

**Employer's Requirements**

**Technical Specification**

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# 1. INTRODUCTION

.....” Describe the Project and Brief Scope of the Project” .....

**Example :**

“This Project covers the rehabilitation of road and a the construction of a new tunnel and a pedestrian rockshed on the Siddhababa stretch along the Siddhartha Highway, between Chainage 28+200 Km to 30+600 Km.

The Siddhababa Road Section is a very hazardous road section, due to the highly fractured rockfall site at the hillside of the road, characterized by an unfavourably discontinuity orientation with respect to the road alignment, and to high and steep slopes easily split by monsoon precipitation.

Since a relevant number of rockfall events has been registered during the time, a detailed design of permanent structures for rockfall protections has been developed to minimize the hazard of rock slope instability and debris flow.

Despite complementary to the main scope of the work, which is related to the permanent protection measures against rockfall, some additional issues have been considered since relevant to provide a complete and effective project design, such as:

- Road alignment improvement;
- Standardizing cross-section and durable pavement;
- Water collection systems design;
- Hydraulic management and flooding protections on crossing streams;
- Permanent protections against debris flow...”

## **2. GENERAL CONDITIONS**

### **2.1. General**

The purpose of this general Technical Specification is to supplement the requirements set forth in the "General Conditions of Contract", in the section "Special Condition of Contract" mainly in regard to specific technical aspects.

This document recall and extend - with reference to other international standards, where necessary - the general requirements set forth in the corresponding section of **“Standard Specifications for Road and Bridge Works – 2073 with 2075 Amendment”**, Government of Nepal, Ministry of Physical Infrastructure and Transport - Department of Roads.

**Only technical requirements from Standard Specifications for Road and Bridge Works – 2073(2075 amended) are applicable for this Contract. For payment, please refer to the specific clause of this Contract.**

#### **2.1.1. Definitions**

All definitions included in this Technical Specification shall have the meaning defined in the "General Conditions of Contract" with the amendments and additions set forth in the section "Special Condition of Contract".

#### **2.1.2. Unit System**

Unless otherwise noted in the specific chapters, the unit system applied throughout this Technical Specification and in all technical documents prepared by the Employer's Engineers and to be prepared by the Contractor shall be the International Unit System SI as defined in international standard ISO 1000:1992(E).

#### **2.1.3. Language**

The English language shall be used throughout the Contract Documents and in all communication, either verbal or written, throughout the Contract. Furthermore the language to be used during all official meetings shall be English, and the relevant minutes shall also be in English. No written communication in any language other than English will have any official Contractual status.

#### **2.1.4. Codes and Standards**

The Codes and Standards to be adopted for the various works included in the project are referred to in the relevant chapters of this Specification and in the previous **Section VI - Employer's Requirement (ERQ) Technical Requirements**).

The Contractor may propose alternative international or internationally recognised Codes and Standards, provided that these offer guarantees of safety, suitability and fitness for purpose equivalent to those offered by the Codes and Standards indicated in this Tender Documents and subject to the approval of the Engineer.

By presenting his bid, the Contractor acknowledges that he is familiar with all Codes and Standards that are referred to in this Specification.

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### **2.1.5. Approval/Review by the Engineer**

Whenever **approval or Review, whichever is applicable**; by the Engineer is mentioned throughout this Technical Specification, this shall be understood to mean approval in writing by the Engineer.

Such approval by the Engineer will not relieve the Contractor of any of his responsibilities under the Contract.

### **2.1.6. Drawings**

All detail design Drawings, shop Drawings and "as built" Drawings prepared by the Contractor shall be submitted to the Engineer in 5 full size copies on paper as well as in digital form in AutoCAD compatible files. All other technical submittals, such as but not limited to: method statements, QC reports, dimensional survey reports and "as built" sections, shall be submitted to the Engineer in 5 copies and in digital form when required by the Engineer.

### **2.1.7. Initial Submittals after Order of Commencement**

After receiving the Order of Commencement (O.o.C.), the Contractor shall, according to the details set forth in this Technical Specification, submit management documents in order to allow the Employer to monitor his initial activities and his organizational capabilities.

The following table gives a summary of the documents to be supplied in the first month. The table is supplied only as a guide-line and it is anyhow the Contractor's sole responsibility to thoroughly check the requirements of this Technical Specification, to identify all requested submittals and to supply them in strict compliance with the deadlines herewith indicated.

Calendar Days after O.o.C.	Document description
14	Drawing showing site facilities
28	General survey of project areas
	Detailed Design
28	Detailed Construction time schedule
28	Description of construction methods
28	QC Manual and description of QC organisation

## **2.2. The Works**

### **2.2.1. Scope of Works**

The scope of work is related to the **Design-Build/EPC** activities for ..... **"Explain the Scope with location / chainage information"** .....

#### **Example :**

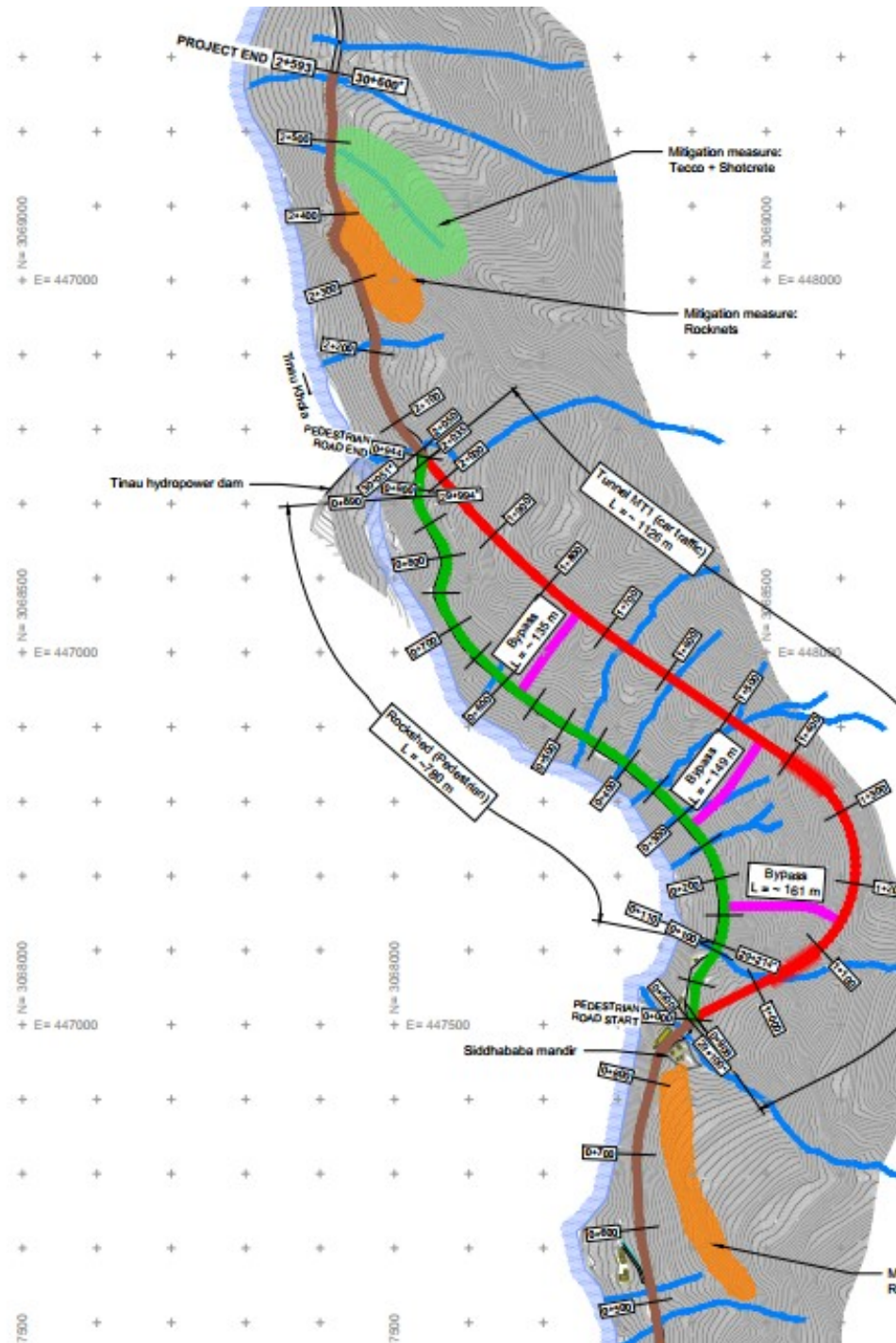
" The scope of work is related to the EPC activities for the rehabilitation of road and the construction of a new tunnel and a new pedestrian rockshed on the Siddhababa stretch along the Siddhartha Highway, between Chainage 28+200 Km to 30+600 Km. "

**2.2.2. Project Description**

....."Describe the details" .....

Example :

"This Project aims at avoiding any risk related to rockfall and slope instability in the high hazard sections for car traffic and, at the same time, finding an attractive solution also for pedestrians and cycles.



**Figure 1: General Plan View of the Project Area**

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The project foresees an existing track diversion in a new two lanes tunnel for motor vehicles only (one lane for each direction), along the whole high hazard sections, departing from the existing road near the Siddha Baba Mandir and reconnects to it near the hydropower plant, for a total length of about 1126 m.

Bicycles and pedestrian keep on following the existing road alignment, protected, along the whole high hazard section, by a rockshed with reduced internal dimensions of 3.6mx3.5m, suitable to house only pedestrians and ambulance (or emergency car), in case of emergency situations.

In detail, the road design foresees both the rehabilitation of the existing road, from chainage 28+200.00 to 29+100.00 (called Main Road 1 - MT1) and from chainage 30+050.00 to 30+600.00, (called Main Road 2 - MT2) and the variation of the existing road alignment to connect the new tunnel road, approximately 1126 m long, by deviating from the old alignment towards East around chainage 29+100.00 and towards West around chainage 30+050.

The rehabilitation of the existing road has been developed and design to limit rock excavation along the mountain side and rock stabilization/earth retaining structures along the valley side, to reduce costs and time of construction.

The new tunnel extends between chainages 0+908.46 (south portal) and 2+034.52 (north portal) and the position of the tunnel portals has been chosen considering a suitable site to minimize necessary excavation, hence entering the mountain almost perpendicularly to the slope, as well as to avoid the whole high hazard stretch. The U-shape of the tunnel horizontal alignment has been chosen in order to reach as soon as possible a sufficient depth (tunnel overburden) to minimize the tunnel excavation in low overburden areas, where weaker and altered rock can be foreseen, as well as larger water income. In order to improve visibility and traffic management, LED "cat's eye" devices will be installed above the kerb on both walkways.

Due to the new tunnel, the pre-existing alignment between around chainage 29+100 and 30+050 has been converted into a pedestrian-only road (called Pedestrian Road (PE)), comprehensive of two emergency aprons for reversal of traffic direction in case of tunnel closure during emergency. Moreover, each apron could be used as heliport in case of emergency. On the pedestrian road, the construction of a covered path with a rockshed has been foreseen from chainage around 29+215 to 29+995.

The pedestrian rockshed structure is connected to the emergency escape routes of the tunnel. According to tunnel safety measures (SIA 197-2), three pedestrian by-passes have been foreseen along the tunnel at chainages 1+145.00, 1+445.00 and ch. 1+745.00, with a spacing of 300m, so that, in case of emergency, the tunnel users can evacuate in the shortest possible time from the danger zone, leading directly to a safe space within the bypass tunnel itself and, from there, to the pedestrian rockshed along the existing road. No emergency escape route for vehicular access is foreseen due to the length of the tunnel (< 1.2 km).

This solution provides a minimal residual risk with regards to rock fall, as the car traffic diverted in tunnel is completely independent from rockfall events along the high hazard stretch and pedestrian are protected by the rockshed structure. The tunnel allows to mitigate the risk of a car traffic block not only in case of rockfall events, but also for unexpected debris flow or flooding due to high level of rainfall. Moreover, the tunnel car only provides maximum safety for pedestrian, as their route is separated from the car traffic.

Local wiremesh and rocknet are placed on adjacent medium and low hazard sections, in addition to local shotcreting for rock wall stabilization and local barring of instable rock mass.

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During construction, no diversion routes are necessary for cars as the construction of the tunnel can be carried on keeping in service the current route, while the rockshed for pedestrian can be built once tunnel is in service.

Please note that the general absolute chainage referred to the existing Siddhartha Highways has to be abandoned for this project due to the new alignment of the Siddhartha stretch and the new tunnel road.

The main features of the projects can be summarized as:

### **Road Improvements:**

including all works needed to guarantee expected improvements of existing road as by design criteria, such as works related to local widened of the existing road, pavement package replacement and construction of a carriageway drainage system. According to geometry requirement discussed during the feasibility stage and in line with the existing road dimensions, the design roadway total width is 8.50 m, including the 7.50 m width of carriageway, composed of two lanes 3.75 m wide and 0.50 m of shoulder on either side, and excluding the side drains.

### **Environmental protection measures: Hydraulic regimentation measures**

including all works related to the hydraulic regimentation of crossing streams, especially during monsoon period, by means of concrete culverts of different dimensions and geometry, which also allow the mitigation of risks related to unexpected debris flow or flooding.

Concrete culverts of different dimensions and geometry have been foreseen along the road alignment: embedded concrete pipes (internal dimension: from 900mm to 1200mm) and rectangular section culverts (from 1500x1500mm to 2000x2000mm) are provided along the main road, while open channel with inner section 1500mmx1500mm have been placed on the top of the pedestrian rockshed. Two double channel rectangular culverts have been required in the most critical area near the north and the south tunnel portal.

### **Environmental protection measures: Mitigation measures for rockfall medium and low risk areas**

including all works related to the three different types of measures here foreseen:

- Rocknet with Design Energy between 2000 KJ and 5000 KJ
- Local installation of adherence wiremesh (Tecco type) with bolts on stable outcrops upon the road, where only superficial debris and small blocks are expected, and local stabilisation systems by shotcrete with additional rock bolts, in areas interested by mudstone or other erosive or other erosive , i.e.material subject to erosion due to wash out or other causes.
- Local removal of single unstable blocks that cannot be withstood by the rocknet or to protect thick clay layers within an outcrop, that could otherwise get unstable because of gradual washout of clay during monsoon season.

### **Road diversion and Road Tunnel for rockfall high risk areas**

including all works related to the construction of the rock tunnel and the three emergency escape routes foreseen along its alignment with a maximum distance lower than required 300 m. The tunnel cross-section has been studied in accordance to European and Swiss tunnel guidelines, in order to house: a carriageway width of 7.5 m, sideways on both side with minimum width of 1 m and all necessary hydraulic systems and operational and safety equipment. The operational traffic space considered for design includes not only the necessary space for passing cars and trucks

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(height up to 4.5 m), but also standard space for signalling, upon the carriageway and on both sides, and for standard safety margins. Thanks to the almost circular section, upon the operation traffic space there is space to house air fans for the longitudinal ventilation system.

