as well as pedestrians and animals involved in, or associated with accidents. Vulnerable Road Users (VRU) include pedestrians as well as riders of motorised two-wheelers, bicycles and other vehicles which do not provide adequate occupant protection.

1.3 Safety Requirements apply to all phases of construction, operation and maintenance with emphasis on identification of factors associated with accidents, consideration of the same, and implementation of appropriate remedial measures.

1.4 Safety Requirements include measures associated with traffic management and regulation such as road signs, pavement marking, traffic control devices, roadside furniture, highway design elements, enforcement and emergency response.

2 Obligations of the Concessionaire

The Concessionaire shall abide by the following insofar as they relate to safety of the Users:

(a) Applicable Laws and Applicable Permits;

(b) Manual for Safety in Road Design, issued by MORTH;

(c) relevant Standards/Guidelines of IRC relating to safety, road geometrics, bridges, culverts, road signs, pavement marking and roadside furniture;

(d) provisions of this Agreement; and

(e) Good Industry Practice.

3 Appointment of Safety Consultant

For carrying out safety audit of the Project Highway under and in accordance with this Schedule-L, the Authority shall appoint from time to time, one or more qualified firms or organisations as its consultants (the "Safety Consultant"). The

Safety Consultant shall employ a team comprising, without limitation, one road safety expert and one traffic planner to undertake safety audit of the Project Highway.

4 Safety measures during Development Period

4.1 Not later than 90 (ninety) days from the date of this Agreement, the Authority shall appoint a Safety Consultant for carrying out safety audit at the design stage of the Project. The Safety Consultant shall collect data on all fatal crashes and other road accidents which occurred on the Project Highway in the preceding two years by obtaining copies of the relevant First Information Reports (FIRs) from the police stations having jurisdiction. The information contained in such FIRs shall be summarised in the form prescribed by IRC/MORTH for this purpose and the data shall be analysed for the type of victims killed or injured, impacting vehicles, location of accidents and other relevant factors.

4.2 The Concessionaire shall provide to the Safety Consultant, in four copies, the relevant drawings containing the design details that have a bearing on safety of Users (the "Safety Drawings"). Such design details shall include horizontal and vertical alignments; sightlines; layouts of intersections; interchanges; road cross-section; bridges and culverts; side drains; provision for parked vehicles, slow moving vehicles (tractors, bullock carts, bicycles) and pedestrians; bus bays; truck lay-bys; and other incidental or consequential information. The Safety Consultant shall review the design details and forward three copies of the Safety Drawings with its recommendations, if any, to the Independent Engineer who shall record its comments, if any, and forward one copy each to the Authority and the Concessionaire.

4.3 The accident data and the design details shall be compiled, analysed and used by the Safety Consultant for evolving a package of recommendations consisting of safety related measures for the Project Highway. The safety audit shall be completed in a period of three months and a report thereof (the "Safety Report") shall be submitted to the Authority, in five copies. One copy each of the Safety Report shall be forwarded by the Authority to the Concessionaire and the Independent Engineer forthwith.

4.4 The Concessionaire shall endeavour to incorporate the recommendations of the Safety Report in the design of the Project Highway, as may reasonably be required in accordance with Applicable Laws, Applicable Permits, Manuals and Guidelines of MORTH and IRC, Specifications and Standards, and Good Industry Practice. If the Concessionaire does not agree with any or all of such recommendations, it shall state the reasons thereof and convey them to the Authority forthwith. In the event that any or all of the works and services recommended in the Safety Report fall beyond the scope of Schedule-B, Schedule-C or Schedule-D, the Concessionaire shall make a report thereon and seek the instructions of the Authority for funding such works in accordance with the provisions of Article 18.

4.5 Without prejudice to the provisions of Paragraph 4.4, the Concessionaire and the Independent Engineer shall, within 15 (fifteen) days of receiving the Safety Report, send their respective comments thereon to the Authority, and not later than 15 (fifteen) days of receiving such comments, the Authority shall review the same alongwith the Safety Report and by notice direct the Concessionaire to carry out any or all of the recommendations contained therein with such modifications as the Authority may specify; provided that any works or services required to be undertaken hereunder shall be governed by the provisions of Article 18.

5 Safety measures during Construction Period

5.1 A Safety Consultant shall be appointed by the Authority, not later than 4 (four) months prior to the expected Project Completion Date, for carrying out a safety audit of the completed Construction Works.

5.2 The Safety Consultant shall collect and analyse the accident data for the preceding two years in the manner specified in Paragraph 4.1 of this Schedule-L. It shall study the Safety Report for the Development Period and inspect the Project Highway to assess the adequacy of safety measures. The Safety Consultant shall complete the safety audit within a period of 4 (four) months and submit a Safety Report recommending a package of additional road safety measures, if any, that are considered essential for reducing accident hazards on the Project Highway. Such recommendations shall be processed, mutatis mutandis, and acted upon in the manner set forth in Paragraphs 4.3, 4.4 and 4.5 of this Schedule-L.

5.3 The Concessionaire shall make adequate arrangements during the Construction Period for the safety of workers and road Users in accordance with the guidelines of IRC for safety in construction zones, and notify the Authority and the Independent Engineer about such arrangements.

6 Safety measures during Operation Period

6.1 The Concessionaire shall develop, implement and administer a surveillance and safety programme for Users, including correction of safety violations and deficiencies and all other actions necessary to provide a safe environment in accordance with this Agreement.

6.2 The Concessionaire shall establish a Highway Safety Management Unit (the "HSMU") to be functional on and after COD, and designate one of its officers to be in-charge of the HSMU. Such officer shall have specialist knowledge and training in road safety and traffic engineering by having attended a course conducted by a reputed organisation on the subject.

6.3 The Concessionaire shall keep a copy of every FIR recorded by the Police with respect to any accident occurring on the Project Highway. In addition, the Concessionaire shall also collect data for all cases of accidents not recorded by the Police but where a vehicle rolled over or had to be towed away. The information so collected shall be summarised in the form prescribed by IRC/

MORTH for this purpose. The Concessionaire shall also record the exact location of each accident on a road map. The aforesaid data shall be submitted to the Authority at the conclusion of every quarter and to the Safety Consultant as and when appointed.

6.4 The Concessionaire shall submit to the Authority before the 31st (thirty first) May of each year, an annual report (in ten copies) containing, without limitation, a detailed listing and analysis of all accidents of the preceding Accounting Year and the measures taken by the Concessionaire pursuant to the provisions of Paragraph 6.1 of this Schedule-L for averting or minimising such accidents in future.

6.5 Once in every Accounting Year, a safety audit shall be carried out by the Safety Consultant to be appointed by the Authority. It shall review and analyse the annual report and accident data of the preceding year, and undertake an inspection of the Project Highway. The Safety Consultant shall complete the safety audit within a period of 1 (one) month and submit a Safety Report recommending specific improvements, if any, required to be made to the road, bridges, culverts, markings, signs, road furniture and Project Facilities, including cattle crossings and pedestrian crossings. Such recommendations shall be processed, mutatis mutandis, and acted upon in the manner set forth in Paragraphs 4.3, 4.4 and 4.5 of this Schedule-L.

7 Costs and expenses

Costs and expenses incurred in connection with the Safety Requirements set forth herein, including the provisions of Paragraph 2 of this Schedule, shall be met in accordance with Article 18, and in particular, the remuneration of the Safety Consultant, safety audit, and costs incidental thereto, shall be met out of the Safety Fund.

Chenani Nashri Tunnelway Limited

SCHEDULE –M
(See Clause27.1.1)

ANNUITY PAYMENT SCHEDULE

S. No.	Annuity Payment Date	Annuity Amount (Rs. million)
1.	June 21, 2016	Rs. 3175.2 million
2.	December 18, 2016	Rs. 3175.2 million
3.	June 21, 2017	Rs. 3175.2 million
4.	December 18, 2017	Rs. 3175.2 million
5.	June 21, 2018	Rs. 3175.2 million
6.	December 18, 2018	Rs. 3175.2 million
7.	June 21, 2019	Rs. 3175.2 million
8.	December 18, 2020	Rs. 3175.2 million
9.	June 21, 2021	Rs. 3175.2 million
10.	December 18, 2021	Rs. 3175.2 million
11.	June 21, 2022	Rs. 3175.2 million
12.	December 18, 2022	Rs. 3175.2 million
13.	June 21, 2023	Rs. 3175.2 million
14.	December 18, 2023	Rs. 3175.2 million
15.	June 21, 2024	Rs. 3175.2 million
16.	December 18, 2024	Rs. 3175.2 million
17.	June 21, 2025	Rs. 3175.2 million
18.	December 18, 2025	Rs. 3175.2 million
19.	June 21, 2026	Rs. 3175.2 million
20.	December 18, 2026	Rs. 3175.2 million
21.	June 21, 2027	Rs. 3175.2 million
22.	December 18, 2027	Rs. 3175.2 million
23.	June 21, 2028	Rs. 3175.2 million
24.	December 18, 2028	Rs. 3175.2 million
25.	June 21, 2029	Rs. 3175.2 million
26.	December 18, 2029	Rs. 3175.2 million
27.	June 21, 2030	Rs. 3175.2 million
28.	December 18, 2030	Rs. 3175.2 million
29.	June 21, 2031	Rs. 3175.2 million
30.	December 18, 2031	Rs. 3175.2 million

Note: Based on the Bid submitted by the Bidder / Concessionaire

Chenani Nashri Tunnelway Limited

SCHEDULE –N

WEEKLY TRAFFIC CENSUS

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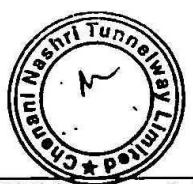


SCHEDULE –O
(See Clause 22.3.1)

TRAFFIC SAMPLING

1 Traffic sampling

The Authority may, in its discretion and at its own cost, undertake traffic sampling, pursuant to Clause 22.3, in order to determine the actual traffic on the Project Highway. Such traffic sampling shall be undertaken through the Independent Engineer in the manner set forth below.

2 Manual traffic count

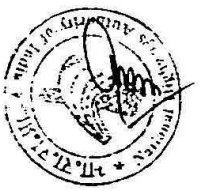
The Independent Engineer shall employ the required number of enumerators who shall count, classify and record all the vehicles as they pass by, and divide the survey into fixed time periods. The count stations shall be located near the Toll Plazas on a straight section of the road with good visibility. The survey shall be conducted continuously for a minimum of 24 (twenty four) hours and maximum of 7 (seven) days at a time. The count period shall be 15 (fifteen) minutes with results summarised hourly.

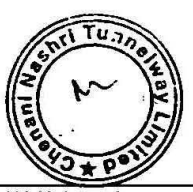
3 Automatic traffic count

For automatic traffic count to be conducted on intermittent (non-continuous) basis, the Independent Engineer shall use suitable and standardised equipment to classify and record the range of vehicles passing through the Toll Plazas. For this purpose, the counter shall be checked with at least 100 (one hundred) vehicles, including all major vehicle types, over a range of speeds to ensure that all vehicles are being counted and classified correctly.