Tunnel design also includes all the equipment and systems needed for the structure to be operational, such as:

- No. 2 technologic Buildings, at northern and southern portal.
- Energy supply
- Lighting
- Ventilation
- Signage
- Surveillance system
- Control system and communication network
- Cabling system
- Auxiliary systems
- Control room

### **Pedestrian Rockshed for rockfall high risk areas**

including all works related to the construction of the cast-in-situ concrete structure characterized by a reinforced concrete slab covered with a cushion layer. Main characteristics of the rockshed are:

- Inner dimensions, to comply with pedestrian walkaway (**B x H = 3.5m x 5.0m**), with a length of about L = 800m;
- Cushion material, made of Leca 0-30 (or similar) with a medium height of 2m on the top slab of the shed, to protect the structure from falling rocks;
- Roof grade, to be at least 5% to provide drainage of the cushion material and possibly allow falling rock rolling over the rockshed roof.

Special Condition of Condition of [42. Extension of the Intended Completion Date.](#)

The layout of Works and the type of construction are presented in the drawings as defined in Volume 5 of the present contract documents. For the SYSTEMS and PLANTS scope of works, as defined in the Sub-Clause 1.1.5.9 in Volume 2 of the Tender Documents, other specific reports have been also included in Volume 5. The dimensions and the characteristics of structures and plants presented in the documents are indicative only and the Contractor has to develop his own design and assume the full responsibility of the design. ....”



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### 2.2.3. Site Conditions

....."Explain and Indicate the documents related to Site Condition....."

#### Example :

" The following reports have been prepared during the DPR phase by the Consultant and they are made available to the bidders:

List of Technical References available to the Tenderers

695013-D-A-G-R-001	Geological And Geotechnical Characterization Report
695013-D-A-G-R-002	Geological And Geotechnical Characterization Report - Annex 1: Geological Report
695013-D-A-G-R-003	Geological And Geotechnical Characterization Report - Annex 2: Geotechnical Investigation (Site Tests)
695013-D-A-G-R-004	Geological And Geotechnical Characterization Report - Annex 2: Geotechnical Investigation (Laboratory Tests)
695013-D-A-Z-S-001	Topographic Survey - Annex 1: D-Cards
695013-D-A-Z-R-002	Hydrogeological Report

The above documents are available for examination during the Tender. In order to have access to these documents, the Tenderers shall contact:

Government of Nepal

Ministry of Physical Infrastructure and Transport

Department of Roads

Sanogaucharan, Kathmandu, Nepal

Tel: +977-1-4440236

Email : dorfc@dor.gov.np ; Website: <http://www.dor.gov.np>

In consideration of the dimensions and complexity of the above reports and the logistic difficulties to have access to these documents, upon request to the Contracting Authority those documents can be provided to the Tenderers by email.

The Tenderers should be aware that said documents are provided **for information only**, and that they do not have any contractual validity. ...."

### 2.2.4. Ground Conditions

The Contractor shall satisfy himself as to the ground conditions appertaining to the works area by study of the site, site data and samples available, based on results of any additional investigation he may deem necessary.

The Contractor shall verify and make his own evaluations on stratigraphy and geotechnical parameters provided in the Tender Design, based on an independent interpretation of all the available information and on any additional investigation he may deem necessary. To its sole responsibility, Contractor may decide to endorse the given geotechnical characterization parameters or to define his own geotechnical characterization based on the available soil investigation results. In any case, He shall present a thorough interpretation report supporting the geotechnical characterization.

## **2.3. Mobilization and Demobilization**

### **2.3.1. General**

This Clause of the Specification covers all the operations required for Mobilization and Demobilization of plant, equipment and facilities required for executing the Works. Any additional requirement not included in this Clause is deemed to be included in the contract prices and will not be paid for separately.

It includes the supply at the site of all equipment required for the execution of the Works, including setting up the Contractor and Engineer site facilities, the warehouse, the workshop, provision of water, fuel, electric power and telephone supply, surveying of all type and everything else required to ensure continuous and uninterrupted performance of the Contract obligations during the construction period.

The Mobilization also includes routine and breakdown maintenance of all equipment, structures, devices, fixed points, etc. during the whole of the construction period.

On completion of the works, all equipment and materials shall be removed and the Site cleaned-up in accordance to the directives of the Engineer and to his full satisfaction.

The Contractor shall submit with his offer a detailed list of all the equipment, installations and facilities that are considered by him necessary for the execution of the works and that he had included in the different items for mobilization and demobilization. The list should indicate equipment that is wholly owned by the Contractor and equipment that is likely to be hired.

### **2.3.2. General mobilisation**

The Contractor obligations and all relevant expenses included in the lump sum price for mobilisation of the works under this Chapter shall include, but not limited to:

- Obtaining permits and authorizations from the relevant Authorities for the occupation of the working site, for extracting construction materials and for the exploitation of the ponds.
- Construction of the Contractor site in accordance with clause - "Construction site requirements."
- Supply, install and maintain the offices and facilities, security and safety for the Engineer in accordance with clause 2.3.5 requirements, within the required timeframe.
- Provide to the Engineer the vehicles in accordance with clause 2.3.6.
- Provide Fire truck and fire rescue vehicle for first aid and medical emergencies, within the required timeframe.
- Provide Toilet and Washing Facilities.
- Install Security Fencing.
- Transport, install, ready for use, and maintain during construction all equipment and whatever else required, as listed in the Contractor bid documents, for the execution of the Works.
- Install and/or maintain during the construction period all facilities deemed by the Contractor to be necessary for operating and safeguarding his land in full compliance with Nepali regulations.
- Provide, install and maintain the necessary lights and markers as be necessary to mark off the boundaries of the construction site as per relevant clause.

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### **2.3.3. Development of Contractor's design**

#### **2.3.3.1 General Requirements**

The Contractor shall prepare the detailed design of the whole works under this Contract.

The Contractor's design shall be developed in accordance with the criteria as specified in the **Employer's Requirements : Technical Requirements** and shall be submitted for approval to the Engineer.

For provisional works, i.e. those works which are instrumental to execute the Works under this Contract, the Contractor's design shall be submitted only for information to the Engineer and for approval, if required, to the competent authorities.

The Contractor shall verify and make his own evaluations on **rockfall hazard, stratigraphy, geotechnical and topographic parameters** provided in the Tender Design, based on an independent interpretation of all the available information and on any additional investigation he may deem necessary, to be used as base of his own design. To its sole responsibility, Contractor may decide to endorse the given geotechnical and topographic characterization parameters. In such a case, and if the original assumptions will be proven not to be adequate, the Contractor shall not be entitled to any additional compensation nor extension of time during the Contract execution. On the contrary, should the Contractor decide to define his own geotechnical, topographic characterization, he shall not be entitled to any additional compensation nor extension of time in case such characterization will be proven not to be adequate. The present provision shall prevail on any other statement may be differently interpreted and otherwise contained either in the Contract (including but not limited to Sub-Clause 4.12 of the General Conditions of the Contract). In any case, Contractor shall present a thorough interpretation report supporting the geotechnical characterization

The Contractor may divide the design of the entire project into smaller and independent design packages as may be deemed appropriate and as agreed upon with the Engineer to suit the construction.

The design activities shall include, but not be limited to:

- Further site investigation as deemed necessary by the Contractor;
- Data collection;
- Design reports and drawings

Shop and construction drawings relative to each Section of Works will be developed during construction and submitted to the Engineer for approval **not later than 1 month before the commencement of that work Section.**

The following criteria shall govern both the designs submitted at bidding stage and the Contract Works.

#### Design Standards

The Contractor's design shall fully comply with all relevant Main Standards, Norms and Legal Provisions presented in these Technical Specifications, and the Contractor shall check the applicability of each standard during design.

Should **European standards**, norms and specifications fail to give guidance on an element of design the Designer shall incorporate "best practice" from other International codes and standards to ensure a state-of-the-art, economical and viable design.

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The Contractor shall clearly identify the Standards and Norms to be used as the basis of their designs as part of each tender and construction submission, and shall provide full calculations with submissions so that the Engineer's may thoroughly check the tender submissions.

### Design Programme:

The Contractor shall submit the design documents, including drawings and other supporting documents forming the Contractor's Documents, in the form of design packages.

The timing of the design package submission shall be shown on the Contractor's programme.

The Contractor shall allow in his programme for technical submissions to the Authorities at the various stages. The Contractor shall make his own enquiries concerning the durations of these procedures and shall be responsible for managing the approval process.

The timing of the design package submission shall be approved by the Engineer and shall be phased, in accordance with the required permits, to allow time for the proper examination and **approval/review (as applicable)** by the Engineer. On receipt of the Engineer's **approval/review**, the Contractor shall apply for the necessary permits (on behalf of the Employer), or shall, as the case may be, prepare complete submissions allowing the Employer to apply for necessary permits.

### Specifications

The Contractor shall submit the construction specification as part of the design and in accordance with the Programme.

The construction specifications shall be specific to the Works designed by the Contractor. The construction specification shall be in full accordance with European standards and Nepali standards where applicable. The construction specifications shall include explicit references to standards used.

In addition to the above requirements, the construction specifications shall establish a level of quality for the Works consistent with best international practice.

The construction specifications shall be divided into separate parts covering all aspects of the temporary and permanent Works. The construction specifications shall be subject to approval by the Engineer.

### Calculations

The following information, without limitations, shall be included in the design calculations and reflected on the drawings:

- the governing design criteria such as design life, exposure conditions and seismic categories;
- standards used in the design and execution;
- design loads
- any other calculations or substantiation which the Engineer may request.

Calculations are to be typed in double spaced format with a clear and detailed index. All formulas and code clauses relied on are to be referenced in the text.

### Computer Calculations

The Contractor shall use industry standard software for the modelling, analysis and drawing of the design.

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Calculations prepared with appropriate Computer Programs shall have the following information attached, without limitations:

- name of the program and the version number;
- description of the program with general assumptions and limitations;
- basis of calculation and a description of the calculation process with any approximations or simplification being used;
- rules for notation;
- details of input loads, their method of derivation and quantity and load combinations used.

The results from any computer calculations shall include the following information, without limitations

- name of the structure and computer program with version number;
- list of contents;
- page number;
- data input;
- graphic representation of the calculation model

Output data shall be provided under Engineer's request. Calculations prepared with computer programs shall if necessary be supplemented with checks done by hand.

### Detailed Design Drawings

The Contractor will prepare all detailed design drawings necessary to construct the Works. All drawings shall be submitted to the Engineer for approval/review not later than 1 month before the programmed start of construction of the relevant element of the Works.

### Design of Temporary Works

The Contractor shall ensure all Temporary Works are in accordance with codes and standards above referenced in the relevant General Design Specification applied to each section of this document as appropriate. The Contractor shall submitted to the Engineer at least 14 days before the Temporary Works are constructed. If the Temporary Works are changed during construction the as-built Temporary Works must be covered by a new Temporary Works design and check certificate.

### Copies

All Contractor's Documents, including design submissions, calculations, drawings and supporting documents, shall be submitted in one original and four copies. The submissions shall be accompanied by indexes and drawings lists showing the documents unique reference number, date and revision number.

### Electronic Data

The Contractor shall provide electronic copies of all drawings and documents, including the models used to generate drawings in a format approved by the Engineer.

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### **2.3.3.2 Additional Requirements for PLANT and SYSTEMS**

**Example :**

"The Contractor's design of the PLANT and SYSTEMS works, as defined in the Sub-Clause 1.1.5.9 in Volume 2 of the Tender Documents, shall be developed in accordance with the following additional requirements.

695013-T-A-Z-F-003 - Tender Documents - Volume 3 - Annex C: "Exploitation and Safety Equipment - Technical Report And Design Basis"

695013-T-A-Z-F-003 - Tender Documents - Volume 3 - Annex D: "Ventilation System - Technical Report And Design Basis "

695013-T-A-Z-F-005 - Tender Documents - Volume 5:

695013-D-A-R-D-050 Signage Plan

695013-D-A-E-D-001 Synoptic Plan Of Exploitation And Safety Equipment

695013-D-A-E-D-002 Synoptic Plan Of The Ventilation System

695013-D-A-E-D-003 Layout Of The Ese In The Technical Building At The South Portal

695013-D-A-E-D-004 Layout Of The Ese In The Technical Building At The North Portal

695013-D-A-E-D-005 Tunnel Sections With Ese Layout

695013-D-A-E-K-001 Tunnel Control System Architecture

695013-D-A-E-K-002 Automatic Reactions Matrix"

### **2.3.4. Construction Site**

Contractor's areas for the Construction site shall be set up after having obtained the relevant authorization by the competent Authorities.

The Contractor shall carry out all preliminary works for the preparation of the land site (this is to include any storage or stockpile area, access way or road, office, accommodation or any facility to be used on the Project) including UXO & Mine detection survey and clearance in accordance with the local regulations and as required by the relevant Authorities.

The Contractor shall provide sufficient facilities required for the safe and expeditious development of his activities and for locating the environmental issues measuring stations.

Within 2 weeks of the Commencement Date the Contractor shall submit to the Engineer for **approval/review** Drawings of all his proposed site facilities and installations.

Any dwelling of workers on the site should be approved by the competent Authorities in advance. If the Contractor wishes to have worker dwelling on site, he shall install all necessary facilities, to the satisfaction of the competent Authorities.

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**2.3.5. Offices, Facilities, Safety and Security for Engineer and employer Staff**

The Contractor shall provide board, lodging and safety and security for the Engineer and for the Employer personnel for all the duration of works. Office facilities and accommodation must be ready for use from **one (1) month after** the Commencement Date.

**For the List of all the equipment, (if any, please list down below)**

.....  
.....  
.....

**2.3.6. Motor vehicles for the Engineer's and Employer's Staff**

The Contractor shall provide **two (2) vehicles**, with drivers, for the sole and continuous use of the Engineer – as a minimum they should be 4 wheel drive, suitable for the Project site environment. They should be air conditioned. The Contractor shall clean the vehicles at least once a week and shall arrange for servicing, until 6 weeks after the effective date of the issue of the Taking over Certificate for the whole of the works or such earlier times as instructed by the Engineer, whereupon the vehicle shall be removed from site.

The vehicles are to be air-conditioned.

The vehicles shall be licensed and insured to be driven on the site and on public highways by the Engineer and Employer Staff and persons authorized to drive by the Engineer, including use other than in connection with the Contract. All fuel, lubricants and other consumables shall be provided by the Contractor. On commencement of works the Contractor is to provide copies of the Vehicles insurance policies to the Engineer.

Equivalent replacement vehicle shall be provided during servicing and repair.

**2.3.7. Permanent/Temporary Camps – Key Requirements for Engineer's and Employer's Camp**

**2.3.7.1 Design and construction requirements**

A) General

Facilities shall be designed to provide adequate lighting / ventilation, plumbing and temperature control.

Facilities should be designed to prevent ingress of insects, pests, live stock and wild life.

Layout should be designed to prevent internal conflicts and ensure welfare of the workers and the neighbours of the camp. A security plan is to be submitted to the Engineer prior to Construction of the Camp for assessment. The security plan should plan and take into account possible disturbances within the Camp, Public disturbances outside the camp, evacuation plans from the Camp, Local Area or Country dependent on the level of risk. Emergency Procedures Plan for medical emergencies is to be submitted prior to the Camp Construction. The Camp should be equipped with a suitably qualified Nurse or EMT with the facilities and capabilities to treat relatively serious medical emergencies including but not limited to Heat related incidents and incidents requiring defibrillators. There must also be on site a dedicated ambulance.