4 Variation between manual and automatic count

Average Daily Traffic (ADT) for each type of vehicle shall be determined separately by the aforesaid two methods and in the event that the number of vehicles in any category, as counted by the manual method, varies by more than 1% (one per cent) of the number of such vehicles as counted by the automatic method, the manual and automatic count of such category of vehicles shall be repeated, and in the event of any discrepancy between the two counts in the second enumeration, the average thereof shall be deemed to be the actual traffic. For the avoidance of doubt, it is expressly agreed that the Authority may, in consultation with the Concessionaire, adopt modified or alternative processes of traffic sampling for improving the reliability of such sampling.





SCHEDULE –P
(See Clause 23.1)

SELECTION OF INDEPENDENT ENGINEER

1 Selection of Independent Engineer

1.1 The provisions of Part II of the Standard Bidding Documents for Consultancy Assignments: Time Based (Volume V) issued by the Ministry of Finance, GOI in July, 1997 shall apply, mutatis mutandis, for invitation of bids and evaluation thereof save as otherwise provided herein.

1.2 The Authority shall invite expressions of interest from consulting engineering firms or bodies corporate to undertake and perform the duties and functions set forth in Schedule-Q and thereupon shortlist 10 (ten) qualified firms in accordance with pre-determined criteria. The Authority shall convey the aforesaid list of firms to the Concessionaire for scrutiny and comments, if any. The Concessionaire shall be entitled to scrutinise the relevant records of the Authority to ascertain whether the selection of firms has been undertaken in accordance with the prescribed procedure and it shall send its comments, if any, to the Authority within 15 (fifteen) days of receiving the aforesaid list of firms. Upon receipt of such comments, if any, the Authority shall, after considering all relevant factors, finalise and constitute a panel of 10 (ten) firms (the "Panel of Firms") and convey its decision to the Concessionaire.

1.3 The Authority shall invite the aforesaid firms in the Panel of Firms to submit their respective technical and financial offers, each in a separate sealed cover. All the technical bids so received shall be opened and pursuant to the evaluation thereof, the Authority shall shortlist 3 (three) eligible firms on the basis of their technical scores. The financial bids in respect of such 3 (three) firms shall be opened and the order of priority as among these firms shall be determined on the basis of a weighted evaluation where technical and financial scores shall be assigned respective weights of 80:20.

2 Fee and expenses

2.1 In determining the nature and quantum of duties and services to be performed by the Independent Engineer during the Development Period and Construction Period, the Authority shall endeavour that payments to the Independent Engineer on account of fee and expenses do not exceed 2% (two per cent) of the Total Project Cost. Payments not exceeding such 2% (two per cent) shall be borne equally by the Authority and the Concessionaire in accordance with the provisions of this Agreement and any payments in excess thereof shall be borne entirely by the Authority.

2.2 The nature and quantum of duties and services to be performed by the Independent Engineer during the Operation Period shall be determined by the Authority in conformity with the provisions of this Agreement and with due regard for economy in expenditure. All payments made to the Independent Engineer on account of fee and expenses during the Operation Period shall be

borne equally by the Authority and the Concessionaire.

3 Constitution of fresh panel

Not later than 66 (sixty six) months from the date of this Agreement, and every three years thereafter, the Authority shall prepare a fresh panel of firms in accordance with the criteria set forth in this Schedule-P; provided that the Authority may, at any time, prepare a fresh panel with prior written consent of the Concessionaire.

4 Appointment of government entity as Independent Engineer

Notwithstanding anything to the contrary contained in this Schedule, the Authority may in its discretion appoint a government-owned entity as the Independent Engineer; provided that such entity shall be a body corporate having as one of its primary function the provision of consulting, advisory and supervisory services for engineering projects; provided that a government-owned entity which is owned or controlled by the Authority and/or MoRTH shall not be eligible for appointment as Independent Engineer.

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SCHEDULE Q
(See Clause 23.2.1)

TERMS OF REFERENCE FOR INDEPENDENT ENGINEER

1 Scope

1.1 These Terms of Reference for the Independent Engineer (the "TOR") are being specified pursuant to the Concession Agreement dated *** (the "Agreement"), which has been entered into between the Authority and **CHENANI NASHRI TUNNELWAY LIMITED** (the "Concessionaire") for Two/Four-Laning of the Chenani - Nashri section (km 89.00 to 130.00 (new alignment) including 9 Km long tunnel (2 lane) with parallel escape tunnel) of National Highway No. 1A in the State of Jammu & Kashmir on Design build, Finance, operate and transfer on Annuity (DBFOT Annuity) basis, and a copy of which is annexed hereto and marked as Annex-A to form part of this TOR.

1.2 This TOR shall apply to construction, operation and maintenance of the Two/Four-Lane Project Highway.

2 Definitions and interpretation

2.1 The words and expressions beginning with or in capital letters used in this TOR 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.

2.2 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.

2.3 The rules of interpretation stated in Clauses 1.2, 1.3 and 1.4 of the Agreement shall apply, mutatis mutandis, to this TOR.

3 Role and functions of the Independent Engineer

3.1 The role and functions of the Independent Engineer shall include the following:

(i) review of the Drawings and Documents as set forth in Paragraph 4;

(ii) review, inspection and monitoring of Construction Works as set forth in Paragraph 5;

(iii) conducting Tests on completion of construction and issuing Completion/ Provisional Certificate as set forth in Paragraph 5;

(iv) review, inspection and monitoring of O&M as set forth in Paragraph 6;

(v) review, inspection and monitoring of Divestment Requirements as set forth in Paragraph 7;

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(vi) determining, as required under the Agreement, the costs of any works or services and/or their reasonableness;

(vii) determining, as required under the Agreement, the period or any extension thereof, for performing any duty or obligation;

(viii) assisting the Parties in resolution of disputes as set forth in Paragraph 9; and

(ix) undertaking all other duties and functions in accordance with the Agreement.

3.2 The Independent Engineer shall discharge its duties in a fair, impartial and efficient manner, consistent with the highest standards of professional integrity and Good Industry Practice.

4 Development Period

4.1 During the Development Period, the Independent Engineer shall undertake a detailed review of the Drawings to be furnished by the Concessionaire along with supporting data, including the geo-technical and hydrological investigations, characteristics of materials from borrow areas and quarry sites, topographical surveys and traffic surveys. The Independent Engineer shall complete such review and send its comments/observations to the Authority and the Concessionaire within 15 (fifteen) days of receipt of such Drawings. In particular, such comments shall specify the conformity or otherwise of such Drawings with the Scope of the Project and Specifications and Standards.

4.2 The Independent Engineer shall review any modified Drawings or supporting Documents sent to it by the Concessionaire and furnish its comments within 7 (seven) days of receiving such Drawings or Documents.

4.3 The Independent Engineer shall review the Drawings sent to it by the Safety Consultant in accordance with Schedule-L and furnish its comments thereon to the Authority and the Concessionaire within 7 (seven) days of receiving such Drawings. The Independent Engineer shall also review the Safety Report and furnish its comments thereon to the Authority within 15 (fifteen) days of receiving such report.

4.4 The Independent Engineer shall review the detailed design, construction methodology, quality assurance procedures and the procurement, engineering and construction time schedule sent to it by the Concessionaire and furnish its comments within 15 (fifteen) days of receipt thereof.

4.5 Upon reference by the Authority, the Independent Engineer shall review and comment on the EPC Contract or any other contract for construction, operation and maintenance of the Project Highway, and furnish its comments within 7 (seven) days from receipt of such reference from the Authority.

5 Construction Period

5.1 In respect of the Drawings. Documents and Safety Report received by the Independent Engineer for its review and comments during the Construction Period, the provisions of Paragraph 4 shall apply, mutatis mutandis.

5.2 The Independent Engineer shall review the monthly progress report furnished by the Concessionaire and send its comments thereon to the Authority and the Concessionaire within 7 (seven) days of receipt of such report.

5.3 The Independent Engineer shall inspect the Construction Works and the Project Highway once every month, preferably after receipt of the monthly progress report from the Concessionaire, but before the 20th (twentieth) day of each month in any case, and make out a report of such inspection (the "Inspection Report") setting forth an overview of the status, progress, quality and safety of construction, including the work methodology adopted, the materials used and their sources, and conformity of Construction Works with the Scope of the Project and the Specifications and Standards. In a separate section of the Inspection Report, the Independent Engineer shall describe in reasonable detail the lapses, defects or deficiencies observed by it in the construction of the Project Highway. The Inspection Report shall also contain a review of the maintenance of the existing lanes in conformity with the provisions of the Agreement. The Independent Engineer shall send a copy of its Inspection Report to the Authority and the Concessionaire within 7 (seven) days of the inspection.

5.4 The Independent Engineer may inspect the Project Highway more than once in a month if any lapses, defects or deficiencies require such inspections.

5.5 For determining that the Construction Works conform to Specifications and Standards, the Independent Engineer shall require the Concessionaire to carry out, or cause to be carried out, tests on a sample basis, to be specified by the Independent Engineer in accordance with Good Industry Practice for quality assurance. For purposes of this Paragraph 5.5, 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. The Independent Engineer shall issue necessary directions to the Concessionaire for ensuring that the tests are conducted in a fair and efficient manner, and shall monitor and review the results thereof.

5.6 The sample size of the tests, to be specified by the Independent Engineer under Paragraph 5.5, shall comprise 10% (ten per cent) of the quantity or number of tests prescribed for each category or type of tests in the Quality Control Manuals; provided that the Independent Engineer may, for reasons to be recorded in writing, increase the aforesaid sample size by up to 10% (ten per cent) for certain categories or types of tests.

5.7 The timing of tests referred to in Paragraph 5.5, and the criteria for acceptance/ rejection of their results shall be determined by the Independent 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 Concessionaire for its own quality assurance in accordance with Good Industry Practice.

5.8 In the event that the Concessionaire carries out any remedial works for removal or rectification of any defects or deficiencies, the Independent Engineer shall require the Concessionaire to carry out, or cause to be carried out, tests to determine that such remedial works have brought the Construction Works into conformity with the Specifications and Standards, and the provisions of this Paragraph 5 shall apply to such tests.

5.9 In the event that the Concessionaire fails to achieve any of the Project Milestones, the Independent Engineer shall undertake a review of the progress of construction and identify potential delays, if any. If the Independent Engineer shall determine that completion of the Project Highway is not feasible within the time specified in the Agreement, it shall require the Concessionaire 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 Concessionaire, the Independent Engineer shall review the same and send its comments to the Authority and the Concessionaire forthwith.

5.10 If at any time during the Construction Period, the Independent Engineer determines that the Concessionaire has not made adequate arrangements for the safety of workers and Users in the zone of construction or that any work is being carried out in a manner that threatens the safety of the workers and the Users, it shall make a recommendation to the Authority forthwith, identifying the whole or part of the Construction Works that should be suspended for ensuring safety in respect thereof.

5.11 In the event that the Concessionaire carries out any remedial measures to secure the safety of suspended works and Users, it may, by notice in writing, require the Independent Engineer to inspect such works, and within 3 (three) days of receiving such notice, the Independent Engineer shall inspect the suspended works and make a report to the Authority forthwith, recommending whether or not such suspension may be revoked by the Authority.