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Thermal insulation for accommodation units shall meet national standards.

### B) Design requirements

The integrity of the camp shall be evaluated for all relevant design conditions.

Extreme environmental conditions shall be identified for the camp location and include consideration of wind, rainfall, flooding, snow and winter storms. It is advised to consult the local Meteorological Office.

Temporary camp buildings shall be designed to withstand extreme (25-year return period) conditions for:

- wind
- rainfall
- snow
- flooding

Facilities critical to personnel safety shall be designed to withstand an earthquake event with a return period of 100 years.

Accommodation units shall be placed at least 0.50 m above the design flood level.

Accommodation units shall be certified by an international or nationally recognised authority and the certificate shall state at least the following:

- Manufacturers name
- Maximum floor loads
- Lifting point capacities
- Date of Manufacture
- Roof Loads
- Fire resistance
- Weight
- Wind Loads
- Thermal resistance

### C) Fire and Emergency Escape

Units shall have sufficient fire resistance (where fire risks exist) – fire resistant materials shall conform to BS 476-3 certification (or equivalent).

Camps shall have designated escape routes, which are clearly identified and communicated in line with local regulations. Suitable safe muster areas shall be identified as the safe refuge area in the event of an emergency.

There shall safe distances between units to mitigate the risk of the spreading of fire.

Buildings to be fitted with smoke detectors.

Carbon monoxide detectors to be fitted where potential sources exist.

### D) Electrical supply

A certified electrician shall install the electrical supply and wiring in compliance with local regulations.



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The camp units shall be equipped with emergency cut off for electricity.

### E) Wastewater

The camp shall be designed to manage wastewater effluent (black and grey water) in an environmentally responsible manner in line with local regulations and industry practice.

### F) Lifting of accommodation units

Portakabin type units and containers shall be capable of withstanding the lifting operations, where lifted units are used.

The integrity of the pad-eyes of all units (containers and accommodation units) is to be confirmed for the lift weight multiplied with a factor of 1.25 for dynamic loading.

### **2.3.7.2 Design and construction requirements**

#### A) Sleeping arrangements

Bedrooms for the Engineer should be **minimum of 27 m<sup>2</sup> each**, including ensuite. Each person shall be provided their own bed with free floor access. There shall be no shift usage of bunks. Large Single beds (minimum) are to be provided. Engineer's Staff are to have one bedroom each – there is to be no sharing of bedrooms. Space for safe storage of personal possessions. Rooms are to be fully furnished (minimum furnishings to be large bed, wardrobe, desk, sofa, chair, small bedside table, fridge and tea/coffee making facilities, bedside or desk side lamp, TV desk and 32 inch TV with satellite digital box. Box to be capable of using satellite cards, internet/WiFi).

#### B) Sanitary Facilities

The general area toilets and sanitary facilities should be designed and constructed to meet the following criteria:

- Hand basin – 1 per 6 persons • Toilets – 1 per 15 person
- Shower – 1 per 10 persons • Urinals – 1 per 25 men
- Hot and cold water to wash basins and showers

Bedrooms to have ensuite facilities and showers.

#### C) Smoking Designation

Facilities shall be designated non-smoking, with dedicated covered areas available for smokers, separate from the main facilities.

#### D) Recreation and Welfare Facilities

Recreational and welfare facilities should be provided which should include:

- Telephone, email & internet facilities (minimum 1 phone per 100 persons)
- Satellite Television, video and films
- Exercise and sporting facilities
- Religious facilities if appropriate

#### E) Housekeeping and Laundry

Laundry services to be provided for all staff. Housekeeping services are to be provided at the camp an include cleaning of living quarters, sanitary facilities laundry and waste collection.

F) Catering

Catering facilities should be sufficient to seat at least 33% of the labour in one sitting. The food that is to be provided should be prepared in a safe environment reflecting proper hygienic standards. The Catering should be able to provide for a variety of different types of foods reflecting persons' cultural or religious requirements.

G) Water supply

Drinking water shall be from acceptable sources and meet drinking water standards. Prior to the full operation of the Camp the Contractor is to test the Drinking Water with a reputable Laboratory and submit the results to the Engineer.

A system to regular test for chemical and bacteriological contamination from several points of use shall be implemented.

**2.3.8. Water Supply to the Construction Site**

The Contractor shall satisfy himself as to the availability and suitability of water supplies to cover all his requirements in connection with the execution of the Works.

Water can be supplied by fresh water tankers which may moor at the berth reserved for supply vessels or by installing a self-standing water supply plant at the construction site.

The possible water supply plant shall include the execution and maintenance, for all the duration of the works, of deep water wells and/or the installation of a desalination plant, equipped with adequate pumping system, including the provision of storage tanks, as the Contractor may require to give him the requisite quantity of water at the pressure required at all times.

Well characteristics and location shall comply with the requirements of the relevant Water Authority. Construction can start only after the Water Authority and Engineer approval. The Contractor will be solely responsible for the supply and transportation of water from the well to the Site or his place of work or storage.

The water storage tank shall have sufficient capacity to also supply the fire truck.

**2.3.9. Fuel Supply to the Construction Site**

Diesel fuel supply is needed to power diesel generators, vehicles and construction equipment at the site. Depending on Contractor's type of equipment, a gasoline supply might be necessary as well.

In obtaining a supply of fuel the Contractor has to comply with any regulations or requirements that National Agencies or Government Departments may have for the supply, importation or transportation of fuel. All permissions, issues and costs associated with this are the responsibility of the Contractor and to be borne by the Contractor.

It is the responsibility of the Contractor to obtain or transport the fuel supply to site. Any costs associated with providing access for the supply are to be borne by the Contractor.

Ships carrying fuel will use the specific berth to offload and transfer the combustible to dedicated storage tanks at the site. The Contractor shall satisfy himself as to the size and number of the fuel tanks to be installed at the site to cover all his requirements in connection with the execution of the Works. In any case, one of the bulk storage diesel tanks will be a dedicated storage tank to the diesel generators and maintain a minimum of 24 hour emergency fuel supply.

**2.3.10. Electric Power Supply to the Construction Site**

The Contractor shall make his own arrangements for the temporary supply of any electricity and lighting system required for the execution of the Works and he shall issue all notices and pay all fees, dues, charges and other costs in respect thereof.

The Contractor shall be responsible for providing and maintaining the whole of the temporary electrical installation and in relation thereto shall take all reasonable precautions to ensure the safety of every person on the Site. The Engineer may require the disconnection or alteration of any parts that he considers may be dangerous.

The whole of the Contractor's temporary electrical installation shall comply with National Standards, the Institution of Electrical Engineers' "Regulations for the Electrical Equipment of Buildings" and the current British Standard Code of Practice.

As soon as any part or the whole of the Contractor's temporary electrical installation is no longer required for the carrying out of the Works, the Contractor shall disconnect and remove the same. The Contractor is to have adequate backup generators available to provide a backup supply to the Mains or site temporary supply.

**2.3.11. Telephone**

The Contractor shall provide such telephones as are required for his own use on Site and he shall issue all notices and pay all fees, dues, charges and other costs in respect thereof. All temporary telephone installations shall be removed on completion of the Works.

**2.3.12. Fire truck and fire rescue vehicle for first aid and medical emergencies**

The Contractor shall provide:

- No. 1 fire truck following the requirements of the Nepali Firefighting Authority, or in the absence of these in line with general firefighting requirements for Projects with similar activities;
- No. 1 fire rescue vehicle which shall cover also the function of ambulance service within the site boundary. (At the minimum this is to be provided on the occupation of the camp or start of any temporary or permanent works, whichever comes first)

The fire truck and fire rescue vehicle shall be in operation by Month 6, from the Date of Commencement. The Contractor is to submit his design prior to the truck being in operation.

**2.3.13. Toilet and Washing Facilities**

The Contractor shall provide suitable hygienic toilet and washing facilities for the use of his own workmen at suitable locations around the Site

Where possible the foregoing shall be connected to an existing sewage system, otherwise the contents therefore shall be disposed of at such place and in such manner as approved by the local Authority. The Contractor shall maintain the foregoing in a good sanitary condition throughout the period that they are in use and he shall remove and clear away same on completion of the Works or when no longer required.

The Contractor must exercise strict supervision of all persons employed by him to avoid nuisance or contamination of the Works.

**2.3.14. Security Fencing**

Security fencing approx. shall surround the entire land site facilities. Security perimeter fence lighting shall be provided. A Security Plan prepared for the Contractor by experienced Security Experts shall assess any proposed fence to ensure it is adequate for the Project Security requirements.

The fence shall be galvanized steel chain link, secured to 7-gauge coil spring wire at the top and to galvanized rail at the bottom, for a height of 2.5 m, plus 0.50 m height of 3 strands of barbed wire, and buried a minimum of .5m below ground level. The Contractor is to seek advice on providing other Perimeter Security Measures (Physical or otherwise) to ensure the Camp is fully secure in line with their submitted security plan.

**2.3.15. Batching plants**

The Contractor shall supply, install and maintain throughout the duration of the Contract, the batching plants necessary for the execution of the Works under the Contract, including, water chilling and flake ice production plants.

Mobilization of batching plants also includes formworks and equipment for transport and concrete casting.

**2.3.16. Demobilization**

Demobilization for the Works shall include, but not limited to, the following:

- Dismantling, preparation and loading for removal and shipment of all Contractors' installations and equipment at the Site.
- Transport all above equipment and materials from the Site to the Contractor's home station or elsewhere, outside the Site.
- Cleaning up of the site to the full satisfaction of the Engineer.

**2.4. Contractor's Organization at Site**

**2.4.1. General**

The Contractor shall set up at site a complete technical organization so that the following managerial and technical functions can be achieved:

- a) Management of the Contract with the Employer and of the Contracts with the suppliers and the Sub-Contractors
- b) Management of the Construction activities in the site
- c) Development of all required Drawings (shop Drawings of all steel structures and components, detail Drawings, etc.)
- d) Development of all construction Engineering including, but not limited to:
  - Method statements for all construction activities
  - Check of lifting gear for all lifts exceeding 20 t and for all lifts requiring multiple cranes
  - Check of Bearing capacity of soil and structures for all heavy vehicle movements

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- e) Development of all detailed planning of activities in order to control the progress of the works against the Contract Schedule, to update this schedule when appropriate and to identify problems in time to implement corrective measures
- f) Development of all Quality Control activities in order to monitor that all works are carried out according to the requirements of this Technical Specification and to timely implement corrective actions should the quality of the works fail to comply with the requirements.
- g) Updating "as-made" Drawings
- h) On-line computerized survey operations.
- i) Capability to process construction site data, including Survey data, on site.

The Contractor shall ensure that he has adequate staff on site for the Project for the processing of data, surveys, carrying out of any tests. This include adequate numbers during which periods staff are on rotation. The Contractor shall have the capabilities to process all data on site.

### **2.4.2. Technical Office**

The site technical office shall be staffed with Engineers and technicians employed by the Contractor or under Contract to him. The head of the technical office shall be an Engineer with BSc in Civil Engineering, 20 years of experience; 10 years of specific experience in design and construction of Road Tunnel; fluent in English;

The technical office shall be staffed by Engineers with proven experience, according to the requirements of EQC.

The total number of Engineers and technicians working in the technical office shall be such that all required technical documents are prepared within the time limits indicated in this Technical Specification prior to the execution of the actual site activities.

The Contractor shall submit CV's of Section Engineer's or Department Heads for assessment by the Engineer. These persons should be the direct line Managers between the Site and the Contractor's Management Team with responsibility for planning and carrying out of Construction Works. Any Key Position required in the Contract under the Special Conditions are assessed elsewhere.

### **2.4.3. Planning Office**

The planning office shall be staffed with Engineers and technicians employed by the Contractor or under Contract to him. The head of the planning office shall be an Engineer with at least 10 years proven experience in road works including tunnel.

The total number of Engineers and technicians working in the planning office shall be such that all required documents are prepared as follows:

- Daily
  - a. Activities performed
  - b. Workforce (personnel and equipment) subdivided per type of structure
  - c. Activities planned for next day
  - d. Reporting of vessel and plant transportation movements to/from site
- Weekly
  - a. Activities performed
  - b. Activities planned for next week
  - c. Progress achieved against planned

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- d. One week look ahead
- e. One month look ahead
- Monthly
  - a. Activities performed
  - b. Activities planned for next month
  - c. QC update of all materials due on the Project
  - d. S-curve of progress achieved against planned
  - e. Gantt chart showing original schedule, progress, updated schedule (if applicable)
  - f. One month look ahead
  - g. Three month look ahead

### **2.4.4. Quality Control Office**

The Quality Control Office shall be staffed with Engineers and technicians employed by the Contractor or under Contract to him. The head of the Quality Control Office shall be an Engineer with at least 10 years' experience in road works including the construction of road tunnels, including M&E equipment.

The quality control personnel shall coordinate the work of the Contractor's inspectors and prepare the QC documentation to be submitted to the Site Inspectors. They shall also be responsible for issuing non-conformance reports and for identifying the causes of such non-conformances and proposing the corrective actions to avoid them.

The total number of Engineers and technicians working in the Quality Control Office shall be such that all required QC documents are timely prepared and activities can be developed always under control and without delays.

The Contractor shall submit CV's of all persons involved in the Quality Control Office for assessment by the Engineer.

## **2.5. Health and Safety Requirements**

Due precautions shall be taken by the Contractor, and at his own expense, to ensure the safety of his staff and labour and, in collaboration with and to the requirements of the local health authorities, to ensure that medical staff, first aid equipment and stores, sick bay and suitable ambulance service are available on call at the site at all times throughout the period of the Contract and that suitable arrangements are made for prompt medical assistance and ambulance services in case of emergency. The availability of proper medical treatment and properly trained personnel should reflect the isolated nature of the site.

Detailed requirements concerning health and safety shall comply **Employer's Requirements : Minimum Safety Requirements for Road Tunnels Sections and the clauses** below :

All installations and activities referred to in the present Clause shall be at Contractor's expense.

### **2.5.1. Safety**

The Contractor shall be responsible for carrying out the works in a safe and sound manner to avoid risk or danger to all people employed on the Site, whether or not employed by the Contractor, and the General Public.

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The Contractor shall provide all equipment, training and facilities necessary to fulfil any statutory obligations on matters relating to Safety, Health and Welfare.

The Contractor shall be responsible for acquainting his employees and Sub Contractors with the potential hazards and shall institute positive measures, as necessary to ensure both the safety of his employees and that his own activities cause no additional hazards.

The Contractor shall make his own arrangements for the treatment of casualties on Site and for transporting the injured to hospital or their home at the expense of the Contractor.

### **2.5.2. Safety Officers**

The Contractor shall appoint a responsible person from his staff to undertake the duties of Safety Manager, Safety Officers and Safety Supervisors on Site. The Contractor shall inform the Engineer in writing prior to commencement of any work on the Contract of the nominated Safety Officer's name for formal approval.

### **2.5.3. First Aid**

The Contractor shall provide a qualified first-aider and supply and maintain at each main area of Site a set of first-aid equipment. Each unit shall comprise stretcher equipment and a container holding dressings and medicaments. The availability of proper medical treatment and properly trained personnel should reflect the isolated nature of the site. If there are many Construction fronts adequate first aid treatment should be available at each location and of a type to reflect the type of work.