5.12 If suspension of Construction Works is for reasons not attributable to the Concessionaire, the Independent Engineer shall determine the extension of dates set forth in the Project Completion Schedule, to which the Concessionaire is reasonably entitled, and shall notify the Authority and the Concessionaire of the same.

5.13 The Independent Engineer shall carry out, or cause to be carried out, all the Tests specified in Schedule-I and issue a Completion Certificate or Provisional Certificate, as the case may be. For carrying out its functions under this Paragraph 5.13 and all matters incidental thereto, the Independent Engineer shall act under and in accordance with the provisions of Article 14 and Schedule-I.

5.14 Upon reference from the Authority, the Independent Engineer shall make a fair and reasonable assessment of the costs of providing information, works and services as set forth in Article 16 and certify the reasonableness of such costs for

payment by the Authority to the Concessionaire.

5.15 The Independent Engineer shall aid and advise the Concessionaire in preparing the Maintenance Manual.

6 Operation Period

6.1 In respect of the Drawings, Documents and Safety Report received by the Independent Engineer for its review and comments during the Operation Period, the provisions of Paragraph 4 shall apply, mutatis mutandis.

6.2 The Independent Engineer shall review the annual Maintenance Programme furnished by the Concessionaire and send its comments thereon to the Authority and the Concessionaire within 15 (fifteen) days of receipt of the Maintenance Programme.

6.3 The Independent Engineer shall review the monthly status report furnished by the Concessionaire and send its comments thereon to the Authority and the Concessionaire within 7 (seven) days of receipt of such report.

6.4 The Independent Engineer shall inspect the Project Highway once every month, preferably after receipt of the monthly status report from the Concessionaire, but before the 20th (twentieth) day of each month in any case, and make out an O&M Inspection Report setting forth an overview of the status, quality and safety of O&M including its conformity with the Maintenance Requirements and Safety Requirements. In a separate section of the O&M Inspection Report, the Independent Engineer shall describe in reasonable detail the lapses, defects or deficiencies observed by it in O&M of the Project Highway. The Independent Engineer shall send a copy of its O&M Inspection Report to the Authority and the Concessionaire within 7 (seven) days of the inspection.

6.5 The Independent Engineer may inspect the Project Highway more than once in a month, if any lapses, defects or deficiencies require such inspections.

6.6 The Independent Engineer shall in its O&M Inspection Report specify the tests, if any, that the Concessionaire 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 Concessionaire in this behalf.

6.7 In respect of any defect or deficiency referred to in Paragraph 3 of Schedule-K, the Independent 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.

6.8 The Independent Engineer shall determine if any delay has occurred in completion of repair or remedial works in accordance with the Agreement, and shall also determine the Damages, if any, payable by the Concessionaire to the Authority for such delay.

6.9 The Independent Engineer shall examine the request of the Concessionaire for closure of any lane(s) of the carriageway for undertaking maintenance/repair thereof, keeping in view the need to minimise disruption in traffic and the time required for completing such maintenance/repair in accordance with Good Industry Practice. It shall grant permission with such modifications, as it may deem necessary, within 5 (five) days of receiving a request from the Concessionaire. Upon expiry of the permitted period of closure, the Independent Engineer shall monitor the re-opening of such lane(s), and in case of delay, determine the Damages payable by the Concessionaire to the Authority under Clause 17.7.

6.10 The Independent Engineer shall monitor and review the curing of defects and deficiencies by the Concessionaire as set forth in Clause 19.4.

6.11 In the event that the Concessionaire notifies the Independent Engineer of any modifications that it proposes to make to the Project Highway, the Independent Engineer shall review the same and send its comments to the Authority and the Concessionaire within 15 (fifteen) days of receiving the proposal.

6.12 The Independent Engineer shall undertake traffic sampling, as and when required by the Authority, under and in accordance with Article 22 and Schedule-O.

6.13 As per the provisions of the Concession Agreement the Independent Engineer shall verify the invoices for Annuity payment submitted by the Concessionaire and duly adjust the same for any bonus or reduction in Annuity in accordance with Article 28 of the Concession Agreement along with the necessary documentation in this regard. The Independent Engineer shall after verification and certification of the amount claimed in the invoice alongwith adjustments, forward the invoice to Authority with necessary documentation recommending payment in full or part thereof so as to reach Authority atleast 15 days prior to the relevant Annuity Payment Date.

7 Termination

7.1 At any time, not earlier than 90 (ninety) days prior to Termination but not later than 10 (ten) days prior to such Termination, the Independent Engineer shall, in the presence of a representative of the Concessionaire, inspect the Project Highway for determining compliance by the Concessionaire with the Divestment Requirements set forth in Clause 38.1 and, if required, cause tests to be carried out at the Concessionaire's cost for determining such compliance. If the Independent Engineer determines that the status of the Project Highway is such that its repair and rectification would require a larger amount than the sum set forth in Clause 39.2, it shall recommend retention of the required amount in the Escrow Account and the period of retention thereof.

7.2 The Independent Engineer shall inspect the Project Highway once in every 15(fifteen) days during a period of 90 (ninety) days after Termination for determining the liability of the Concessionaire under Article 39, in respect of the defects or deficiencies specified therein. If any such defect or deficiency is found by the Independent Engineer, it shall make a report in reasonable detail and send

it forthwith to the Authority and the Concessionaire.

8 Determination of costs and time

8.1 The Independent Engineer shall determine the costs, and/or their reasonableness, that are required to be determined by it under the Agreement.

8.2 The Independent Engineer shall determine the period, or any extension thereof, that is required to be determined by it under the Agreement.

9 Assistance in Dispute resolution

9.1 When called upon by either Party in the event of any Dispute, the Independent Engineer shall mediate and assist the Parties in arriving at an amicable settlement.

9.2 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 Independent Engineer shall specify such meaning, scope and nature by issuing a reasoned written statement relying on good industry practice and authentic literature.

10 Other duties and functions

The Independent Engineer shall perform all other duties and functions specified in the Agreement.

11 Miscellaneous

11.1 The Independent Engineer shall notify its programme of inspection to the Authority and to the Concessionaire, who may, in their discretion, depute their respective representatives to be present during the inspection.

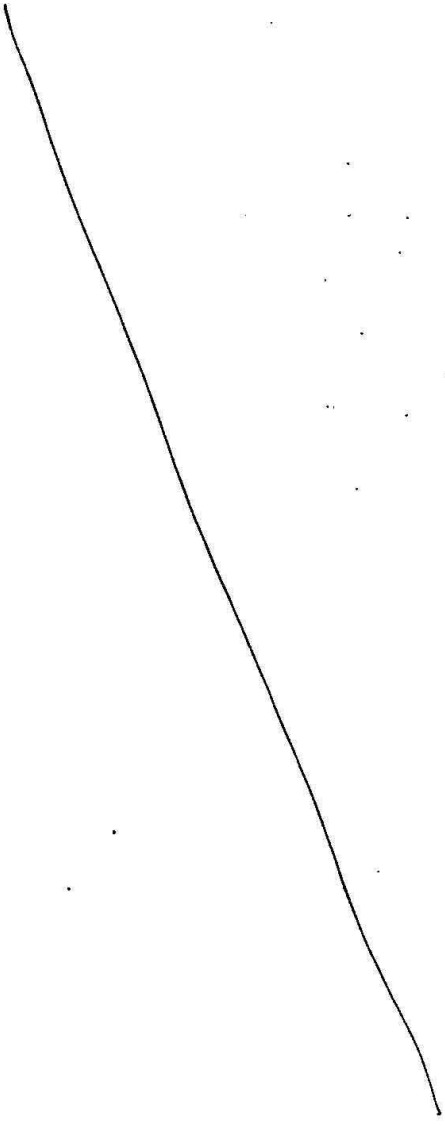
11.2 A copy of all communications, comments, instructions, Drawings or Documents sent by the Independent Engineer to the Concessionaire pursuant to this TOR, and a copy of all the test results with comments of the Independent Engineer thereon shall be furnished by the Independent Engineer to the Authority forthwith.

11.3 The Independent Engineer shall obtain, and the Concessionaire shall furnish in two copies thereof, all communications and reports required to be submitted, under this Agreement, by the Concessionaire to the Independent Engineer, whereupon the Independent Engineer shall send one of the copies to the Authority along with its comments thereon.

11.4 The Independent 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.

11.5 Upon completion of its assignment hereunder, the Independent Engineer shall duly classify and list all Drawings, Documents, results of tests and other relevant records, and hand them over to the Authority or such other person as the Authority may specify, and obtain written receipt thereof. Two copies of the said

documents shall also be furnished in micro film form or in such other medium as may be acceptable to the Authority.



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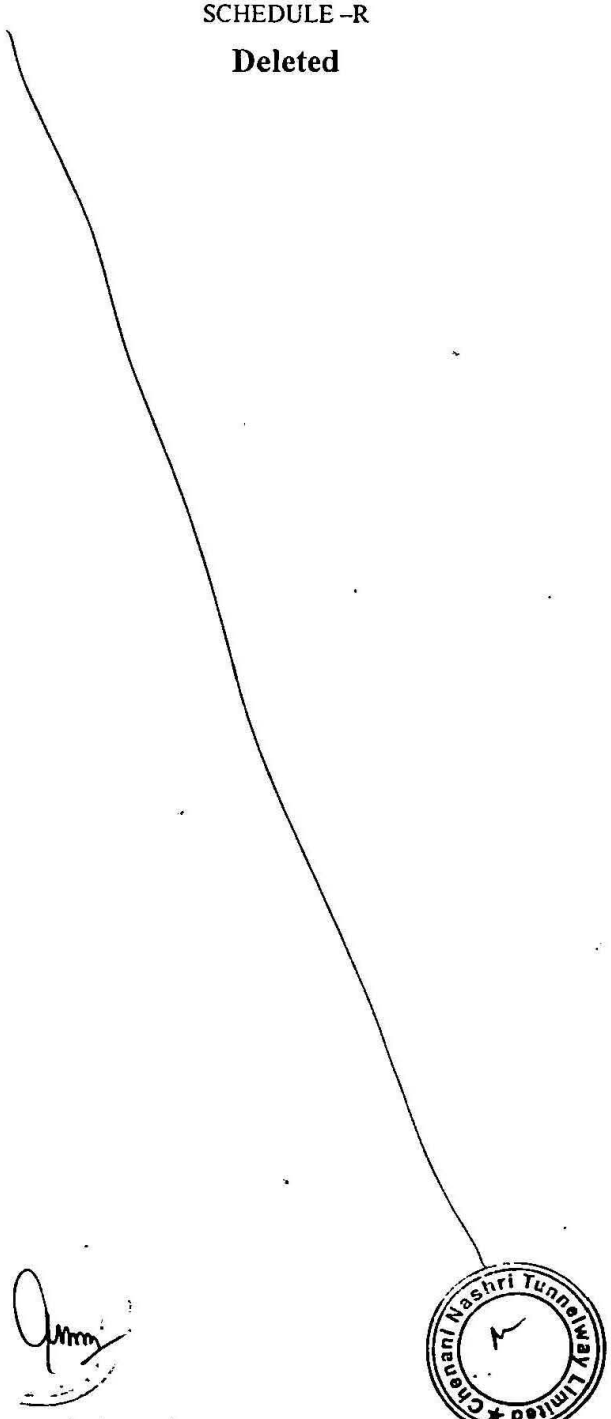

SCHEDULE –S
(See Clause 31.1.2)

ESCROW AGREEMENT

THIS ESCROW AGREEMENT is entered into on this the *** day of *** 20**.

AMONGST

1 **CHENANI NASHRI TUNNELWAY LIMITED**, a company incorporated under the provisions of the Companies Act, 1956 and having its registered office at The IL & FS Financial Center, Plot C-22, G Block, Bandra Kurla Complex, Bandra (E), Mumbai 400 051, Maharashtra, India (hereinafter referred to as the "Concessionaire" which expression shall, unless repugnant to the context or meaning thereof, include its successors, permitted assigns and substitutes);

2 ****name and particulars of Lenders' Representative and having its registered office at *** acting for and on behalf of the Senior Lenders as their duly authorised agent with regard to matters arising out of or in relation to this Agreement (hereinafter referred to as the "Lenders' Representative" which expression shall, unless repugnant to the context or meaning thereof, include its successors and substitutes);

3 ****name and particulars of the Escrow Bank and having its registered office at **** (hereinafter referred to as the "Escrow Bank" which expression shall, unless repugnant to the context or meaning thereof, include its successors and substitutes); and

4 The National Highways Authority of India, established under the National Highways Authority of India Act 1988, represented by its Chairman and having its principal offices at G-5 & 6, Sector 10, Dwarka, New Delhi-110075 (hereinafter referred to as the "Authority" which expression shall, unless repugnant to the context or meaning thereof, include its administrators, successors and assigns).

WHEREAS:

(A) The Authority has entered into a Concession Agreement dated *** with the Concessionaire (the "Concession Agreement") for Two/Four-Laning of the Chenani - Nashri Section (km 89.00 to 130.00 (new alignment) including 9 Km long tunnel (2 lane) with parallel escape tunnel of National Highway No. 1A in the State of Jammu and Kashmir on Design, build, Finance, operate and transfer on annuity (DBFOT Annuity) basis, and a copy of which is annexed hereto and marked as Annex-A to form part of this Agreement

(B) Senior Lenders have agreed to finance the Project in accordance with the terms and conditions set forth in the Financing Agreements.

(C) The Concession Agreement requires the Concessionaire to establish an Escrow Account, inter alia, on the terms and conditions stated therein.

Chenani Nashri Tunnelway Limited ✱ ٣

NOW IT IS HEREBY AGREED as follows:

1 DEFINITIONS AND INTERPRETATION

1.1 Definitions

In this Agreement, the following words and expressions shall, unless repugnant to the context or meaning thereof, have the meaning hereinafter respectively assigned to them:

"Agreement" means this Escrow Agreement and any amendment thereto made in accordance with the provisions contained herein;

"Concession Agreement" means the Concession Agreement referred to in Recital (A) above and annexed hereto as Annex-A, and shall include all of its Recitals and Schedules and any amendments made thereto in accordance with the provisions contained in this behalf therein;

"Cure Period" means the period specified in this Agreement for curing any breach or default of any provision of this Agreement by the Concessionaire, and shall commence from the date on which a notice is delivered by the Authority or the Lenders' Representative, as the case may be, to the Concessionaire asking the latter to cure the breach or default specified in such notice;

"Escrow Account" means an escrow account established in terms of and under this Agreement, and shall include the Sub-Accounts;

"Escrow Default" shall have the meaning ascribed thereto in Clause 6.1;

"Lenders' Representative" means the person referred to as the Lenders' Representative in the foregoing Recitals;

"Parties" means the parties to this Agreement collectively and "Party" shall mean any of the Parties to this Agreement individually;

"Payment Date" means, in relation to any payment specified in Clause 4.1, the date(s) specified for such payment; and

"Sub-Accounts" means the respective Sub-Accounts of the Escrow Account, into which the monies specified in Clause 4.1 would be credited every month and paid out if due, and if not due in a month then appropriated proportionately in such month and retained in the respective Sub Accounts and paid out therefrom on the Payment Date(s).

1.2 Interpretation

1.2.1 References to Lenders' Representative shall, unless repugnant to the context or meaning thereof, mean references to the Lenders' Representative, acting for and on behalf of Senior Lenders.

1.2.2 The words and expressions beginning with capital letters and defined in this Agreement shall have the meaning ascribed thereto herein, and the words and

expressions used in this Agreement and not defined herein but defined in the Concession Agreement shall, unless repugnant to the context, have the meaning ascribed thereto in the Concession Agreement.

1.2.3 References to Clauses are, unless stated otherwise, references to Clauses of this Agreement.

1.2.4 The rules of interpretation stated in Clauses 1.2, 1.3 and 1.4 of the Concession Agreement shall apply, mutatis mutandis, to this Agreement.

2 ESCROW ACCOUNT

2.1 Escrow Bank to act as trustee

2.1.1 The Concessionaire hereby appoints the Escrow Bank to act as trustee for the Authority, the Lenders' Representative and the Concessionaire in connection herewith and authorises the Escrow Bank to exercise such rights, powers, authorities and discretion as are specifically delegated to the Escrow Bank by the terms hereof together with all such rights, powers, authorities and discretion as are reasonably incidental hereto, and the Escrow Bank accepts such appointment pursuant to the terms hereof.

2.1.2 The Concessionaire hereby declares that all rights, title and interest in and to the Escrow Account shall be vested in the Escrow Bank and held in trust for the Authority, the Lenders' Representative and the Concessionaire, and applied in accordance with the terms of this Agreement. No person other than the Authority, the Lenders' Representative and the Concessionaire shall have any rights hereunder as the beneficiaries of, or as third party beneficiaries under this Agreement.

2.2 Acceptance of Escrow Bank

The Escrow Bank hereby agrees to act as such and to accept all payments and other amounts to be delivered to and held by the Escrow Bank pursuant to the provisions of this Agreement. The Escrow Bank shall hold and safeguard the Escrow Account during the term of this Agreement and shall treat the amount in the Escrow Account as monies deposited by the Concessionaire, Senior Lenders or the Authority with the Escrow Bank. In performing its functions and duties under this Agreement, the Escrow Bank shall act in trust for the benefit of, and as agent for, the Authority, the Lenders' Representative and the Concessionaire or their nominees, successors or assigns, in accordance with the provisions of this Agreement.

2.3 Establishment and operation of Escrow Account

2.3.1 Within 30 (thirty) days from the date of this Agreement, and in any case prior to the Appointed Date, the Concessionaire shall open and establish the Escrow Account with the **** (name of Branch) Branch of the Escrow Bank. The Escrow Account shall be denominated in Rupees.

2.3.2 The Escrow Bank shall maintain the Escrow Account in accordance with the

terms of this Agreement and its usual practices and applicable regulations, and pay the maximum rate of interest payable to similar customers on the balance in the said account from time to time.

2.3.3 The Escrow Bank and the Concessionaire shall, after consultation with the Lenders' Representative, agree on the detailed mandates, terms and conditions, and operating procedures for the Escrow Account, but in the event of any conflict or inconsistency between this Agreement and such mandates, terms and conditions, or procedures, this Agreement shall prevail.

2.4 Escrow Bank's fee

The Escrow Bank shall be entitled to receive its fee and expenses in an amount, and at such times, as may be agreed between the Escrow Bank and the Concessionaire. For the avoidance of doubt, such fee and expenses shall form part of the O&M Expenses and shall be appropriated from the Escrow Account in accordance with Clause 4.1.

2.5 Rights of the parties

The rights of the Authority, the Lenders' Representative and the Concessionaire in the monies held in the Escrow Account are set forth in their entirety in this Agreement and the Authority, the Lenders' Representative and the Concessionaire shall have no other rights against or to the monies in the Escrow Account.

2.6 Substitution of the Concessionaire

The Parties hereto acknowledge and agree that upon substitution of the Concessionaire with the Nominated Company, pursuant to the Substitution Agreement, it shall be deemed for the purposes of this Agreement that the Nominated Company is a Party hereto and the Nominated Company shall accordingly be deemed to have succeeded to the rights and obligations of the Concessionaire under this Agreement on and with effect from the date of substitution of the Concessionaire with the Nominated Company.

3 DEPOSITS INTO ESCROW ACCOUNT

3.1 Deposits by the Concessionaire

3.1.1 The Concessionaire agrees and undertakes that it shall deposit into and/or credit the Escrow Account with:

(a) all monies received in relation to the Project from any source, including the Senior Lenders, lenders of Subordinated Debt and the Authority;

(b) all funds received by the Concessionaire from its share-holders, in any manner or form;

(c) all Annuity received by the Concessionaire;

(d) any other revenues from or in respect of the Project Highway; and

(e) all proceeds received pursuant to any insurance claims.

3.1.2 The Concessionaire may at any time make deposits of its other funds into the Escrow Account, provided that the provisions of this Agreement shall apply to such deposits.

3.2 Deposits by the Authority

The Authority agrees and undertakes that, as and when due and payable, it shall deposit into and/or credit the Escrow Account with:

(a) Annuity and any other monies disbursed by the Authority to the Concessionaire;

(b) Deleted;

(c) Deleted and

(d) Termination Payments:

Provided that the Authority shall be entitled to appropriate from the aforesaid amounts, any Concession Fee due and payable to it by the Concessionaire, and the balance remaining shall be deposited into the Escrow Account.

3.3 Deposits by Senior Lenders

The Lenders' Representative agrees, confirms and undertakes that the Senior Lenders shall deposit into and/or credit the Escrow Account with all disbursements made by them in relation to or in respect of the Project; provided that notwithstanding anything to the contrary contained in this Agreement, the Senior Lenders shall be entitled to make direct payments to the EPC Contractor under and in accordance with the express provisions contained in this behalf in the Financing Agreements.

3.4 Interest on deposits

The Escrow Bank agrees and undertakes that all interest accruing on the balances of the Escrow Account shall be credited to the Escrow Account; provided that the Escrow Bank shall be entitled to appropriate therefrom the fee and expenses due to it from the Concessionaire in relation to the Escrow Account and credit the balance remaining to the Escrow Account.

4 WITHDRAWALS FROM ESCROW ACCOUNT

4.1 Withdrawals during Concession Period

4.1.1 At the beginning of every month, or at such shorter intervals as the Lenders' Representative and the Concessionaire may by written instructions determine, the Escrow Bank shall withdraw amounts from the Escrow Account and appropriate them in the following order by depositing such amounts in the relevant Sub-Accounts for making due payments, and if such payments are not due in any month, then retain such monies in such Sub-Accounts and pay out therefrom on

the Payment Date(s):

(a) all taxes due and payable by the Concessionaire;

(b) all payments relating to construction of the Project Highway, subject to and in accordance with the conditions, if any, set forth in the Financing Agreements;

(c) O&M Expenses, subject to the ceiling, if any, set forth in the Financing Agreements;

(d) O&M Expenses incurred by the Authority, provided it certifies to the Escrow Bank that it had incurred such expenses in accordance with the provisions of the Concession Agreement and that the amounts claimed are due to it from the Concessionaire;

(e) Concession Fee due and payable to the Authority;

(f) monthly proportionate provision of Debt Service due in an Accounting Year;

(g) Deleted

(h) all payments and Damages certified by the Authority as due and payable to it by the Concessionaire pursuant to the Concession Agreement,;

(i) debt service payments in respect of Subordinated Debt;

(j) any reserve requirements set forth in the Financing Agreements; and

(k) balance, if any, in accordance with the instructions of the Concessionaire.