First Aid persons, equipment and facilities shall be in place from the start of any activities on site.

### **2.5.4. Emergency Arrangements**

Before commencement of any of the Works the Contractor shall submit his proposed emergency procedures to the Engineer for approval.

In any case the Engineer must be informed as soon as is reasonably practicable of any emergency situation which develops on Site.

### **2.5.5. Contractor's Health and Safety Plan**

The Contractor shall develop the project Health and Safety Plan prior to the commencement of works on site. This development of the plan shall set out the arrangements which, taking account of the risks of health and safety involved, will ensure, so far as it is reasonably practicable, the health and safety of all persons at work on the project or who might be affected by the works. The development of the Health & Safety Plan shall include the arrangements for the management and co-ordination of the construction works including works by others carried out on the Site and for monitoring compliance by all persons with the requirements of relevant statutory provisions.

The Contractor shall be deemed to have included in his tender for:

- the provision for adequately controlling the risks to health and safety arising out of matters identified in the project Health and Safety Plan;
- the monitoring and control of all Contractors on the Site in respect of health and safety;
- the carrying out of all duties under all relevant statutory health and safety legislation.

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All Contractors shall be required to complete appropriate assessments of the risks to health and safety in respect of their works as required under applicable statutory legislation.

The Contractor shall:

- be responsible for coordinating cooperation between Contractors, employees and self-employed persons who are at work on the construction of the project.
- ensure, so far as is reasonably practicable, that all Contractors, employees and self-employed persons conform with the requirements of the project Health and Safety Plan.
- appoint a competent person on the site to manage health and safety during construction.
- ensure, so far as is reasonably practicable, that all persons employed on, or visiting, the site are adequately informed instructed, trained, supervised and equipped such that they are able to carry out their duties safely.
- take the steps necessary to ensure that only authorized persons are allowed into any construction area.

## **2.6. General Provisions during the Works**

### **2.6.1. General**

During the development of his construction activities, the Contractor shall follow the detailed requirements set forth in this Technical Specification and shall adhere to the general provisions defined in the following Clauses.

### **2.6.2. Surveys and Markings**

The geodetic datum and projection to be utilised for the survey horizontal position is :

Projection:	Modified Universal Transverse Mercator
Spheroid:	Everest 1830
Origin:	Longitude 84° East, Latitude 0° North
False Co-Ordinates Of Origin:	500000 M Easting
	0.000 M Northing
Scale Factor At Central Meridian:	0.9999

Reference benchmarks for determining co-ordinates and heights will be provided by the Engineer. Verification of the information provided by the Engineer shall be under Contractor responsibility. The Contractor is responsible for maintaining all markings in good condition throughout the entire construction period. Any correction required as a result of inaccurate measurement shall be made by the Contractor at his own expenses.

Contractor shall establish a firm benchmark reference structure on which the base GPS RTK antenna will be installed. Periodic control of vertical and horizontal coordinates of the antenna shall be carried out by the Contractor.

For surveying with GPS system the geodetic correction must be performed using the most accurate available geoid model.

Verification of the correctness of the model and transformation software shall be performed using optical instrumentation in a survey area of not less than 4 x 1 km.



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During construction of the emergent works periodic control of vertical and horizontal coordinates with optical instrumentation is required.

During the mobilization phase and in any case no later than 2 months following the Date of Commencement the Contractor shall perform a general topographic survey of the Project Site The general survey shall be used as the basis for the detailed design of the Works.

### **2.6.3. Survey and Inspection of Completed Works**

Upon completion of each structure, or portion thereof, as specified in the relevant chapters of this Technical Specification, the Contractor shall inform the Engineer who will arrange for his independent survey or inspection.

Should the Employer's inspectors discover that the structure in question is not completed or is defective, and therefore a further inspection is required, the Contractor shall bear the costs of such additional inspection by the Employer.

### **2.6.4. Avoiding Damage and Protecting Installations and Structures**

The Contractor shall exercise caution to avoid damage throughout the entire work period to over/under ground installations as well as structures and foundations and any type of structures and installations.

The Contractor shall protect the fabricated structures by means of protective measures as instructed by the Engineer.

Execution of supports, lining and other protective measures by the Contractor, though following the Engineer's instructions or approval, shall not provide the Contractor any waiver to his sole responsibility for the intact conditions of the structures and installations.

### **2.6.5. Traffic on Existing Roads**

During the execution of the Works, the stated road section within the project scope must be maintained open to traffic.

In addition to the relevant Contract Clauses, Contractor traffic on existing access roads and public roads for any purpose shall be limited to vehicles equipped with pneumatic wheel tyres.

Any damage caused to existing roads and public works shall be repaired by the Contractor at his expenses, to the satisfaction of the Engineer.

The Contractor shall prepare a plan for the maintenance and protection of traffic in accordance with the Standards and Regulations of the concerned authorities showing details of detours, locations of different types of signs and flashing signals, lights by night, flagmen, barricades, torches etc. and get the plan approved from the concerned authorities and shall provide, erect and maintain all the facilities in accordance with the approved plan. He will remove the above facilities after they are no longer required subject to the approval from the Engineer, and the concerned authorities at no additional cost.

The Contractor is to satisfy himself with the access roads or public road infrastructure to the Site. The Contractor is required to liaise with all Authorities who own, manage or control the traffic and permissions for the use of roads in the area. This liaison must be continued throughout the Project. The Contractor must allow for complying with the instructions. The Contractor must be mindful of

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the general public who use the road network and have alternative routes or plans in place for bringing materials, plant and equipment to site.

### **2.6.6. Compliance with the Environmental Impact Statement Requirements**

The Contractor shall take all the precautions during site activities in order to be in compliance with general environmental requirements presented in the following.

#### Avoidance of Water Pollution

- a) The Contractor shall obtain the standard procedures, if available, of the Environment Authority, and shall on this basis develop a manual indicating his actions in case water pollution occurs.
- b) The Contractor shall bear all damages and expenses caused by his negligence.

#### Avoidance of Air Pollution

- c) All vehicles transporting materials from site, that may cause dispersion of dust and/or other small particles shall be covered.

#### Solid waste management:

- d) Excess material or material unsuitable for re-use within the project should be disposed safely.
- e) If the above conditions cannot be met the excess be disposed of at an officially designated disposal site (Contractor to obtain all necessary license and permits for any such disposal).

The Employer shall not be responsible for any stoppage to the works imposed by the Environment Authority inspectors consequent to the Contractor's failure to comply with the above requirements.

The above stoppage shall not constitute reason to extend the execution period and/or to support any claim by the Contractor.

All installations and activities referred to in the present Clause shall be at Contractor's expense.

### **2.6.7. Inspection and Testing**

All inspectors and laboratories for testing of materials and/or fabrications referred to in this Technical Specification shall be approved by the Engineer.

The Contractor shall submit to the Engineer the c.v.s of the inspectors and full details of the laboratory personnel equipment, experience in carrying out the required tests at least 14 days prior to performance of the relevant activities.

All testing costs shall be borne by the Contractor.

### **2.6.8. Survey and Inspection of Completed Works**

Upon completion of each structure, or portion thereof, as specified in the relevant chapters of this Technical Specification, the Contractor shall inform the Engineer who will arrange for his independent survey or inspection.

Should the Employer's inspectors discover that the structure in question is not completed or is defective, and therefore a further inspection is required, the Contractor shall bear the costs of such additional inspection by the Employer.

The Contractor is to put in place a Procedure for the Notification of Request for Inspection by the Engineer for any section or part thereof that is required to be **Approved/Reviewed** by the Engineer. This Procedure is to be submitted to the Engineer prior to the start of any works.

### **2.6.9. Maintenance of Public Roads**

The Contractor shall regularly maintain the pavement of all the public roads he may use during the transport of material and/or equipment to the constructions site, not later than seven days after any deficiency is observed. However, the Engineer may instruct the Contractor to carry out the said maintenance, at any time, should the Engineer consider that these works are required in order to ensure safety and operational good functioning of the roads.

Asphalt pavement maintenance repair shall be carried out as follows:

- a) sawing of the perimeter of the surface to be repaired
- b) removal of the damaged asphalt layers
- c) compaction of the existing sub-grade layers
- d) spraying with a bituminous emulsion 1 kg/m<sup>2</sup>
- e) laying and compaction of bituminous concrete to the required thickness;

Maintenance repair of the shoulders shall be carried out as follows:

- a) removal of the shoulder material down to the sub base layer
- b) compaction of the sub base surface to 100% Modified AASHO
- c) laying and compaction of shoulder material with a thickness of 30 cm

Road Marking shall be carried out every three calendar months, according to Nepali codes.

### **2.6.10. Keeping Site Clean**

The Contractor shall at all times be responsible for the proper upkeep and maintenance of the site and the works.

The site shall be kept free from all rubbish and offensive matter, which shall be disposed of in a manner agreed by the Engineer. The Contractor shall not burn, nor permit to be burned, any material on site without the written consent of the Engineer on each and every occasion. The Contractor is to put in place an Environmental Plan for the Site, his activities and his Camp. This Environmental Plan is to provide for the encouragement of good environmental practices among all persons on site, and is to be communicated to all persons.

The site shall not be used for storage for materials other than those to be used in the execution of the works.

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Materials and equipment shall be positioned, stored and stacked in a safe and orderly manner.

The Contractor is to have in place an Oil Spill Response Plan and capabilities to deal with spillages up to Tier One Spill Level. For Tier 2 and 3 the Contractor is to include in his Oil Spill Response Plan how he will deal with these and is responsible to deal with the relevant National Authorities.

The Contractor shall remove any graffiti as soon as it is applied, including that applied to boarding and temporary works.

All equipment, materials and other goods shall be removed from the site when no longer required for the purpose of the works.

All activities included in this Clause and whatever needed to remove from the site all rubbish shall be at the expense of the Contractor.

### **2.7. Project Management**

#### **2.7.1. Construction Programme**

The Contractor shall submit, within 1 month of the Commencement Date the detailed programme of his construction activities developed in such a way as to guarantee the achievement of the Contract milestones.

The programme shall be in the form of a PERT diagram and Gantt charts capable of being monitored and updated continuously during the progress of the Contract.

Each month throughout the construction period the Contractor shall submit to the Engineer copies of the programme marked to show the progress to date together with any revisions to the programme that he is required to make. These marked programs shall be submitted with each monthly statement.

Site progress meetings are to be held monthly or at such shorter intervals as may be instructed by the Engineer.

#### **2.7.2. Method Statement**

Before any particular major or critical activity is commenced, the Contractor shall provide the Engineer with copies of his proposals for execution of the activity including details of the major items of equipment that he intends to utilise for the Engineer's review.

This information shall be supplied not less than 1 month in advance of the activity commencing so that the Engineer may study, discuss and comment on the proposal and the Contractor may thereafter amend his proposal accordingly.

No work shall be put in hand without the prior written consent of the Engineer which consent shall in no case relieve the Contractor of any of his obligations, responsibilities and liabilities under the Contract.

The Method Statement should deal with the Contractor's Proposals for execution of works and shall also include any Design considerations the Construction Team must take into account and how to deal with them.

### **2.7.3. Daily Turns**

The Contractor shall supply by 12 noon on every working day, the daily returns including as a minimum:

- Contract no. and date;
- a list of the labour employed on the previous day specifying the number employed in each trade;
- a list of all plants and equipment used and stand-by on the day work;
- day work performed at the previous day;
- materials brought to the site;
- comments, instructions and documents given by the Engineer to the Contractor;
- comments and documents given by the Contractor to the Engineer.

A proforma of the daily returns shall be prepared by the Contractor and submitted for approval to the Engineer before starting work on site. The daily returns will be signed daily by representatives of the Contractor.

### **2.7.4. Weekly Progress Meetings**

The Contractor shall present in the weekly progress meetings the following information for discussion:

- a schedule of the main work items completed in each section of the works, showing quantitative progress during the previous week and cumulative progress;
- detailed programme of work for the present week;
- record and notification of any QC activities and testing in the past week or in the upcoming period;
- summary of plant and equipment planned to be used in the present week;
- comments.

### **2.7.5. Monthly Progress Report**

The Contractor shall submit to the Engineer, with the monthly statement, a progress report for the previous month that shall include as a minimum the following items and information:

- the marked-up construction programme;
- weather conditions;
- summary of staff and labour employed at site (on a daily basis);
- schedule of constructional and dredging plant on site including dates of arrival and departure of individual items;
- summary of principal materials and manufactured items placed on order;
- summary of principal materials and manufactured items delivered to site;
- record of site safety;
- should progress of executing the works fall behind the scheduled programme, a written method of retrieving lost time shall be included.

**2.7.6. Progress Photographs**

The Contractor shall have photographs taken to illustrate the progress of the works. Such photographs shall be taken monthly.

In addition to these, the Engineer may from time to time direct to take additional pictures, including air pictures, during the progress of the works.

The copyright of such photographs and all rights of reproduction shall be reserved exclusively to the Employer.

All photographs shall be coordinated with the Port Security Officer. No other photographs will be allowed to be taken without prior permission obtained from the Engineer in writing. All negatives shall be submitted to the Engineer, together with 6 (six) copies.

## **3. DEMINING AND UXO CLEARANCE**

### **3.1. General**

This section provides the technical specification for the procedures related to the mine and Explosives Remnants Of War (ERW) clearance which shall be applied by the Contractor in the project area, if any, in compliance with International Mine Action Standards (IMAS), National Mine Action Standards (NMAS) and in agreement with the Nepalese Authority.

The Contractor shall strictly follow IMAS and NMAS relating to Mine and ERW clearance operations for land and underwater clearance activities, utilizing highly qualified and experienced personnel, equipped with the most efficient equipment to undertake the project.

The area requiring clearance shall be accepted as 'cleared' when the Contractor has ensured the removal and/or destruction of all mine and ERW hazards, (including unexploded sub-munitions), from the specified area and confirmed with the Engineer. Clearance certificates shall be issued by the Contractor to confirm the area has been cleared.

## **4. SECTION 300: SOIL IMPROVEMENT**

### **4.1. General**

The purpose of this Technical Specification for Civil Works is to recall and extend, where necessary, the general requirements set forth in the corresponding section of "Standard Specifications for Road and Bridge Works – 2073 (2075 Amendment)", Government of Nepal, Ministry of Physical Infrastructure and Transport - Department of Roads.

See also specific paragraphs in **Employer's Requirement (ERQ), TECHNICAL REQUIREMENTS and DRAWING Sections in the Contract Document**, which prevail over the requirements contained the "Standard Specifications for Road and Bridge Works - 2073(2075 Amendment)"



## **5. SECTION 400: FENCING**

### **5.1. General**

The purpose of this Technical Specification for Civil Works is to recall and extend, where necessary, the general requirements set forth in the corresponding section of "Standard Specifications for Road and Bridge Works – 2073 (2075 Amendment)", Government of Nepal, Ministry of Physical Infrastructure and Transport - Department of Roads.

See also specific paragraphs in **Employer's Requirement (ERQ), TECHNICAL REQUIREMENTS and DRAWING Sections in the Contract Document**, which prevail over the requirements contained the "Standard Specifications for Road and Bridge Works - 2073(2075 Amendment)"

## **6. SECTION 500: QUALITY CONTROL**

### **6.1. General**

The purpose of this Technical Specification for Civil Works is to recall and extend, where necessary, the general requirements set forth in the corresponding section of "Standard Specifications for Road and Bridge Works – 2073 (2075 Amendment)", Government of Nepal, Ministry of Physical Infrastructure and Transport - Department of Roads.

See also specific paragraphs in **Employer's Requirement (ERQ), TECHNICAL REQUIREMENTS and DRAWING Sections in the Contract Document**, which prevail over the requirements contained the "Standard Specifications for Road and Bridge Works - 2073(2075 Amendment)"

## **7. SECTION 600: MATERIALS AND TESTING OF MATERIALS**

### **7.1. General**

The purpose of this Technical Specification for Civil Works is to recall and extend, where necessary, the general requirements set forth in the corresponding section of "Standard Specifications for Road and Bridge Works – 2073 (2075 Amendment)", Government of Nepal, Ministry of Physical Infrastructure and Transport - Department of Roads.

See also specific paragraphs in **Employer's Requirement (ERQ), TECHNICAL REQUIREMENTS and DRAWING Sections in the Contract Document**, which prevail over the requirements contained the "Standard Specifications for Road and Bridge Works - 2073(2075 Amendment)"

## **8. SECTION 700: PIPE DRAINS, PIPE CULVERTS AND CONCRETE CHANNELS**

### **8.1. General**

The purpose of this Technical Specification for Civil Works is to recall and extend, where necessary, the general requirements set forth in the corresponding section of "Standard Specifications for Road and Bridge Works – 2073 (2075 Amendment)", Government of Nepal, Ministry of Physical Infrastructure and Transport - Department of Roads.

See also specific paragraphs in **Employer's Requirement (ERQ), TECHNICAL REQUIREMENTS and DRAWING Sections in the Contract Document**, which prevail over the requirements contained the "Standard Specifications for Road and Bridge Works - 2073(2075 Amendment)"

## **9. SECTION 800: TRANSPORTATION OF MATERIAL**

### **9.1. General**

The purpose of this Technical Specification for Civil Works is to recall and extend, where necessary, the general requirements set forth in the corresponding section of "Standard Specifications for Road and Bridge Works – 2073 (2075 Amendment)", Government of Nepal, Ministry of Physical Infrastructure and Transport - Department of Roads.

See also specific paragraphs in **Employer's Requirement (ERQ), TECHNICAL REQUIREMENTS and DRAWING Sections in the Contract Document**, which prevail over the requirements contained the "Standard Specifications for Road and Bridge Works - 2073(2075 Amendment)"

## **10. SECTION 900: EARTHWORKS**

### **10.1. General**

The purpose of this Technical Specification for Civil Works is to recall and extend, where necessary, the general requirements set forth in the corresponding section of "Standard Specifications for Road and Bridge Works – 2073 (2075 Amendment)", Government of Nepal, Ministry of Physical Infrastructure and Transport - Department of Roads.

See also specific paragraphs in **Employer's Requirement (ERQ), TECHNICAL REQUIREMENTS and DRAWING Sections in the Contract Document**, which prevail over the requirements contained the "Standard Specifications for Road and Bridge Works - 2073(2075 Amendment)"

### **10.2. Permanent Shotcrete for excavated rock stabilization for external areas (100 to 200mm thick)**

Within the following articles of this Technical Specification, the minimum technical requirements for permanent shotcrete to be used on external excavation surfaces, both at the tunnel portals and on existing rock walls to be stabilized and excavation foreseen along the existing road to widen it accordingly to design.

#### **10.2.1. Shotcrete type**

<b>Characteristic</b>	<b>Requirements</b>
Maximum size of Coarse Aggregate	≤ 8 mm
Compressive strength class (EN 206-1)	C30/37
Minimum characteristic cube strength	37 MPa
Minimum exposure classes	XC4, XD1, XF1
Maximum chloride content, % by weight of cement	0.2
Initial resistance class according to SIA 198	J2
Minimum compressive strength after 3 h (cylindric $f_c$ )	1 MPa
Minimum compressive strength after 24 h (cylindric $f_c$ )	5 MPa
Other requirements	Resistant to AAR

#### **10.2.2. Shotcrete execution**

Basically wet-mix underground application shall be preferred to dry-mix application. In case of dry-mix application, the Contractor must prove effectiveness and provide all safety measures to prevent dust propagation and to maintain a sound air quality. Alkali-free accelerator shall be used in the shotcrete mixture: no silicate based accelerator can be used.

All voids and fissures must be completely filled, as well as wire meshes must be completely covered by shotcrete (inside and outside) with a minimum cover of 5 cm. Wire meshes shall be placed and fixed so that, during, shotcreting, they will not vibrate and can be completely wrapped by shotcrete.

#### **10.2.3. Preliminary tests**

Preliminary tests shall be provided by the Contractor.

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For each shotcrete production cycle, at least 10 cylindrical samples ( $\phi$ 50 mm, height 50 mm) shall be tested: 5 compressive strength tests after 7 days and 5 compressive strength tests after 28 days.

### **10.2.4. Contractor Qualification and Obligations**

The Contractor shall provide certificate stating the admixture used for the shotcrete, as well as documentation regarding aggregate origin and composition; moreover, shall provide all relevant tests results demonstrating that minimum requirements as above described are fulfilled, following relevant standards and "Standard Specifications for Road and Bridge Works – 2073(2075 Amendment)".

Projection of concrete shall be done in layers of 5 cm thickness: to avoid shade effect, shotcrete behind wiremesh shall be projected before wiremesh installation. All void due to excavation face irregularities shall be filled before to place the wiremesh and cast the final shotcrete layer.

The Contractor shall consider as included in his prices all component, activity and safety measure needed to provide and install the shotcrete layers.

## **10.3. Wire mesh for Shotcrete - external areas**

Within the following articles of this Technical Specification, the minimum technical requirements for the wiremesh to be used as reinforcement of permanent shotcrete are given.

### **10.3.1. Wire mesh type**

$\phi$  6 mm, pattern 10 cm x 10 cm.

K283 Ruwa Matten or similar.

### **10.3.2. Material Types**

Min. B500 A (according to European standards).

### **10.3.3. Contractor Qualification and Obligations**

The Contractor shall provide certificate stating the supplier of the materials used and their properties that shall satisfy aforementioned requirements and requirements accordingly to "Standard Specifications for Road and Bridge Works – 2073(2075 Amendment)"

## **10.4. Permanent rock bolts - external areas**

Within the following articles of this Technical Specification, the minimum technical requirements for the permanent rockbolt to be used in different works along the road part of the project are given. The works related to this articles are:

- Support measures for excavation at the tunnel portals;
- Support measures for excavations at the mountain side of the existing road;
- Support measures of existing rockwalls above existing road along mudstone or other erosive or other erosive layers

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- Foundation micropiles and horizontal supports of retaining walls at the river side of existing road

### 10.4.1. Bolts type

Type Permanent GEWI Bar 25 or equivalent

<b>Characteristic</b>	<b>Requirements</b>
Minimum ultimate load (Ftk)	285 kN
Minimum yielding load (Fyk)	246 kN
Profile diameter	25 mm
Drilling diameter	≥ 110 mm
Steel Grade	S500/550 or superior
Corrosion protection	Double (preinjected corrugated plastic sheathing)

Type Permanent GEWI Bar 28 or equivalent

<b>Characteristic</b>	<b>Requirements</b>
Minimum ultimate load (Ftk)	357 kN
Minimum yielding load (Fyk)	308 kN
Profile diameter	28 mm
Drilling diameter	≥ 110 mm
Steel Grade	S500/550 or superior
Corrosion protection	Double (preinjected corrugated plastic sheathing)

Type Permanent GEWI Bar 32 or equivalent

<b>Characteristic</b>	<b>Requirements</b>
Minimum ultimate load (Ftk)	442 kN
Minimum yielding load (Fyk)	402 kN
Profile diameter	32 mm
Drilling diameter	≥ 120 mm
Steel Grade	S500/550 or superior
Corrosion protection	Double (injected corrugated plastic sheathing)

Type Permanent GEWI Plus 43 or equivalent

<b>Characteristic</b>	<b>Requirements</b>
Minimum breaking load (Ftk)	973 kN
Minimum yielding load (Fyk)	1162 kN
Profile diameter	43 mm
Drilling diameter	≥ 120 mm
Steel Grade	S670/800 or superior
Corrosion protection	Double (preinjected corrugated plastic sheathing)



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Length of bolts varies, according to design drawings. The application of the different bolt types follow indications provided in design documents attached to the tender and shall be updated accordingly to construction design by the Contractor.

For all these bolts, the double corrosion protection shall be provided (in accordance to Swiss norm SIA267 type of corrosion protection 2a) by a corrugated plastic sheathing, with at least 2 cm thick injection between the sheathing and the bar; moreover, borehole diameter shall be enough large to guarantee at least 2 cm of grouting between the sheathing and the rock. Both preinjected plastic sheathing and plastic sheathing injected on site can be used, but in latter case, injection procedure shall be agreed in advance by the Engineer.

All permanent bolts shall guarantee a service life not lower than 50 years.

### **10.4.2. Cement based grout**

The injection procedure shall be able to guarantee continuous and full anchorage between the bolt and surrounding rock. The cement based grout shall comply to the following minimum requirements. However, independently by compliance to them, the Contractor is required to demonstrate proper anchorage of the bolts by suitable tension tests.

<i>Characteristic</i>	<i>Requirements</i>
Type	High strength, non-shrink cementitious construction grout with aggregate size suitable for the effective pouring thickness
W/C (max)	0.5
Plasticizer	1% - 2% on weight
Strength (cylindric)	5MPa after 48h, 25MPa after 28d

### **10.4.3. Tension / Pull-out tests**

The Contractor shall demonstrate that injected bolts are properly anchored to the rock by performing suitable pull out and tension tests. The pull-out tests shall demonstrate that the characteristic external resistance of the bolts reaches at least the characteristic internal resistance of the bolt; whereas the tension tests shall demonstrate that the installed rockbolt reaches the assumed design resistance.

Both pull-out and tension tests shall be performed following relevant rules provided by Eurocodes for this type of tests and the indications provided in relevant design documents attached to the tender; the following minimum number of tests shall be performed:

- Pull-out tests: a number of 3 for each type of bolt and each type of geotechnical conditions and rock mass (where a type of rock mass is defined as characterized by a certain percentage of mudstone or other erosive and sandstone or other rock type, admitted range +/- 10% at the tunnel face, and a certain GSI, admitted range +/- 5 points);
- Tension tests: on 2% of all realized bolts.

In case during the tension tests the bolt shall show plastic behaviour or is pulled out, it shall be replaced. Bolts used for pull-out tests shall not be considered as resistant bolt in the support system.

### 10.4.4. Corrosion resistance tests

The Contractor shall perform on 1% of installed bolts a corrosion resistance test, measuring the electrical resistance between the bolt and the surrounding soil, that should result to be lower than 0.1 M $\Omega$  (procedure accordingly to swiss norm **SIA267/1**).

### 10.4.5. Other components

The Contractor must design and provide all other components, such as redistribution plates, and the relevant costs must be included in the rock bolt rates.

### 10.4.6. Contractor Qualification and Obligations

Contractor shall produce technical sheet of proposed type of permanent bolts and get approval by the Engineer before construction. The Contractor shall produce for every bolt:

- Drilling record, with indication of length, diameter, drilling system and type of excavated material;
- Injection record with description of injection system, adopted pressure and injected cement volume.

Moreover, the Contractor shall produce a layout with bolts numbering in order to let the Contracting authority understand to which bolt every document is referred to. Finally, the Contractor shall produce for every performed test a report with description of testing device, procedure and results, according to relevant Eurocodes.

The Contractor shall consider as included in his prices all component, activity, tests and safety measure needed to provide and install the permanent bolts.

## 10.5. Temporary active anchors

Within the following articles of this Technical Specification, the minimum technical requirements for the temporary active anchors foreseen by design at the tunnel portals

### 10.5.1. Anchor type

Pretensioned grouted anchors made by strands

<b>Characteristic</b>	<b>Requirements</b>
Strands Material	Harmonic steel
Strands diameter	0.6"
Strands number	5
Nominal Strand area	140 mm <sup>2</sup>
Ultimate load (F <sub>tk</sub> )	260 kN/strand
yelding load (F <sub>yk</sub> )	234 kN/strand
Prestress load	70 kN/strand
Free length	10 m
Anchored length	10 m
Drilling diameter	≥ 200 mm

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Steel Grade	S1670/1860
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### 10.5.2. Cement based grout

The injection procedure shall be able to guarantee continuous and full anchorage between the bolt and surrounding rock. The cement based grout shall comply to the following minimum requirements. However, independently by compliance to them, the Contractor is required to demonstrate proper anchorage of the bolts by suitable tension tests.

<i>Characteristic</i>	<i>Requirements</i>
Type	High strength, non-shrink cementitious construction grout with aggregate size suitable for the effective pouring thickness
W/C (max)	0.5
Plasticizer	1% - 2% on weight
Strength (cylindric)	5MPa after 48h, 25MPa after 28d

### 10.5.3. Tension / Pull-out tests

The Contractor shall demonstrate that injected anchors are properly anchored to the rock by performing suitable pull out and tension tests. The pull-out tests shall demonstrate that the characteristic external resistance of the anchors reaches at least the characteristic internal resistance of the anchor; whereas the tension tests shall be performed in all anchors to prestress them and, on a certain percentain, the detailed tensioning procedure shall be applied to verify proper behaviour of the anchors.

Both pull-out and tension tests shall be performed following relevant rules provided by Eurocodes for this type of tests and the indications provided in relevant design documents attached to the tender; the number of tests to be performed shall be minimum:

- Pull-out tests: a number of 3 for each type of anchor and each type of geotechnical conditions and rock mass (where a type rock mass is defined as characterized by a certain percentage of mudstone or other erosive and sandstone or other rock type, admitted range +/- 10%, and a certain GSI, admitted range +/- 5 points);
- Detailed tension tests: on 2% of all realized anchors.

In case during the tension tests the anchor shall show plastic behaviour or is pulled out, it shall be replaced. Anchors used instead for pull-out tests shall not be considered as resistant anchor in the support system.

### 10.5.4. Other components

The Contractor must design all other components, such as redistribution plates, and the relevant costs must be included in the rock bolt rates.

**10.5.5. Contractor Qualification and Obligations**

Contractor shall produce technical sheet of proposed type of anchors and get approval by the Engineer before construction. The Contractor shall produce for every bolt:

- Drilling record, with indication of length, diameter, drilling system and type of excavated material;
- Injection record with description of injection system, adopted pressure and injected cement volume;
- Tensioning record, following eurocodes procedure

Moreover, the Contractor shall produce a layout with bolts numbering in order to let the Contracting authority understand to which bolt every document is referred to. Finally, the Contractor shall produce for every performed test a report with description of testing device and procedure and results, accordingly to relevant eurocodes.