4.1.2 Not later than 60 (sixty) days prior to the commencement of each Accounting Year, the Concessionaire shall provide to the Escrow Bank, with prior written approval of the Lenders' Representative, details of the amounts likely to be required for each of the payment obligations set forth in this Clause 4.1; provided that such amounts may be subsequently modified, with prior written approval of the Lenders' Representative, if fresh information received during the course of the year makes such modification necessary.

4.2 Withdrawals upon Termination

Upon Termination of the Concession Agreement, all amounts standing to the credit of the Escrow Account shall, notwithstanding anything in this Agreement, be appropriated and dealt with in the following order:

(a) all taxes due and payable by the Concessionaire;

(b) 90% (ninety per cent) of Debt Due excluding Subordinated Debt;

(c) outstanding Concession Fee;

Covenant Nashri Tunnelway Limited

(d) all payments and Damages certified by the Authority as due and payable to it by the Concessionaire pursuant to the Concession Agreement, including any claims in connection with or arising out of Termination;

(e) retention and payments arising out of, or in relation to, liability for defects and deficiencies set forth in Article 39 of the Concession Agreement;

(f) outstanding Debt Service including the balance of Debt Due;

(g) outstanding Subordinated Debt;

(h) incurred or accrued O&M Expenses;

(i) any other payments required to be made under the Concession Agreement; and

(j) balance, if any, in accordance with the instructions of the Concessionaire:

Provided that the disbursements specified in Sub-clause (j) of this Clause 4.2 shall be undertaken only after the Vesting Certificate has been issued by the Authority.

4.3 Application of insufficient funds

Funds in the Escrow Account shall be applied in the serial order of priority set forth in Clauses 4.1 and 4.2, as the case may be. If the funds available are not sufficient to meet all the requirements, the Escrow Bank shall apply such funds in the serial order of priority until exhaustion thereof.

4.4 Application of insurance proceeds

Notwithstanding anything in this Agreement, the proceeds from all insurance claims, except life and injury, shall be deposited into and/or credited to the Escrow Account and utilised for any necessary repair, reconstruction, reinstatement, replacement, improvement, delivery or installation of the Project Highway, and the balance remaining, if any, shall be applied in accordance with the provisions contained in this behalf in the Financing Agreements.

4.5 Withdrawals during Suspension

Notwithstanding anything to the contrary contained in this Agreement, the Authority may exercise all or any of the rights of the Concessionaire during the period of Suspension under Article 36 of the Concession Agreement. Any instructions given by the Authority to the Escrow Bank during such period shall be complied with as if such instructions were given by the Concessionaire under this Agreement and all actions of the Authority hereunder shall be deemed to have been taken for and on behalf of the Concessionaire.

5 OBLIGATIONS OF THE ESCROW BANK

5.1 Segregation of funds

Monies and other property received by the Escrow Bank under this Agreement

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shall, until used or applied in accordance with this Agreement, be held by the Escrow Bank in trust for the purposes for which they were received, and shall be segregated from other funds and property of the Escrow Bank.

5.2 Notification of balances

7 (seven) business days prior to each Payment Date (and for this purpose the Escrow Bank shall be entitled to rely on an affirmation by the Concessionaire and/or the Lenders' Representative as to the relevant Payment Dates), the Escrow Bank shall notify the Lenders' Representative of the balances in the Escrow Account and Sub-Accounts as at the close of business on the immediately preceding business day.

5.3 Communications and notices

In discharge of its duties and obligations hereunder, the Escrow Bank:

(a) may, in the absence of bad faith or gross negligence on its part, rely as to any matters of fact which might reasonably be expected to be within the knowledge of the Concessionaire upon a certificate signed by or on behalf of the Concessionaire;

(b) may, in the absence of bad faith or gross negligence on its part, rely upon the authenticity of any communication or document believed by it to be authentic;

(c) shall, within 5 (five) business days after receipt, deliver a copy to the Lenders' Representative of any notice or document received by it in its capacity as the Escrow Bank from the Concessionaire or any other person hereunder or in connection herewith; and

(d) shall, within 5 (five) business days after receipt, deliver a copy to the Concessionaire of any notice or document received by it from the Lenders' Representative in connection herewith.

5.4 No set off

The Escrow Bank agrees not to claim or exercise any right of set off, banker's lien or other right or remedy with respect to amounts standing to the credit of the Escrow Account. For the avoidance of doubt, it is hereby acknowledged and agreed by the Escrow Bank that the monies and properties held by the Escrow Bank in the Escrow Account shall not be considered as part of the assets of the Escrow Bank and being trust property, shall in the case of bankruptcy or liquidation of the Escrow Bank, be wholly excluded from the assets of the Escrow Bank in such bankruptcy or liquidation.

5.5 Regulatory approvals

The Escrow Bank shall use its best efforts to procure, and thereafter maintain and comply with, all regulatory approvals required for it to establish and operate the Escrow Account. The Escrow Bank represents and warrants that it is not aware of

any reason why such regulatory approvals will not ordinarily be granted to the Escrow Bank.

6 ESCROW DEFAULT

6.1 Escrow Default

6.1.1 Following events shall constitute an event of default by the Concessionaire (an "Escrow Default") unless such event of default has occurred as a result of Force Majeure or any act or omission of the Authority or the Lenders' Representative:

(a) the Concessionaire commits breach of this Agreement by failing to deposit any receipts into the Escrow Account as provided herein and fails to cure such breach by depositing the same into the Escrow Account within a Cure Period of 5 (five) business days;

(b) the Concessionaire causes the Escrow Bank to transfer funds to any account of the Concessionaire in breach of the terms of this Agreement and fails to cure such breach by depositing the relevant funds into the Escrow Account or any Sub-Account in which such transfer should have been made, within a Cure Period of 5 (five) business days; or

(c) the Concessionaire commits or causes any other breach of the provisions of this Agreement and fails to cure the same within a Cure Period of 5 (five) business days.

6.1.2 Upon occurrence of an Escrow Default, the consequences thereof shall be dealt with under and in accordance with the provisions of the Concession Agreement.

7 TERMINATION OF ESCROW AGREEMENT

7.1 Duration of the Escrow Agreement

This Agreement shall remain in full force and effect so long as any sum remains to be advanced or is outstanding from the Concessionaire in respect of the debt, guarantee or financial assistance received by it from the Senior Lenders, or any of its obligations to the Authority remain to be discharged, unless terminated earlier by consent of all the Parties or otherwise in accordance with the provisions of this Agreement.

7.2 Substitution of Escrow Bank

The Concessionaire may, by not less than 45 (forty five) days prior notice to the Escrow Bank, the Authority and the Lenders' Representative, terminate this Agreement and appoint a new Escrow Bank, provided that the new Escrow Bank is acceptable to the Lenders' Representative and arrangements are made satisfactory to the Lenders' Representative for transfer of amounts deposited in the Escrow Account to a new Escrow Account established with the successor Escrow Bank. The termination of this Agreement shall take effect only upon coming into force of an Escrow Agreement with the substitute Escrow Bank.

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7.3 Closure of Escrow Account

The Escrow Bank shall, at the request of the Concessionaire and the Lenders' Representative made on or after the payment by the Concessionaire of all outstanding amounts under the Concession Agreement and the Financing Agreements including the payments specified in Clause 4.2, and upon confirmation of receipt of such payments, close the Escrow Account and Sub-Accounts and pay any amount standing to the credit thereof to the Concessionaire. Upon closure of the Escrow Account hereunder, the Escrow Agreement shall be deemed to be terminated.

8 SUPPLEMENTARY ESCROW AGREEMENT

8.1 Supplementary Escrow Agreement

The Lenders' Representative and the Concessionaire shall be entitled to enter into a supplementary escrow agreement with the Escrow Bank providing, inter alia, for detailed procedures and documentation for withdrawals from Sub-Accounts pursuant to Clause 4.1.1 and for matters not covered under this Agreement such as the rights and obligations of Senior Lenders and lenders of Subordinated Debt, investment of surplus funds, restrictions on withdrawals by the Concessionaire in the event of breach of this Agreement or upon occurrence of an Escrow Default, procedures relating to operation of the Escrow Account and withdrawal therefrom, reporting requirements and any matters incidental thereto; provided that such supplementary escrow agreement shall not contain any provision which is inconsistent with this Agreement and in the event of any conflict or inconsistency between provisions of this Agreement and such supplementary escrow agreement, the provisions of this Agreement shall prevail.

9 INDEMNITY

9.1 General indemnity

9.1.1 The Concessionaire will indemnify, defend and hold the Authority, Escrow Bank and the Senior Lenders, acting through the Lenders' Representative, harmless against any and all proceedings, actions and third party claims for any loss, damage, cost and expense arising out of any breach by the Concessionaire of any of its obligations under this Agreement or on account of failure of the Concessionaire to comply with Applicable Laws and Applicable Permits.

9.1.2 The Authority will indemnify, defend and hold the Concessionaire harmless against any and all proceedings, actions and third party claims for any loss, damage, cost and expense arising out of failure of the Authority to fulfil any of its obligations under this Agreement materially and adversely affecting the performance of the Concessionaire's obligations under the Concession Agreement or this Agreement other than any loss, damage, cost and expense arising out of acts done in discharge of their lawful functions by the Authority, its officers, servants and agents.

9.1.3 The Escrow Bank will indemnify, defend and hold the Concessionaire harmless against any and all proceedings, actions and third party claims for any loss,

damage, cost and expense arising out of failure of the Escrow Bank to fulfil its obligations under this Agreement materially and adversely affecting the performance of the Concessionaire's obligations under the Concession Agreement other than any loss, damage, cost and expense, arising out of acts done in discharge of their lawful functions by the Escrow Bank, its officers, servants and agents.

9.2 Notice and contest of claims

In the event that any Party hereto receives a claim from a third party in respect of which it is entitled to the benefit of an indemnity under Clause 9.1 or in respect of which it is entitled to reimbursement (the "Indemnified Party"), it shall notify the other Party responsible for indemnifying such claim hereunder (the "Indemnifying Party") within 15 (fifteen) days of receipt of the claim and shall not settle or pay the claim without the prior approval of the Indemnifying Party, which approval shall not be unreasonably withheld or delayed. In the event that the Indemnifying Party wishes to contest or dispute the claim, it may conduct the proceedings in the name of the Indemnified Party and shall bear all costs involved in contesting the same. The Indemnified Party shall provide all cooperation and assistance in contesting any claim and shall sign all such writings and documents as the Indemnifying Party may reasonably require.

10 DISPUTE RESOLUTION

10.1 Dispute resolution

10.1.1 Any dispute, difference or claim arising out of or in connection with this Agreement, which is not resolved amicably, shall be decided finally by reference to arbitration to a Board of Arbitrators comprising one nominee of each Party to the dispute, and where the number of such nominees is an even number, the nominees shall elect another person to such Board. Such arbitration shall be held in accordance with the Rules of Arbitration of the International Centre for Alternative Dispute Resolution, New Delhi (the "Rules") or such other rules as may be mutually agreed by the Parties, and shall be subject to the provisions of the Arbitration and Conciliation Act, 1996.

10.1.2 The Arbitrators shall issue a reasoned award and such award shall be final and binding on the Parties. The venue of arbitration shall be Delhi and the language of arbitration shall be English.

11 MISCELLANEOUS PROVISIONS

11.1 Governing law and jurisdiction

This Agreement shall be construed and interpreted in accordance with and governed by the laws of India, and the Courts at Delhi shall have jurisdiction over all matters arising out of or relating to this Agreement.

11.2 Waiver of sovereign immunity

The Authority unconditionally and irrevocably:

(a) agrees that the execution, delivery and performance by it of this Agreement constitute commercial acts done and performed for commercial purpose;

(b) agrees that, should any proceedings be brought against it or its assets, property or revenues in any jurisdiction in relation to this Agreement or any transaction contemplated by this Agreement, no immunity (whether by reason of sovereignty or otherwise) from such proceedings shall be claimed by or on behalf of the Authority with respect to its assets;

(c) waives any right of immunity which it or its assets, property or revenues now has, may acquire in the future or which may be attributed to it in any jurisdiction; and

(d) consents generally in respect of the enforcement of any judgement or award against it in any such proceedings to the giving of any relief or the issue of any process in any jurisdiction in connection with such proceedings (including the making, enforcement or execution against it or in respect of any assets, property or revenues whatsoever irrespective of their use or intended use of any order or judgement that may be made or given in connection therewith).

11.3 Priority of agreements

In the event of any conflict between the Concession Agreement and this Agreement, the provisions contained in the Concession Agreement shall prevail over this Agreement.

11.4 Alteration of terms

All additions, amendments, modifications and variations to this Agreement shall be effectual and binding only if in writing and signed by the duly authorised representatives of the Parties.

11.5 Waiver

11.5.1 Waiver by any Party of a default by another Party in the observance and performance of any provision of or obligations under this Agreement:

(a) shall not operate or be construed as a waiver of any other or subsequent default hereof or of other provisions of or obligations under this Agreement;

(b) shall not be effective unless it is in writing and executed by a duly authorised representative of the Party; and

(c) shall not affect the validity or enforceability of this Agreement in any manner.

11.5.2 Neither the failure by any Party to insist on any occasion upon the performance of the terms, conditions and provisions of this Agreement or any obligation

thereunder nor time or other indulgence granted by any Party to another Party shall be treated or deemed as waiver of such breach or acceptance of any variation or the relinquishment of any such right hereunder.

11.6 No third party beneficiaries

This Agreement is solely for the benefit of the Parties and no other person or entity shall have any rights hereunder.

11.7 Survival

11.7.1 Termination of this Agreement:

(a) shall not relieve the Parties of any obligations hereunder which expressly or by implication survive termination hereof; and

(b) except as otherwise provided in any provision of this Agreement expressly limiting the liability of either Party, shall not relieve either Party of any obligations or liabilities for loss or damage to the other Party arising out of, or caused by, acts or omissions of such Party prior to the effectiveness of such termination or arising out of such termination.

11.7.2 All obligations surviving the cancellation, expiration or termination of this Agreement shall only survive for a period of 3 (three) years following the date of such termination or expiry of this Agreement.

11.8 Severability

If for any reason whatever any provision of this Agreement is or becomes invalid, illegal or unenforceable or is declared by any court of competent jurisdiction or any other instrumentality to be invalid, illegal or unenforceable, the validity, legality or enforceability of the remaining provisions shall not be affected in any manner, and the Parties will negotiate in good faith with a view to agreeing to one or more provisions which may be substituted for such invalid, unenforceable or illegal provisions, as nearly as is practicable to such invalid, illegal or unenforceable provision. Failure to agree upon any such provisions shall not be subject to dispute resolution under Clause 10.1 of this Agreement or otherwise.

11.9 Successors and assigns

This Agreement shall be binding on and shall inure to the benefit of the Parties and their respective successors and permitted assigns.

11.10 Notices

All notices or other communications to be given or made under this Agreement shall be in writing and shall either be delivered personally or sent by courier or registered post with an additional copy to be sent by facsimile. The address for service of each Party and its facsimile number are set out under its name on the signing pages hereto. A notice shall be effective upon actual receipt thereof, save that where it is received after 5:30 (five thirty) p.m. on a business day, or on a day

Chenani Nashri Tunnelway Limited

that is not a business day, the notice shall be deemed to be received on the first business day following the date of actual receipt. Without prejudice to the foregoing, a Party giving or making a notice or communication by facsimile shall promptly deliver a copy thereof personally, or send it by courier or registered post to the addressee of such notice or communication. It is hereby agreed and acknowledged that any Party may by notice change the address to which such notices and communications to it are to be delivered or mailed. Such change shall be effective when all the Parties have notice of it.

11.11 Language

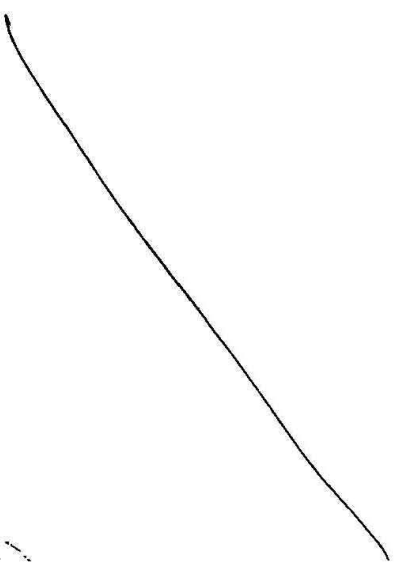
All notices, certificates, correspondence and proceedings under or in connection with this Agreement shall be in English.

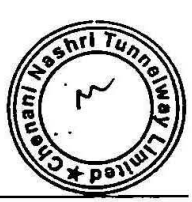
11.12 Authorised representatives

Each of the Parties shall, by notice in writing, designate their respective authorised representatives through whom only all communications shall be made. A Party hereto shall be entitled to remove and/or substitute or make fresh appointment of such authorised representative by similar notice.

11.13 Original Document

This Agreement may be executed in four counterparts, each of which when executed and delivered shall constitute an original of this Agreement.





IN WITNESS WHEREOF THE PARTIES HAVE EXECUTED AND DELIVERED THIS AGREEMENT AS OF THE DATE FIRST ABOVE WRITTEN.

SIGNED, SEALED AND DELIVERED
For and on behalf of
CONCESSIONAIRE by:

(Signature)

(Name)
(Designation)
(Address)
(Fax No.)

SIGNED, SEALED AND DELIVERED
For and on behalf of
SENIOR LENDERS by the Lenders' Representative:

(Signature)

(Name)
(Designation)
(Address)
(Fax No.)

SIGNED, SEALED AND DELIVERED
For and on behalf of
ESCROW BANK by:

(Signature)

(Name)
(Designation)
(Address)
(Fax No.)

SIGNED, SEALED AND DELIVERED
For and on behalf of
NATIONAL HIGHWAYS AUTHORITY OF INDIA by:

(Signature)

(Name)
(Designation)
(Address)
(Fax No.)

In the presence of:

1.

2.

Chenani Nashri Tunnelway Limited

SCHEDULE –T
(See Clause 33.2.1)

PANEL OF CHARTERED ACCOUNTANTS

1 Panel of Chartered Accountants

Pursuant to the provisions of Clause 33.2.1 of the Agreement, the Authority and the Concessionaire shall prepare a mutually agreed panel of 10 (ten) reputable firms of Chartered Accountants having their registered offices in India (the "Panel of Chartered Accountants"). The criteria for preparing such Panel and the procedure to be adopted in this behalf shall be as set forth in this Schedule-T.

2 Invitation for empanelment

2.1 The Authority shall invite offers from all reputable firms of Chartered Accountants who fulfil the following eligibility criteria, namely:

(a) the firm should have conducted statutory audit of the annual accounts of at least one hundred companies registered under the Companies Act, 1956, of which at least ten should have been public sector undertakings;

(b) the firm should have at least 5 (five) practising Chartered Accountants on its rolls, each with a minimum experience of ten years in the profession;

(c) the firm or any of its partners should not have been disqualified or black-listed by the Comptroller and Auditor General of India or the Authority; and

(d) the firm should have an office in the State or in an adjacent State with at least 2 (two) practising Chartered Accountants on its rolls in such State.

2.2 Interested firms meeting the eligibility criteria shall be required to submit a statement of their capability including the bio-data of all the practising Chartered Accountants on its rolls. In particular, each firm shall be required to furnish year-wise information relating to the names of all the companies with an annual turnover exceeding Rs. 100,00,00,000 (Rs. one hundred crore) whose annual accounts were audited by such firm in any of the preceding 5 (five) Accounting Years.

3 Evaluation and selection

3.1 The information furnished by each firm shall be scrutinised and evaluated by the Authority and 1 (one) point shall be awarded for each annual audit of the companies specified in Paragraph 2.2 above. (For the avoidance of doubt, a firm which has conducted audit of the annual accounts of any such company for five years shall be awarded five points).

3.2 The Authority shall prepare a list of all the eligible firms along with the points scored by each such firm and 10 (ten) firms scoring the highest points shall be identified and included in the draft Panel of Chartered Accountants.

4 Consultation with the Concessionaire

The Authority shall convey the aforesaid panel of firms to the Concessionaire for scrutiny and comments, if any. The Concessionaire shall be entitled to scrutinise the relevant records of the Authority to ascertain whether the selection of firms has been undertaken in accordance with the prescribed procedure and it shall send its comments, if any, to the Authority within 15 (fifteen) days of receiving the aforesaid panel.

5 Mutually agreed panel

5.1 The Authority shall, after considering all relevant factors including the comments, if any, of the Concessionaire, finalise and constitute a panel of 10 (ten) firms which shall be deemed to be the mutually agreed Panel of Chartered Accountants.

5.2 After completion of every five years from the date of preparing the mutually agreed Panel of Chartered Accountants, or such earlier period as may be agreed between the Authority and the Concessionaire, a new panel shall be prepared in accordance with the provisions of this Schedule - T.

SCHEDULE –U
(See Clause38.3)

VESTING CERTIFICATE

1 The Chairman, National Highways Authority of India (the "Authority") refers to the Concession Agreement dated *** (the "Agreement") entered into between the Authority and **CHENANI NASHRI TUNNELWAY LIMITED**, (the "Concessionaire") for Two/Four-Laning of the Chenani - Nashri Section of National Highway No.1A (the "Project Highway") on Design, build, Finance, operate and transfer on annuity ("DBFOT Annuity") basis.