The Contractor shall consider as included in his prices all component, activity, tests and safety measure needed to provide and install the anchors.

## **11. SECTION 1000: SUBGRADES**

### **11.1. General**

The purpose of this Technical Specification for Civil Works is to recall and extend, where necessary, the general requirements set forth in the corresponding section of "Standard Specifications for Road and Bridge Works – 2073 (2075 Amendment)", Government of Nepal, Ministry of Physical Infrastructure and Transport - Department of Roads.

See also specific paragraphs in **Employer's Requirement (ERQ), TECHNICAL REQUIREMENTS and DRAWING Sections in the Contract Document**, which prevail over the requirements contained the "Standard Specifications for Road and Bridge Works - 2073(2075 Amendment)"

## **12. SECTION 1100: ROADWORKS OVERALL REQUIREMENTS**

### **12.1. General**

The purpose of this Technical Specification for Civil Works is to recall and extend, where necessary, the general requirements set forth in the corresponding section of "Standard Specifications for Road and Bridge Works – 2073 (2075 Amendment)", Government of Nepal, Ministry of Physical Infrastructure and Transport - Department of Roads.

See also specific paragraphs in **Employer's Requirement (ERQ), TECHNICAL REQUIREMENTS and DRAWING Sections in the Contract Document**, which prevail over the requirements contained the "Standard Specifications for Road and Bridge Works - 2073(2075 Amendment)"

## **13. SECTION 1200: SUBBASE, BASE, HARD SHOULDER AND GRAVEL**

### **13.1. General**

The purpose of this Technical Specification for Civil Works is to recall and extend, where necessary, the general requirements set forth in the corresponding section of "Standard Specifications for Road and Bridge Works – 2073 (2075 Amendment)", Government of Nepal, Ministry of Physical Infrastructure and Transport - Department of Roads.

See also specific paragraphs in **Employer's Requirement (ERQ), TECHNICAL REQUIREMENTS and DRAWING Sections in the Contract Document**, which prevail over the requirements contained the "Standard Specifications for Road and Bridge Works - 2073(2075 Amendment)"

## **14. SECTION 1300: BITUMINOUS SURFACE AND BASE COURSE**

### **14.1. General**

The purpose of this Technical Specification for Civil Works is to recall and extend, where necessary, the general requirements set forth in the corresponding section of "Standard Specifications for Road and Bridge Works – 2073 (2075 Amendment)", Government of Nepal, Ministry of Physical Infrastructure and Transport - Department of Roads.

See also specific paragraphs in **Employer's Requirement (ERQ), TECHNICAL REQUIREMENTS and DRAWING Sections in the Contract Document**, which prevail over the requirements contained the "Standard Specifications for Road and Bridge Works - 2073(2075 Amendment)"



## **15. SECTION 1400: KERBS AND FOOTPATHS**

### **15.1. General**

The purpose of this Technical Specification for Civil Works is to recall and extend, where necessary, the general requirements set forth in the corresponding section of "Standard Specifications for Road and Bridge Works – 2073 (2075 Amendment)", Government of Nepal, Ministry of Physical Infrastructure and Transport - Department of Roads.

See also specific paragraphs in **Employer's Requirement (ERQ), TECHNICAL REQUIREMENTS and DRAWING Sections in the Contract Document**, which prevail over the requirements contained the "Standard Specifications for Road and Bridge Works - 2073(2075 Amendment)"

## **16. SECTION 1500: TRAFFIC SIGNS, ROAD MARKING, ROAD MARKER STONES AND DELINEATORS**

### **16.1. General**

The purpose of this Technical Specification for Civil Works is to recall and extend, where necessary, the general requirements set forth in the corresponding section of "Standard Specifications for Road and Bridge Works – 2073 (2075 Amendment)", Government of Nepal, Ministry of Physical Infrastructure and Transport - Department of Roads.

See also specific paragraphs in **Employer's Requirement (ERQ), TECHNICAL REQUIREMENTS and DRAWING Sections in the Contract Document**, which prevail over the requirements contained the "Standard Specifications for Road and Bridge Works - 2073(2075 Amendment)"

## **17. SECTION 1600: PILING FOR STRUCTURES**

### **17.1. General**

The purpose of this Technical Specification for Civil Works is to recall and extend, where necessary, the general requirements set forth in the corresponding section of "Standard Specifications for Road and Bridge Works – 2073 (2075 Amendment)", Government of Nepal, Ministry of Physical Infrastructure and Transport - Department of Roads.

See also specific paragraphs in **Employer's Requirement (ERQ), TECHNICAL REQUIREMENTS and DRAWING Sections in the Contract Document**, which prevail over the requirements contained the "Standard Specifications for Road and Bridge Works - 2073(2075 Amendment)"

## **18. SECTION 1700: WELL FOUNDATION**

### **18.1. General**

The purpose of this Technical Specification for Civil Works is to recall and extend, where necessary, the general requirements set forth in the corresponding section of "Standard Specifications for Road and Bridge Works – 2073 (2075 Amendment)", Government of Nepal, Ministry of Physical Infrastructure and Transport - Department of Roads.

See also specific paragraphs in **Employer's Requirement (ERQ), TECHNICAL REQUIREMENTS and DRAWING Sections in the Contract Document**, which prevail over the requirements contained the "Standard Specifications for Road and Bridge Works - 2073(2075 Amendment)"

## **19. SECTION 1800: FALSEWORK, FORMWORK AND SURFACE FINISH FOR CONCRETE STRUCTURES**

### **19.1. General**

The purpose of this Technical Specification for Civil Works is to recall and extend, where necessary, the general requirements set forth in the corresponding section of "Standard Specifications for Road and Bridge Works – 2073 (2075 Amendment)", Government of Nepal, Ministry of Physical Infrastructure and Transport - Department of Roads.

See also specific paragraphs in **Employer's Requirement (ERQ), TECHNICAL REQUIREMENTS and DRAWING Sections in the Contract Document**, which prevail over the requirements contained the "Standard Specifications for Road and Bridge Works - 2073(2075 Amendment)"

## **20. SECTION 1900: BEARINGS AND EXPANSION JOINTS**

### **20.1. General**

The purpose of this Technical Specification for Civil Works is to recall and extend, where necessary, the general requirements set forth in the corresponding section of "Standard Specifications for Road and Bridge Works – 2073 (2075 Amendment)", Government of Nepal, Ministry of Physical Infrastructure and Transport - Department of Roads.

See also specific paragraphs in **Employer's Requirement (ERQ), TECHNICAL REQUIREMENTS and DRAWING Sections in the Contract Document**, which prevail over the requirements contained the "Standard Specifications for Road and Bridge Works - 2073(2075 Amendment)"

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## **21. SECTION 2000: CONCRETE FOR STRUCTURES**

### **21.1. General**

The purpose of this Technical Specification for Civil Works is to recall and extend, where necessary, the general requirements set forth in the corresponding section of "Standard Specifications for Road and Bridge Works – 2073 (2075 Amendment)", Government of Nepal, Ministry of Physical Infrastructure and Transport - Department of Roads.

See also specific paragraphs in **Employer's Requirement (ERQ), TECHNICAL REQUIREMENTS and DRAWING Sections in the Contract Document**, which prevail over the requirements contained the "Standard Specifications for Road and Bridge Works - 2073(2075 Amendment)"

## **22. SECTION 2100: PRE-STRESSING**

### **22.1. General**

The purpose of this Technical Specification for Civil Works is to recall and extend, where necessary, the general requirements set forth in the corresponding section of "Standard Specifications for Road and Bridge Works – 2073 (2075 Amendment)", Government of Nepal, Ministry of Physical Infrastructure and Transport - Department of Roads.

See also specific paragraphs in **Employer's Requirement (ERQ), TECHNICAL REQUIREMENTS and DRAWING Sections in the Contract Document**, which prevail over the requirements contained the "Standard Specifications for Road and Bridge Works - 2073(2075 Amendment)"



## **23. SECTION 2200: STRUCTURAL STEEL WORK**

### **23.1. General**

The purpose of this Technical Specification for Civil Works is to recall and extend, where necessary, the general requirements set forth in the corresponding section of "Standard Specifications for Road and Bridge Works – 2073 (2075 Amendment)", Government of Nepal, Ministry of Physical Infrastructure and Transport - Department of Roads.

See also specific paragraphs in **Employer's Requirement (ERQ), TECHNICAL REQUIREMENTS and DRAWING Sections in the Contract Document**, which prevail over the requirements contained the "Standard Specifications for Road and Bridge Works - 2073(2075 Amendment)"

## **24. SECTION 2300: TIMBER CONSTRUCTION**

### **24.1. General**

The purpose of this Technical Specification for Civil Works is to recall and extend, where necessary, the general requirements set forth in the corresponding section of "Standard Specifications for Road and Bridge Works – 2073 (2075 Amendment)", Government of Nepal, Ministry of Physical Infrastructure and Transport - Department of Roads.

See also specific paragraphs in **Employer's Requirement (ERQ), TECHNICAL REQUIREMENTS and DRAWING Sections in the Contract Document**, which prevail over the requirements contained the "Standard Specifications for Road and Bridge Works - 2073(2075 Amendment)"

## **25. SECTION 2400: RIVER TRAINING AND PROTECTION WORKS**

### **25.1. General**

The purpose of this Technical Specification for Civil Works is to recall and extend, where necessary, the general requirements set forth in the corresponding section of "Standard Specifications for Road and Bridge Works – 2073 (2075 Amendment)", Government of Nepal, Ministry of Physical Infrastructure and Transport - Department of Roads.

See also specific paragraphs in **Employer's Requirement (ERQ), TECHNICAL REQUIREMENTS and DRAWING Sections in the Contract Document**, which prevail over the requirements contained the "Standard Specifications for Road and Bridge Works - 2073(2075 Amendment)"

## **26. SECTION 2500: BRICKWORKS FOR STRUCTURES**

### **26.1. General**

The purpose of this Technical Specification for Civil Works is to recall and extend, where necessary, the general requirements set forth in the corresponding section of "Standard Specifications for Road and Bridge Works – 2073 (2075 Amendment)", Government of Nepal, Ministry of Physical Infrastructure and Transport - Department of Roads.

See also specific paragraphs in **Employer's Requirement (ERQ), TECHNICAL REQUIREMENTS and DRAWING Sections in the Contract Document**, which prevail over the requirements contained the "Standard Specifications for Road and Bridge Works - 2073(2075 Amendment)"

## **27. SECTION 2600: MASONRY FOR STRUCTURES**

### **27.1. General**

The purpose of this Technical Specification for Civil Works is to recall and extend, where necessary, the general requirements set forth in the corresponding section of "Standard Specifications for Road and Bridge Works – 2073 (2075 Amendment)", Government of Nepal, Ministry of Physical Infrastructure and Transport - Department of Roads.

See also specific paragraphs in **Employer's Requirement (ERQ), TECHNICAL REQUIREMENTS and DRAWING Sections in the Contract Document**, which prevail over the requirements contained the "Standard Specifications for Road and Bridge Works - 2073(2075 Amendment)"

## **28. SECTION 2700: REPAIR OF STRUCTURES**

### **28.1. General**

The purpose of this Technical Specification for Civil Works is to recall and extend, where necessary, the general requirements set forth in the corresponding section of "Standard Specifications for Road and Bridge Works – 2073 (2075 Amendment)", Government of Nepal, Ministry of Physical Infrastructure and Transport - Department of Roads.

See also specific paragraphs in **Employer's Requirement (ERQ), TECHNICAL REQUIREMENTS and DRAWING Sections in the Contract Document**, which prevail over the requirements contained the "Standard Specifications for Road and Bridge Works - 2073(2075 Amendment)"

## **29. SECTION 2800: BIO ENGINEERING WORKS**

### **29.1. General**

The purpose of this Technical Specification for Civil Works is to recall and extend, where necessary, the general requirements set forth in the corresponding section of "Standard Specifications for Road and Bridge Works – 2073 (2075 Amendment)", Government of Nepal, Ministry of Physical Infrastructure and Transport - Department of Roads.

See also specific paragraphs in **Employer's Requirement (ERQ), TECHNICAL REQUIREMENTS and DRAWING Sections in the Contract Document**, which prevail over the requirements contained the "Standard Specifications for Road and Bridge Works - 2073(2075 Amendment)"

## **30. SECTION 2900: MAINTENANCE OF ROADS**

### **30.1. General**

The purpose of this Technical Specification for Civil Works is to recall and extend, where necessary, the general requirements set forth in the corresponding section of "Standard Specifications for Road and Bridge Works – 2073 (2075 Amendment)", Government of Nepal, Ministry of Physical Infrastructure and Transport - Department of Roads.

See also specific paragraphs in **Employer's Requirement (ERQ), TECHNICAL REQUIREMENTS and DRAWING Sections in the Contract Document**, which prevail over the requirements contained the "Standard Specifications for Road and Bridge Works - 2073(2075 Amendment)"



## **31. SECTION 3000: SUB-SURFACE GEOTECHNICAL INVESTIGATION**

### **31.1. General**

The purpose of this Technical Specification for Civil Works is to recall and extend, where necessary, the general requirements set forth in the corresponding section of "Standard Specifications for Road and Bridge Works – 2073 (2075 Amendment)", Government of Nepal, Ministry of Physical Infrastructure and Transport - Department of Roads.

See also specific paragraphs in **Employer's Requirement (ERQ), TECHNICAL REQUIREMENTS and DRAWING Sections in the Contract Document**, which prevail over the requirements contained the "Standard Specifications for Road and Bridge Works - 2073(2075 Amendment)"

## **32. SECTION 3100: MISCELLANEOUS WORKS**

### **32.1. General**

The purpose of this Technical Specification for Civil Works is to recall and extend, where necessary, the general requirements set forth in the corresponding section of "Standard Specifications for Road and Bridge Works – 2073 (2075 Amendment)", Government of Nepal, Ministry of Physical Infrastructure and Transport - Department of Roads.

See also specific paragraphs in **Employer's Requirement (ERQ), TECHNICAL REQUIREMENTS and DRAWING Sections in the Contract Document**, which prevail over the requirements contained the "Standard Specifications for Road and Bridge Works - 2073(2075 Amendment)"

## **33. CIVIL WORKS FOR ROADS**

### **33.1. General**

The purpose of this Technical Specification for Civil Works is to recall and extend, where necessary, the general requirements set forth in the corresponding section of "Standard Specifications for Road and Bridge Works – 2073 (2075 Amendment)", Government of Nepal, Ministry of Physical Infrastructure and Transport - Department of Roads.

The works under this Section consists of the provision of all labour, plant, equipment, supplies and materials necessary to carry out the following works:

- Pedestrian Rockshed
- RCC walls
- RCC culverts
- Technical Buildings at Portals
- Secondary RCC pre-cast/cast-in-situ elements

See also specific paragraphs in **Employer's Requirement (ERQ), TECHNICAL REQUIREMENTS and DRAWING Sections in the Contract Document**, which prevail over the requirements contained the "Standard Specifications for Road and Bridge Works - 2073(2075 Amendment)"

### **33.2. Pre-cast and cast in situ structures**

#### **33.2.1. General**

The work covered by this chapter includes the furnishing of all plant, equipment, forms, labour and materials and the performance of all operations required to produce all the cast-in-place or pre-cast R.C. elements for the works.