2 The Authority hereby acknowledges compliance and fulfilment by the Concessionaire of the Divestment Requirements set forth in Clause 38.1 of the Agreement on the basis that upon issue of this Vesting Certificate, the Authority shall be deemed to have acquired, and all title and interest of the Concessionaire in or about the Project Highway shall be deemed to have vested unto the Authority, free from any encumbrances, charges and liens whatsoever.

3 Notwithstanding anything to the contrary contained hereinabove, it shall be a condition of this Vesting Certificate that nothing contained herein shall be construed or interpreted as waiving the obligation of the Concessionaire to rectify and remedy any defect or deficiency in any of the Divestment Requirements and/or relieving the Concessionaire in any manner of the same.

Signed this *** day of ***, 20** at Delhi.

AGREED, ACCEPTED AND SIGNED	SIGNED, SEALED AND DELIVERED
For and on behalf of	For and on behalf of
CONCESSIONAIRE by:	NATIONAL HIGHWAYS AUTHORITY OF INDIA by:
(Signature)	(Signature)
(Name)	(Name)
(Designation)	(Designation)
(Address)	(Address)

In the presence of:

1.

2.

Chenani Nashri Tunnelway Limited

SCHEDULE –V
(See Clause 40.3.1)

SUBSTITUTION AGREEMENT

THIS SUBSTITUTION AGREEMENT is entered into on this the *** day of *** 20**.

AMONGST

1 The National Highways Authority of India, established under the National Highways Authority of India Act 1988, represented by its Chairman and having its principal offices at G-5 & 6, Sector 10, Dwarka, New Delhi-110075 (hereinafter referred to as the "Authority" which expression shall unless repugnant to the context or meaning thereof include its administrators, successors and assigns);

2 **CHENANI NASHRI TUNNELWAY LIMITED**, a company incorporated under the provisions of the Companies Act, 1956 and having its registered office at The IL & FS Financial Center, Plot C-22, G Block, Bandra Kurla Complex, Bandra (E), Mumbai 400 051, Maharashtra, India, (hereinafter referred to as the "Concessionaire" which expression shall unless repugnant to the context or meaning thereof include its successors and permitted assigns and substitutes);

3 **** name and particulars of Lenders' Representative and having its registered office at ****, acting for and on behalf of the Senior Lenders as their duly authorised agent with regard to matters arising out of or in relation to this Agreement (hereinafter referred to as the "Lenders' Representative", which expression shall unless repugnant to the context or meaning thereof include its successors and substitutes);

WHEREAS:

(A) The Authority has entered into a Concession Agreement dated *** with the Concessionaire (the "Concession Agreement") for Two/Four-Laning of the Chenani - Nashri Section (km 89.00 to 130.00 (new alignment) including 9 Km long tunnel (2 lane) with parallel escape tunnel) of National Highway No. 1A in the State of Jammu and Kashmir on Design, build, Finance, operate and transfer basis on annuity (DBFOT Annuity), and a copy of which is annexed hereto and marked as Annex-A to form part of this Agreement.

(B) Senior Lenders have agreed to finance the Project in accordance with the terms and conditions set forth in the Financing Agreements.

(C) Senior Lenders have requested the Authority to enter into this Substitution Agreement for securing their interests through assignment, transfer and

substitution of the Concession to a Nominated Company in accordance with the provisions of this Agreement and the Concession Agreement.

(D) In order to enable implementation of the Project including its financing, construction, operation and maintenance, the Authority has agreed and undertaken to transfer and assign the Concession to a Nominated Company in accordance with the terms and conditions set forth in this Agreement and the Concession Agreement.

NOW IT IS HEREBY AGREED as follows:

1 DEFINITIONS AND INTERPRETATION

1.1 Definitions

In this Substitution Agreement, the following words and expressions shall, unless repugnant to the context or meaning thereof, have the meaning hereinafter respectively assigned to them:

"Agreement" means this Substitution Agreement and any amendment thereto made in accordance with the provisions contained in this Agreement;

"Financial Default" means occurrence of a material breach of the terms and conditions of the Financing Agreements or a continuous default in Debt Service by the Concessionaire for a minimum period of 3 (three) months;

"Lenders' Representative" means the person referred to as the Lenders' Representative in the foregoing Recitals;

"Nominated Company" means a company, incorporated under the provisions of the Companies Act, 1956, selected by the Lenders' Representative, on behalf of Senior Lenders, and proposed to the Authority for assignment/transfer of the Concession as provided in this Agreement;

"Notice of Financial Default" shall have the meaning ascribed thereto in Clause 3.2.1; and

"Parties" means the parties to this Agreement collectively and "Party" shall mean any of the Parties to this Agreement individually.

1.2 Interpretation

1.2.1 References to Lenders' Representative shall, unless repugnant to the context or meaning thereof, mean references to the Lenders' Representative, acting for and on behalf of Senior Lenders.

1.2.2 References to Clauses are, unless stated otherwise, references to Clauses of this Agreement.

1.2.3 The words and expressions beginning with capital letters and defined in this Agreement shall have the meaning ascribed thereto herein, and the words and expressions used in this Agreement and not defined herein but defined in the Concession Agreement shall, unless repugnant to the context, have the meaning ascribed thereto in the Concession Agreement.

1.2.4 The rules of interpretation stated in Clauses 1.2, 1.3 and 1.4 of the Concession Agreement shall apply, mutatis mutandis, to this Agreement.

2 ASSIGNMENT

2.1 Assignment of rights and title

The Concessionaire hereby assigns the rights, title and interest in the Concession to, and in favour of, the Lenders' Representative pursuant to and in accordance with the provisions of this Agreement and the Concession Agreement by way of security in respect of financing by the Senior Lenders under the Financing Agreements.

3 SUBSTITUTION OF THE CONCESSIONAIRE

3.1 Rights of substitution

3.1.1 Pursuant to the rights, title and interest assigned under Clause 2.1, the Lenders' Representative shall be entitled to substitute the Concessionaire by a Nominated Company under and in accordance with the provisions of this Agreement and the Concession Agreement.

3.1.2 The Authority hereby agrees to substitute the Concessionaire by endorsement on the Concession Agreement in favour of the Nominated Company selected by the Lenders' Representative in accordance with this Agreement. (For the avoidance of doubt, the Senior Lenders or the Lenders' Representative shall not be entitled to operate and maintain the Project Highway as Concessionaire either individually or collectively).

3.2 Substitution upon occurrence of Financial Default

3.2.1 Upon occurrence of a Financial Default, the Lenders' Representative may issue a notice to the Concessionaire (the "Notice of Financial Default") along with particulars thereof, and send a copy to the Authority for its information and record. A Notice of Financial Default under this Clause 3 shall be conclusive evidence of such Financial Default and it shall be final and binding upon the

Concessionaire for the purposes of this Agreement.

3.2.2 Upon issue of a Notice of Financial Default hereunder, the Lenders' Representative may, without prejudice to any of its rights or remedies under this Agreement or the Financing Agreements, substitute the Concessionaire by a Nominated Company in accordance with the provisions of this Agreement.

3.2.3 At any time after the Lenders' Representative has issued a Notice of Financial Default, it may by notice require the Authority to suspend all the rights of the Concessionaire and undertake the operation and maintenance of the Project Highway in accordance with the provisions of Article 36 of the Concession Agreement, and upon receipt of such notice, the Authority shall undertake Suspension under and in accordance with the provisions of the Concession Agreement. The aforesaid Suspension shall be revoked upon substitution of the Concessionaire by a Nominated Company, and in the event such substitution is not completed within 180 (one hundred and eighty) days from the date of such Suspension, the Authority may terminate the Concession Agreement forthwith by issuing a Termination Notice in accordance with the provisions of the Concession Agreement; provided that upon written request from the Lenders' Representative and the Concessionaire, the Authority may extend the aforesaid period of 180 (one hundred and eighty) days by a period not exceeding 90 (ninety) days.

3.3 Substitution upon occurrence of Concessionaire Default

3.3.1 Upon occurrence of a Concessionaire Default, the Authority shall by a notice inform the Lenders' Representative of its intention to issue a Termination Notice and grant 15 (fifteen) days time to the Lenders' Representative to make a representation, stating the intention to substitute the Concessionaire by a Nominated Company.

3.3.2 In the event that the Lenders' Representative makes a representation to the Authority within the period of 15 (fifteen) days specified in Clause 3.3.1, stating that it intends to substitute the Concessionaire by a Nominated Company, the Lenders' Representative shall be entitled to undertake and complete the substitution of the Concessionaire by a Nominated Company in accordance with the provisions of this Agreement within a period of 180 (one hundred and eighty) days from the date of such representation, and the Authority shall either withhold Termination or undertake Suspension for the aforesaid period of 180 (one hundred and eighty) days; provided that upon written request from the Lenders' Representative and the Concessionaire, the Authority shall extend the aforesaid period of 180 (one hundred and eighty) days by a period not exceeding 90 (ninety) days.

3.4 Procedure for substitution

3.4.1 The Authority and the Concessionaire hereby agree that on or after the date of Notice of Financial Default or the date of representation to the Authority under Clause 3.3.2, as the case may be, the Lenders' Representative may, without prejudice to any of the other rights or remedies of the Senior Lenders, invite, negotiate and procure offers, either by private negotiations or public auction or tenders for the take over and transfer of the Project Highway including the Concession to the Nominated Company upon such Nominated Company's assumption of the liabilities and obligations of the Concessionaire towards the Authority under the Concession Agreement and towards the Senior Lenders under the Financing Agreements.

3.4.2 To be eligible for substitution in place of the Concessionaire, the Nominated Company shall be required to fulfil the eligibility criteria that were laid down by the Authority for shortlisting the bidders for award of the Concession; provided that the Lenders' Representative may represent to the Authority that all or any of such criteria may be waived in the interest of the Project, and if the Authority determines that such waiver shall not have any material adverse effect on the Project, it may waive all or any of such eligibility criteria.

3.4.3 Upon selection of a Nominated Company, the Lenders' Representative shall request the Authority to:

(a) accede to transfer to the Nominated Company the right to construct, operate and maintain the Project Highway in accordance with the provisions of the Concession Agreement;

(b) endorse and transfer the Concession to the Nominated Company, on the same terms and conditions, for the residual Concession Period; and

(c) enter into a Substitution Agreement with the Lenders' Representative and the Nominated Company on the same terms as are contained in this Agreement.

3.4.4 If the Authority has any objection to the transfer of Concession in favour of the Nominated Company in accordance with this Agreement, it shall within 7 (seven) days from the date of proposal made by the Lenders' Representative, give a reasoned order after hearing the Lenders' Representative. If no such objection is raised by the Authority, the Nominated Company shall be deemed to have been accepted. The Authority thereupon shall transfer and endorse the Concession within 7 (seven) days of its acceptance/deemed acceptance of the Nominated Company; provided that in the event of such objection by the Authority, the Lenders' Representative may propose another Nominated Company whereupon

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the procedure set forth in this Clause 3.4 shall be followed for substitution of such Nominated Company in place of the Concessionaire.