The Contractor shall design the proportion of each concrete mix to obtain concrete of a homogeneous structure which can be worked into the corners and angles of the formwork without segregation of the material or bleeding of free water at the surface and shall also, on striking of formwork present a uniform face free from honeycombing and crazing.

The different properties will be tested and approved in a preliminary test programme using materials from approved sources and of the quality required. Once the minimum requirements have been approved they will be binding. To achieve these properties, hard dense aggregates with good bonding surfaces will be used.

In order to reduce thermal tensile stresses on the concrete surface, due to temperature differences between core and surface and excessive maximum temperature inside the core, caused by heat of hydration, the lowest possible cement content compatible with workability, density, strength and water permeability should be used.

For the same reason, blended cements (type III/B or IV/B or V/B according to EN 197-1 or combinations of ordinary Portland cement with mineral additions will be used to reduce heat of hydration.

## Employer's Requirements : Technical Specification

Other means to reduce hydration heating include the use of set retarders or set retarding/high-range water reducing admixtures, low temperature of fresh concrete and thermal insulation of concrete surface during curing period.

Cementitious materials and aggregates shall be chosen so as to ensure the durability of concrete to sulphates, avoid alkali-silica reaction and better face the ingress of chlorides.

Also in order to ensure the durability of concrete works, particular attention shall be paid to the control of cracking due to restrained drying shrinkage.

For this purpose the use of shrinkage reducing admixtures (SRA) and/or non-metallic or fibres is allowed and recommended.

### 33.2.2. Approval

#### 33.2.2.1 Documentation

All materials, origin of materials, equipment, methods of batching, pouring and curing must be approved by the Engineer before commencement of work. **Not later than two months** after Order of Commencement, the Contractor shall submit the following for approval by the Engineer:

- Layout of batching and casting yard.
- Detailed drawings and description of forms.
- Details of equipment for batching, chilled water and/or flake ice production, control system, numerical calculations of heat balance, mixing, transporting and placing of concrete.
- Details of the methods proposed for pouring and curing.
- Proposed sources of all materials: cement, aggregates, admixtures, etc. including laboratory certificates showing compliance with the Specifications.
- Plans for quality control and quality assurance.

All above listed information shall fully comply with all requirements set forth in the different chapters of these Specifications.

### 33.2.3. Requirements for concrete mixes

#### 33.2.3.1 General

All concrete shall be prepared and cast under «good control conditions», and shall comply with the following requirements.

#### LEAN AND STRUCTURAL CONCRETE:

	CONCRETE STRENGTH CLASS	MINIMUM CHARACTERISTIC CUBIC STRENGTH $R_{ck}$ (MPa)	EXPOSURE CLASS	MAXIMUM NOMINAL AGGREGATE SIZE (mm)	CONSIST CLASS
LEAN CONCRETE	C12/15 (M15/20mm)	15	X0	20	S2
TUNNEL LINING	C30/37 (M40/32mm)	37	XC4, XD1, XF1	32	S4
ROCKSHED AND TECHNICAL BUILDINGS (FOUNDATIONS)	C25/30 (M30/32mm)	30	XC2	32	S4
ROCKSHED AND TECHNICAL BUILDINGS (EXTERNAL WALLS)	C30/37 (M40/32mm)	37	XC4, XD1, XF1	32	S4
ROCKSHED AND TECHNICAL BUILDINGS (TOP SLAB)	C30/37 (M40/32mm)	37	XC4, XF3	32	S4
TECHNICAL BUILDINGS (INNER WALLS AND SLABS)	C30/37 (M40/32mm)	37	XC3	32	S4
BURIED CULVERTS	C25/30 (M30/32mm)	30	XC2	32	S4

Figure 2: Concrete requirements

## **Employer's Requirements : Technical Specification**

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For the detailed of requirements, please refer to **Employer's Requirement (ERQ), TECHNICAL REQUIREMENTS – Annex A – Civil Works: Design Basis.**

### **33.2.4. Engineer's approval of mix proportions binding on the Contractor**

Approval of mix proportions by the Engineer based on the results of the trial casting shall be binding upon the Contractor who shall comply with the following conditions during casting operations:

- a) Materials only of the same origin and quality used for the approved preliminary tests shall be used.
- b) The approved mix proportions shall be used unchanged except for adjustments due to different moisture content of aggregates and ambient temperature. Compacting conditions, cement content and water cement ratio of fresh concrete shall remain constant.
- c) The Contractor may propose, during the execution of the works, alternate source, mix proportions or aggregate grading, provided that he shows by carrying out new preliminary tests and trial casting, as detailed above, that the proposed changes comply with the requirements of the Specification, and provided that the proposed changes do not interfere with the progress of work. No changes shall be made in the use of materials or mix proportions without the Contractor obtaining the prior approval of the Engineer.

### **33.2.5. Concrete placing – Formwork**

#### **33.2.5.1 General**

Prior to ordering the forms the Contractor shall submit to the Engineer for his approval, detailed drawings and a description of the forms he proposes to use.

All forms shall be made of wood, at least 30 mm thick, sufficiently reinforced by steel stiffeners.

Means shall be provided in the design of the forms to avoid inducing damaging stresses in the young concrete, when removing the forms. Forms shall be protected from direct sun radiation by white colour. During castings the Engineer may require, at no extra cost to the Employer, thermal insulation of the forms made of expanded polystyrene boards or polyurethane foam. Joints between the various sections of the forms shall be tight, so as to prevent escape of water and cement paste during casting.

#### **33.2.5.2 Number of Forms**

A sufficient number of forms shall be provided to permit the casting and proper curing of the concrete to meet the construction progress schedule. The number of forms, including spare parts, shall be subject to the Engineer's approval, which shall be granted only upon completion of the trial castings.

#### **33.2.5.3 Tolerances**

The forms shall be constructed in such a manner that any dimension of the sections shall be within +/- 0.5% of the prescribed dimensions in the Drawings.

## **Employer's Requirements : Technical Specification**

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Should deformation in the forms occur during casting operations, resulting in the above requirements not being observed, the Contractor shall on his own account, immediately repair or replace the forms as instructed by the Engineer.

Tolerances for formworks:

- spacing of form ribs shall be within  $\pm 0.5\%$  but not more than 20 mm
- differences in thickness for boards in one form element shall be within  $\pm 2$  mm
- deviation from the for vertical line shall be within  $\pm 0.2\%$  of the wall height but not more than 10 mm
- forms deviation from straight line or in plane shall be within  $\pm 0.1\%$
- form ribs linearity shall be within  $\pm 0.1\%$  along their length
- local irregularities in surfaces, measured with 3-m staff, shall be within  $\pm 3$  mm
- permissible deflections for formworks:
  - $1/400$  of length for form boards for visible surfaces
  - $1/250$  of length for formwork boards for invisible surfaces

All other tolerances shall be as indicated in the drawings.

### **33.2.6. Concrete Placing**

#### **33.2.6.1 General**

Pre-cast elements shall be cast in a single solution without construction joints. Cast-in-place elements, shall be cast by reducing as much as possible the number of the construction joints.

The number and location of the construction joints must be defined in construction drawings and submitted to the approval of the Engineer.

When concreting of a portion between two construction joints has started, it shall be carried on as a continuous operation until the section being cast is completed. No concrete that has partially hardened or been contaminated by foreign materials shall be deposited in the forms, nor shall re-tempered concrete be used.

Should a breakdown occur in the continuous supply of concrete and the already poured concrete has started to set, the concrete shall be rejected and the Contractor shall demolish the already cast section and re-cast in full compliance with these specifications to his own account.

#### **33.2.6.2 Placing Methodology**

Concrete shall be placed in its final position before initial set has commenced and shall not be subsequently disturbed. All concrete shall be placed within 15 min of mixing unless carried in purpose made agitators.

Concrete shall be carefully placed in horizontal layers which shall be kept at an even height throughout the work. The depth of layers and time between placement of layers shall be such that each layer can be properly merged into the preceding layer before initial set takes place, the depth of layer shall be determined from the type of plant the Contractor proposes to use.

Concrete shall not be placed in standing water in the formwork. Underwater placing of concrete is allowed only for unreinforced components, the placing being effected exclusively with stationary tremies or with a bottom-opening watertight boxes and shall be in accordance with the requirements of DIN 1045 or equivalent as accepted. Underwater concrete is to be placed continuously without interruption.

## **Employer's Requirements : Technical Specification**

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All work connected with the placing of concrete under water shall be designed, directed and inspected with due regard to local circumstances and purposes. Work shall not proceed until all phases and methods to be used in the placing operations have been accepted by the Engineer.

### Compaction by Vibration

Concrete shall be compacted by means of needle vibrators of at least 6 inch diameter. The frequency shall be at least 8000 vibrations per minute. However, the type, diameter, number, arrangement and frequency of the vibrators shall be finally determined based on trial casting results.

In the case of pre-cast works, the use of vibrating metal formwork or vibrating tables in substitution of needle vibrators it is allowed. In this case the frequency of vibration shall not be less than 3000 cycles per minute.

Immersion type vibrators shall be inserted into the uncompacted concrete vertically and at regular intervals. Where the uncompacted concrete is in a layer above freshly compacted concrete the vibrator shall penetrate vertically for about 100 mm into the previous layer.

Vibrators shall not come into contact with the reinforcement or the formwork. They shall be drawn back slowly from the mass concrete so as to leave no voids. Internal type vibrators shall not be placed in the concrete in a random or haphazard manner nor shall concrete be moved from one part of the work to another by means of the vibrators.

### **33.2.6.3 Construction Joints**

The casting program adopted by the Contractor shall be aimed at reducing, as much as possible, the introduction of construction joints compatibly with the requirements of minimizing thermal and hygrometric stresses.

Vertical interruption of concreting, if necessary, should be performed by preparing vertical stop boards and/or permanent wire mesh approved by the Engineer.

Both in vertical and horizontal construction joint, before placing new concrete against concrete which has already set, the latter shall be treated to expose the aggregate over the full section and leave a sound irregular surface. This shall be done while the concrete is still fresh by means of water spray and light brushing or other means approved by the Engineer.

Immediately before the new concrete is placed all foreign matter shall be cleaned away and the surface moistened.

Where it is necessary to interrupt casting for more than two hours, before resuming operations, the surface of the concrete already in place shall be moisturized and covered with a layer of plastic mortar that penetrate all the irregularities. The mortar shall have the same characteristics of the cement paste of the concrete.

### **33.2.6.4 Expansion Joints**

Expansion joints shall be constructed in accordance with the details and to the dimension shown on the drawings or where otherwise ordered by the Engineer and shall be formed of the elements specified.

Generally an expansion joint will be carried out by interposing, between two portions of the structure, a panel of polystyrene or polyurethane foam, (or other deformable but sufficiently rigid material) having initial thickness corresponding to twice the maximum expansion should be allowed.

## **Employer's Requirements : Technical Specification**

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The steel reinforcement that crosses the joint, if any, shall be designed so as to allow for expansion.

The Contractor can use special connections specifically manufactured to create expansion joints. These devices must first be submitted to the Engineer for approval and tested in a trial casting.

### **33.2.6.5 Permission to Cast**

Before commencing each pour, the Contractor's Quality Control shall inspect the bed, forms, preparations, etc. and shall receive the written approval of the Engineer to pour the section.

### **33.2.7. Protection and Curing**

#### **33.2.7.1 Horizontal Surfaces**

Exposed horizontal surfaces of freshly poured concrete shall be covered immediately after final finishing with a white polyethylene sheeting in contact with the concrete surface with the edges lapped or tied down to exclude air circulation. After the concrete has stiffened but no longer than two hours, the sheeting shall be removed and replaced with one of the following wet curing methods:

- a) Ponding with water.
- b) Application of absorptive mats of fabrics or hessian kept continuously wet and covered with sealed polyethylene sheet.

Wet curing shall commence immediately after finishing and continue for a minimum of seven days.

#### **33.2.7.2 Forms Removal**

The lateral formwork shall remain in place for at least seven days after completion of casting. The Engineer may request longer periods if so required preventing thermal shock and unsuitable meteorological conditions.

The Engineer may allow an earlier removal of formwork, where the Contractor replace it with a protection and curing system that prevent the evaporation of water from the surface and, if necessary, avoid its premature cooling.

For example, the protection system prepared in replacement of the formwork can be the following:

- immediately after stripping of forms the concrete surface is first sprayed with curing compound, then covered with a wind tight, insulating tent made of a framework of wood boards 15-20 mm thick covered with white burlap polyethylene sheets;
- the tent is kept in place at least till the age of the concrete is 7 days.

### **33.2.8. Concrete Quality Control & Tests**

#### **33.2.8.1 General**

All concrete shall be prepared under good control conditions as per EN 206-1.

#### **33.2.8.2 Specimens**

For quality control and preliminary tests, trial and actual casting samples of concrete will be taken in the size required by EN 12390-1 for concrete containing maximum size aggregate of 32 mm. In particular:

- Compressive strength shall be tested by 150 x 150 x 150 mm cubes
- Splitting tensile strength shall be tested by 150 x 300 mm (d x h) cylinders



## Employer's Requirements : Technical Specification

- Flexural strength shall be tested by 150 x 150 x 600 mm prisms

For the other test specified in the above clauses, size and shape specimens will be those specified in the relevant, above mentioned, standards.

### 33.2.8.3 Temperature Measurements

Measurements of temperature development in the concrete works during curing period shall be performed by means of thermocouples, connected to multi-cell automatic continuous temperature recording equipment.

The number of measuring points shall be at least three, placed as follows: one at the centre of the member, two at a distance of 5 cm from the top and bottom (or side) surface. The temperature recordings shall commence immediately after casting and shall be carried out for a period of seven days.

The maximum temperature difference recorded between any one couple of close to surface and centre of the member shall not exceed twenty degrees Centigrade.

Thermocouples shall be installed and temperature measurements shall be carried out according to Tab. 33.1. However, the Engineer may instruct the Contractor to carry temperature measurements for each 500 m<sup>3</sup> during autumn and spring seasons (approximately four months per year), with no extra cost to the Employer.

### 33.2.8.4 Quality Control

The Contractor shall provide that the quality control tests with the frequency indicated in Tab. 33.1. The responsibility for ordering tests in the Authorised Laboratory (AL) is solely on the Contractor's Quality Control Manager.

**Tab. 33.1: Number of specimens and frequency of sampling**

Type of test	Number of specimens at each sample	Frequency of sampling
Compressive strength at 28 days	4 [1]	every 100 mc of concrete
Unit weight of fresh concrete	1	every day
Flexural strength	4	every week for the first month and then every month
Splitting tensile strength	4	every week for the first month and then every month
Water permeability	3	every week for the first month and then every month
Rapid Chlorides permeability Test	3	every month
Drying shrinkage	3	every month
Temperature measurements		every week for the first month and then every month or whenever required by the Engineer

[1] Two cubes will be tested, the other two kept for at least six months as a reference

### **33.2.9. Compliance with specifications**

Cast in place or pre-cast concrete shall comply with the Specifications if the following conditions are satisfied.