3.5 Selection to be binding

The decision of the Lenders' Representative and the Authority in selection of the Nominated Company shall be final and binding on the Concessionaire. The Concessionaire irrevocably agrees and waives any right to challenge the actions of the Lenders' Representative or the Senior Lenders or the Authority taken pursuant to this Agreement including the transfer/assignment of the Concession in favour of the Nominated Company. The Concessionaire agrees and confirms that it shall not have any right to seek revaluation of assets of the Project or the Concessionaire's shares. It is hereby acknowledged by the Parties that the rights of the Lenders' Representative are irrevocable and shall not be contested in any proceedings before any court or Authority and the Concessionaire shall have no right or remedy to prevent, obstruct or restrain the Authority or the Lenders' Representative from effecting or causing the transfer by substitution and endorsement of the Concession as requested by the Lenders' Representative.

4 PROJECT AGREEMENTS

4.1 Substitution of Nominated Company in Project Agreements

The Concessionaire shall ensure and procure that each Project Agreement contains provisions that entitle the Nominated Company to step into such Project Agreement, in its discretion, in place and substitution of the Concessionaire in the event of such Nominated Company's assumption of the liabilities and obligations of the Concessionaire under the Concession Agreement.

5 TERMINATION OF CONCESSION AGREEMENT

5.1 Termination upon occurrence of Financial Default

At any time after issue of a Notice of Financial Default, the Lenders' Representative may by a notice in writing require the Authority to terminate the Concession Agreement forthwith, and upon receipt of such notice, the Authority shall undertake Termination under and in accordance with the provisions of Article 37 of the Concession Agreement.

5.2 Termination when no Nominated Company is selected

In the event that no Nominated Company acceptable to the Authority is selected and recommended by the Lenders' Representative within the period of 180 (one hundred and eighty) days or any extension thereof as set forth in Clause 3.3.2, the Authority may terminate the Concession Agreement forthwith in accordance with

Chenani Nashri Tunnelway Limited

the provisions thereof.

5.3 Realisation of Debt Due

The Authority and the Concessionaire hereby acknowledge and agree that, without prejudice to their any other right or remedy, the Lenders' Representative is entitled to receive from the Concessionaire, without any further reference to or consent of the Concessionaire, the Debt Due upon Termination of the Concession Agreement. For realisation of the Debt Due, the Lenders' Representative shall be entitled to make its claim from the Escrow Account in accordance with the provisions of the Concession Agreement and the Escrow Agreement.

6 DURATION OF THE AGREEMENT

6.1 Duration of the Agreement

This Agreement shall come into force from the date hereof and shall expire at the earliest to occur of the following events:

(a) Termination of the Agreement; or

(b) no sum remains to be advanced, or is outstanding to the Senior Lenders, under the Financing Agreements.

7 INDEMNITY

7.1 General indemnity

7.1.1 The Concessionaire will indemnify, defend and hold the Authority and the Lenders' Representative harmless against any and all proceedings, actions and third party claims for any loss, damage, cost and expense of whatever kind and nature arising out of any breach by the Concessionaire of any of its obligations under this Agreement or on account of failure of the Concessionaire to comply with Applicable Laws and Applicable Permits.

7.1.2 The Authority will indemnify, defend and hold the Concessionaire harmless against any and all proceedings, actions and third party claims for any loss, damage, cost and expense arising out of failure of the Authority to fulfil any of its obligations under this Agreement, materially and adversely affecting the performance of the Concessionaire's obligations under the Concession Agreement or this Agreement, other than any loss, damage, cost and expense, arising out of acts done in discharge of their lawful functions by the Authority, its officers, servants and agents.

7.1.3 The Lenders' Representative will indemnify, defend and hold the Concessionaire harmless against any and all proceedings, actions and third party claims for any

loss, damage, cost and expense arising out of failure of the Lenders' Representative to fulfil its obligations under this Agreement, materially and adversely affecting the performance of the Concessionaire's obligations under the Concession Agreement, other than any loss, damage, cost and expense, arising out of acts done in discharge of their lawful functions by the Lenders' Representative, its officers, servants and agents.

7.2 Notice and contest of claims

In the event that any Party hereto receives a claim from a third party in respect of which it is entitled to the benefit of an indemnity under Clause 7.1 or in respect of which it is entitled to reimbursement (the "Indemnified Party"), it shall notify the other Party responsible for indemnifying such claim hereunder (the "Indemnifying Party") within 15 (fifteen) days of receipt of the claim and shall not settle or pay the claim without the prior approval of the Indemnifying Party, such approval not to be unreasonably withheld or delayed. In the event that the Indemnifying Party wishes to contest or dispute the claim, it may conduct the proceedings in the name of the Indemnified Party and shall bear all costs involved in contesting the same. The Indemnified Party shall provide all cooperation and assistance in contesting any claim and shall sign all such writings and documents as the Indemnifying Party may reasonably require.

8 DISPUTE RESOLUTION

8.1 Dispute resolution

8.1.1 Any dispute, difference or claim arising out of or in connection with this Agreement which is not resolved amicably shall be decided by reference to arbitration to a Board of Arbitrators comprising one nominee each of the Authority, Concessionaire and the Lenders' Representative. Such arbitration shall be held in accordance with the Rules of Arbitration of the International Centre for Alternative Dispute Resolution, New Delhi (the "Rules") or such other rules as may be mutually agreed by the Parties, and shall be subject to provisions of the Arbitration and Conciliation Act, 1996.

8.1.2 The Arbitrators shall issue a reasoned award and such award shall be final and binding on the Parties. The venue of arbitration shall be Delhi and the language of arbitration shall be English.

9 MISCELLANEOUS PROVISIONS

9.1 Governing law and jurisdiction

This Agreement shall be construed and interpreted in accordance with and governed by the laws of India, and the Courts at Delhi shall have jurisdiction over

Chenani Nashri Tunnelway Limited

all matters arising out of or relating to this Agreement.

9.2 Waiver of sovereign immunity

The Authority unconditionally and irrevocably:

(a) agrees that the execution, delivery and performance by it of this Agreement constitute commercial acts done and performed for commercial purpose;

(b) agrees that, should any proceedings be brought against it or its assets, property or revenues in any jurisdiction in relation to this Agreement or any transaction contemplated by this Agreement, no immunity (whether by reason of sovereignty or otherwise) from such proceedings shall be claimed by or on behalf of the Authority with respect to its assets;

(c) waives any right of immunity which it or its assets, property or revenues now has, may acquire in the future or which may be attributed to it in any jurisdiction; and

(d) consents generally in respect of the enforcement of any judgement or award against it in any such proceedings to the giving of any relief or the issue of any process in any jurisdiction in connection with such proceedings (including the making, enforcement or execution against it or in respect of any assets, property or revenues whatsoever irrespective of their use or intended use of any order or judgement that may be made or given in connection therewith).

9.3 Priority of agreements

In the event of any conflict between the Concession Agreement and this Agreement, the provisions contained in the Concession Agreement shall prevail over this Agreement.

9.4 Alteration of terms

All additions, amendments, modifications and variations to this Agreement shall be effectual and binding only if in writing and signed by the duly authorised representatives of the Parties.

9.5 Waiver

9.5.1 Waiver by any Party of a default by another Party in the observance and performance of any provision of or obligations under this Agreement:

(a) shall not operate or be construed as a waiver of any other or subsequent

default hereof or of other provisions of or obligations under this Agreement;

(b) shall not be effective unless it is in writing and executed by a duly authorised representative of the Party; and

(c) shall not affect the validity or enforceability of this Agreement in any manner.

9.5.2 Neither the failure by either Party to insist on any occasion upon the performance of the terms, conditions and provisions of this Agreement or any obligation thereunder nor time or other indulgence granted by a Party to another Party shall be treated or deemed as waiver of such breach or acceptance of any variation or the relinquishment of any such right hereunder.

9.6 No third party beneficiaries

This Agreement is solely for the benefit of the Parties and no other person or entity shall have any rights hereunder.

9.7 Survival

9.7.1 Termination of this Agreement:

(a) shall not relieve the Parties of any obligations hereunder which expressly or by implication survive termination hereof; and

(b) except as otherwise provided in any provision of this Agreement expressly limiting the liability of either Party, shall not relieve either Party of any obligations or liabilities for loss or damage to the other Party arising out of or caused by acts or omissions of such Party prior to the effectiveness of such termination or arising out of such termination.

9.7.2 All obligations surviving the cancellation, expiration or termination of this Agreement shall only survive for a period of 3 (three) years following the date of such termination or expiry of this Agreement.

9.8 Severability

If for any reason whatever any provision of this Agreement is or becomes invalid, illegal or unenforceable or is declared by any court of competent jurisdiction or any other instrumentality to be invalid, illegal or unenforceable, the validity, legality or enforceability of the remaining provisions shall not be affected in any manner, and the Parties will negotiate in good faith with a view to agreeing to one or more provisions which may be substituted for such invalid, unenforceable or

Chenani Nashri Tunnelway Limited

illegal provisions, as nearly as is practicable to such invalid, illegal or unenforceable provision. Failure to agree upon any such provisions shall not be subject to dispute resolution under Clause 8 of this Agreement or otherwise.

9.9 Successors and assigns

This Agreement shall be binding on and shall inure to the benefit of the Parties and their respective successors and permitted assigns.

9.10 Notices

All notices or other communications to be given or made under this Agreement shall be in writing, shall either be delivered personally or sent by courier or registered post with an additional copy to be sent by facsimile. The address for service of each Party and its facsimile number are set out under its name on the signing pages hereto. A notice shall be effective upon actual receipt thereof, save that where it is received after 5.30 (five thirty) p.m. on any day, or on a day that is a public holiday, the notice shall be deemed to be received on the first working day following the date of actual receipt. It is hereby agreed and acknowledged that any Party may by notice change the address to which such notices and communications to it are to be delivered or mailed. Such change shall be effective when all the Parties have notice of it.

9.11 Language

All notices, certificates, correspondence and proceedings under or in connection with this Agreement shall be in English.

9.12 Authorised representatives

Each of the Parties shall by notice in writing designate their respective authorised representatives through whom only all communications shall be made. A Party hereto shall be entitled to remove and/or substitute or make fresh appointment of such authorised representative by similar notice.

9.13 Original Document

This Agreement may be executed in three counterparts, each of which when executed and delivered shall constitute an original of this Agreement.

Chenani Nashri Tunnelway Limited

IN WITNESS WHEREOF THE PARTIES HAVE EXECUTED AND DELIVERED THIS AGREEMENT AS OF THE DATE FIRST ABOVE WRITTEN.

SIGNED, SEALED AND DELIVERED
For and on behalf of
CONCESSIONAIRE by:

(Signature)
(Name)
(Designation)
(Address)
(Fax No.)

SIGNED, SEALED AND DELIVERED
For and on behalf of
NATIONAL HIGHWAYS AUTHORITY OF INDIA by:

(Signature)
(Name)
(Designation)
(Address)
(Fax No.)

SIGNED, SEALED AND DELIVERED

For and on behalf of
SENIOR LENDERS by the Lenders' Representative:

(Signature)
(Name)
(Designation)
(Address)
(Fax)

In the presence of:

1.

2.