#### **33.2.9.1 Compressive Strength**

The 28 days compressive strength of 150 mm standard cubes shall comply with the following requirements:

At the beginning of casting operations (first 15 samples)

$$f_{cm,cube} \geq f_{ck,cube} + 4 \quad (\text{MPa})$$
$$f_{ci,cube} \geq f_{ck,cube} - 4 \quad (\text{MPa})$$

were:

$f_{ck,cube}$  is the minimum characteristic cube strength shown from 33.2.3.1  
 $f_{ci,cube}$  is the average compressive 28 day strength of two cubes belonging to the same sample  
 $f_{cm,cube}$  is the average compressive 28 day strength of 3 consecutive samples

Continuous production (after the first 15 samples)

$$f_{cm,cube} \geq f_{ck,cube} + 1.48\sigma \quad (\text{MPa})$$
$$f_{ci,cube} \geq f_{ck,cube} - 4 \quad (\text{MPa})$$

were:

$f_{ck,cube}$  is the minimum characteristic cube strength shown from 33.2.3.1  
 $f_{ci,cube}$  is the average compressive 28 day strength of two cubes belonging to the same sample  
 $f_{cm,cube}$  is the average compressive 28 day strength of at least 15 samples  
 $\sigma$  is the standard deviation of all the tested batches.  
 $\rho$  is the 5% fractile of the ratio between the compressive strength at 60 days and that at 28 days assessed on the 15 samples taken for the trial casting.

#### **33.2.9.2 Flexural and splitting tensile strength**

The average splitting tensile strength and the average flexural strength shall comply, at 28 days with requirements from **Employer's Requirement (ERQ), TECHNICAL REQUIREMENTS – Annex A – Civil Works: Design Basis.**

#### **33.2.9.3 Unit Weight**

The average unit weight for each type of concrete of the test sample of fresh concrete, prepared each day, is not less than that required from **Employer's Requirement (ERQ), TECHNICAL REQUIREMENTS – Annex A – Civil Works: Design Basis.**

#### **33.2.9.4 Temperature Gradient**

Maximum temperature gradient between the centre of the cube and any one of the top, side and bottom points, located at a distance of 5 cm from the surface does not exceed twenty degrees centigrade during first week after concreting.

**33.2.9.5 Cracking Allowances for castings**

One week after the end of the curing period, the Contractor shall submit to the Engineer the « as built » measurement of the cast which shall include indication of eventual cracking. It is defined as preliminary cracking allowance the following criteria:

- a) Cracking length density : maximum cracking length for each squared meter surface of casting shall be lesser than 0.2 m/m<sup>2</sup>;
- b) Max cracking width:  $b < 0.20$  mm;
- c) No observed evolution on crackings.

When all the cracking criteria above mentioned are matched and the resistance of the cracks is not systematically present on all the castings, the crackings can result acceptable, if the Engineer agree concerning the peculiar situation.

**33.2.9.6 Cracking Reparatons and Corrective Actions**

If the cracking width is equal or larger than 0.20 mm, the density is larger than the criteria, or is observed a progressive evolution of the cracks after the end of curing, the Contractor shall submit to the Engineer a procedure for cracking control and reparation.

Non-active cracks shall be injected with a low viscosity epoxy resin to fill and seal the crack and restore the structural integrity.

Before to starting the injection operation it shall be established by testing and investigation work that cracks manifest within concrete elements are not steel -active.

Grease, oil or other contaminants shall be removed. Algae and other biological growth shall also be removed by scrubbing with bactericide or detergent and clean water. If necessary, wire brushes shall be used. Loose or spalling areas of concrete, laitance, traces of paint or other coating materials within the marked out scope of the work shall be removed.

All cracks shall be thoroughly cleaned out using clean, oil-free compressed air. Both the concrete surface and the cracks shall be allowed to dry thoroughly before continuing.

The injection nipples shall be fixed at intervals along the length of each crack. The distance between each nipple will depend on the width and depth of the crack.

Spacing shall be close enough to ensure that the resin will penetrate along the crack to the next point of injection. This will normally be between 200 mm and 100 mm.

Each nipple shall be firmly bonded to the concrete surface by using a sealant. In the case of a wall or slab which is cracked all the way through, nipples shall be located on both sides with those at the back placed at midway points between those at the front.

The surface of the cracks between the nipples shall be sealed with a band of sealant. Both sides if cracks which go all the way through a wall or slab shall be sealed in this way.

The preparation, mixing and application of the materials shall be undertaken in strict accordance with the manufacturer's recommendations. The Contractor is to ensure that all necessary tools and equipment are on Site.

Each crack shall be treated in a single, continuous operation.

If the cracks are systematically present on all the castings, the Contractor shall submit to the Engineer a bundle of corrective actions to improve the quality of the cast; the corrective actions

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could involve curing methodology, concrete placing, cooling and transportation, mixing modifications and consequent new pre-trial and trial tests on concrete. Any corrective action to be implemented shall be previously formally approved by the Engineer.

Is demanded to the Engineer the possibility to apply a minus-payment for defected and/or not properly repaired structures. The minus-payment will be defined considering the compressive and tensile strength of the elements and durability criteria.

### **33.3. Reinforcing steel**

#### **33.3.1. General**

This Specification is for the supply, fabrication, handling and placing of plain reinforcing steel, epoxy coated reinforcing steel. All reinforcing steel shall be supplied and installed in the lengths and shapes shown on the Drawings. No substitution of bars or changes to bar details will be permitted without prior approval of the Engineer.

#### **33.3.2. Material Types**

Carbon steel reinforcement in form of bars, welded fabrics or lattice girders shall be Grade B500C and comply with EN 10080 and BS 4449 + amendment 2.

#### **33.3.3. Material Production and Testing**

Reinforcing steel shall be produced and tested in accordance with the applicable standard(s). Material manufacturer mill test certificates showing proof of compliance shall be submitted to the Engineer for review and acceptance prior to the placement of any reinforcing steel.

Mill test certificates shall be provided for each lot delivered to the site.

#### **33.3.4. Fabrication**

All bars requiring bends shall be cold bent at the fabrication facility. Heating of bars to facilitate bending will not be permitted.

Bars shall be cut by shearing or with fluid-cooled saws. Torch cutting will not be permitted. Bars showing evidence of torch cutting will be rejected.

Reinforcing steel shall be fabricated without laminations or burrs.

#### **33.3.5. Supply and storage of steel reinforcement**

The Contractor shall submit to the Engineer for source approval details of the proposed source of supply of the reinforcement. Details shall include chemical and physical tests for the past six months production and any independent test results for this period.

Reinforcing steel shall be covered and protected at all times during transportation.

The Contractor shall take all precautions necessary to prevent damage to the material during handling operations. Bundles shall be handled with spreaders and non-metallic slings, or by other methods acceptable to the Engineer. Damaged materials shall be replaced by the Contractor at his expense.

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On delivery, bars in each lot shall be legibly tagged by the manufacturer. The tag shall show the manufacturer's test number and lot number and other applicable data that will identify the material with the certificate issued for that lot of steel. The fabricator shall furnish three copies of a certification which shows the batch number or numbers from which each size of bar in the shipment was fabricated.

Reinforcing steel of differing material types shall be stored separately. Bar tags identifying the material type shall be clearly visible and shall be maintained in-place until installation of the material.

Storage of reinforcement shall be on suitable structures a minimum of 500 mm above the ground surface to prevent damage and accumulation of dirt, rust and other deleterious matter. Storage facilities shall be such as to permit easy access for inspection and identification. Reinforcement bundles shall be clearly tagged with bar schedule and bar mark reference.

### **33.3.6. Placing and Fastening**

Reinforcing steel incorporated into the work shall be free from loose rust, scale, dirt, paint, oil or other foreign materials.

Reinforcing steel shall be accurately placed in the positions shown on the Drawings, and shall be securely tied and chaired before placing the concrete. Bars shall be tied at all intersections except when the bar spacing is less than 250 mm in each direction; alternate intersections may be tied at these locations. Specified distances from forms shall be maintained by supports, spacers, or other means approved by the Engineer.

Reinforcing cover shall not be less than that specified on the Volume 3 – Technical Requirements. Supports used to prevent bars from contact with forms or for separation between layers of bars shall be of adequate strength, shape and dimension, and approved for use by the Engineer. Supports shall be either plastic or pre-cast concrete. Where additional reinforcing support bars are proposed by the Contractor they shall be of the same material type and grade used in the work.

Supports and spacers fabricated from alternate material types may be used upon approval by the Engineer.

### **33.3.7. Splicing**

Splicing of bars, unless shown on the Drawings or approved in writing by the Engineer, is prohibited.

Splices, where permitted, shall be staggered. For lapped splices, bars shall be placed in contact and wired together while maintaining the minimum required clear distance to other bars and the required minimum distance to the surface of the concrete.

### **33.3.8. Cutting, Bending and fixing of steel reinforcement**

All reinforcement shall be securely and accurately fixed in positions shown on the drawings to ensure that the reinforcement steel framework as a whole shall retain its shape. The framework shall be so temporarily supported as to retain its correct position in the forms during the process of placing and consolidating the concrete.

Cutting and bending of reinforcement shall be in accordance with ISO 3766:2003 and BS 8666 and shall be done without the application of heat. Bends shall have a substantially constant curvature.

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Field bending of reinforcing steel, regardless of circumstance, will not be permitted unless specified on the Drawings.

Field cutting of epoxy coated reinforcing steel shall be carried out only where necessary and approved by the Engineer. Cuts shall be made by shearing or saw cutting only. The epoxy coating on sheared or saw cut ends shall be patched in accordance with the specifications contained herein.

Reinforcement shall not be straightened or re-bent without the approval of the Engineer. If permission is given to bend projecting reinforcement care shall be taken not to damage the concrete and to ensure that the radius is not less than the minimum specified by EN 1992-1-1.

Lapped joints shall be as indicated on the Drawings and/or in accordance with the requirements of EN 1992-1-1.

Welding shall not be used unless authorised by the Engineer and recommended by the reinforcement manufacturer.

### **33.3.9. Concrete cover and spacers**

Correct concrete cover to reinforcement shall be maintained with the aid of approved non-metallic spacer pieces. Spacers, chairs and other supports shall be made of concrete, plastic or other material to the approval of the Engineer.

Where supports are made of concrete they shall have at least the same cube strength as the concrete in the host member.

The thickness of the concrete cover is indicated in the **Employer's Requirement (ERQ), TECHNICAL REQUIREMENTS.**

### **33.3.10. Inspection**

Placing of all reinforcement steel bars will be checked by the Engineer and in no case concrete is to be placed around any reinforcement steel that has not been approved by the Engineer.

The Contractor shall give 24 hour notice to the Engineer before closing forms or placing concrete.

The Engineer may instruct the Contractor to break out and remove completely all sections of the work already constructed under any of the following circumstances:

- a) reinforcing steel sample under test fails to meet the specification requirements at any time;
- b) the Engineer considers that samples which were presented to him for test were not truly representative;
- c) it becomes apparent that reinforcing steel which has not been approved has been used on the Works;
- d) reinforcing bars disposal, diameters, cover, spacing, or also tolerances are not compliant with specifications and/or detail design drawings;
- e) spacers are not compliant with specifications and/or detail design drawings;
- f) tolerances are not respected.

### **33.4. Additional provisions**

#### **33.4.1. Waterstop for construction joints**

At constructions joints in RCC structures, hydrophilic rubber water-stops shall be provided to ensure watertight.

##### **33.4.1.1 Materials**

Hydrophilic rubber waterstops shall have the minimum physical properties shown below:

- Tensile Strength: 2.4 MPa (ASTM Method D-412)
- Ultimate Elongation: 600% (ASTM Method D-412)
- Tear Resistance: 9 kN/m (ASTM Method D-624)
- Hardness Shore A: 50 ± 5, 10 sec delay (ASTM Method D-2240)
- Expansion ratio: 3 to 1 (volumetric change, distilled water at 70°F)

Waterstops shall have a delay coating to inhibit initial expansion due to moisture present in fresh concrete.

##### **33.4.1.2 Material Storage**

During progress of work all hydrophilic rubber waterstops shall be protected from damage and should be free of oil, dirt and concrete spatter. Waterstop coils should be uncoiled several days before installation to insure ease of installation and fabrication.

##### **33.4.1.3 Placement**

The location of the waterstop shall be as shown on the drawings.

Rubber waterstop shall be placed according to manufacturer recommendations; anyway rubber waterstop shall be secured to rough dry concrete by an hydrophilic sealant or similar and waterstop ends shall be cut square (or at proper angle for mitered corners) with shears or sharp blade to fit splices together without overlaps.

#### **33.4.2. Waterstop for expansion joints**

At expansion joints between RCC Structures (including rockshed and culverts), PVC water-stops shall be provided to ensure watertight.

##### **33.4.2.1 Materials**

PVC waterstops shall have the minimum physical properties shown below:

- Water Absorption: 0.15% (ASTM Method D-570)
- Tear Resistance: 53.5 kN/m (ASTM Method D-792)
- Specific gravity: 1.40 ± 0.05 (ASTM Method D-792)
- Hardness Shore A: 80 ± 5, 10 sec delay (ASTM Method D-2240)
- Tensile Strength: 13.8 MPa (ASTM Method D-638)
- Elongation: 350% (ASTM Method D-638)
- Brittle point: No failure at -35° F / -37° C (ASTM Method D-746)
- Stiffness in flexure: 4.1 MPa (ASTM Method D-747)
- Ozone Resistance: No failure (ASTM Method D-1149)
- After accelerated extraction (ASTM Method CRD-C572):
  - Tensile Strength: 11.0 MPa (ASTM Method D-638)

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- Elongation: 300% (ASTM Method D-638)
- Effects of Alkalies after 7 days (ASTM Method CRD-C572):
  - Weight Change: -0.10% /+0.25 % (ASTM Method CRD-C 572)
  - Change in Hardness, Shore A:  $\pm 5$  (ASTM Method D-2240)

### **33.4.2.2 Material Storage**

During progress of work all waterstops shall be protected from damage and should be free of oil, dirt and concrete spatter. Waterstop coils should be uncoiled several days before installation to insure ease of installation and fabrication.

### **33.4.2.3 Placement**

The location and embedment of the waterstop shall be as shown on the drawings, with approximately one-half of the width of the waterstop embedded in the concrete on each side of the joint.

All waterstops shall be sufficiently held in place to insure that they are correctly positioned to form a continuous watertight diaphragm in the joint unless otherwise shown. The method used to fasten the waterstop may be as follows:

- extending through a slot in the keyway;
- held in place by split bulkheads;
- hog ring and wire tie to reinforcing bars every 30 cm. Always secure hog ring or wire at edges of waterstop; hog ring shall not penetrate the waterstop.

Care should be taken during concrete placement on horizontal sections to prevent excessive movement of the waterstop to insure against displacement. Always thoroughly and systematically vibrate concrete around the waterstop to avoid air entrapment and to provide a positive contact between the waterstop and the concrete.

On the second pour, sweep horizontal joints to insure there is no foreign matter to interfere with positive contact between the waterstop and the concrete.

### **33.4.3. Waterproofing**

Waterproofing shall be applied to concrete surfaces exposed to backfill where shown on the drawings and shall be constituted by a PVC membrane reinforced with non-woven synthetic fibers or glass fibers.

The waterproofing membrane system shall not be placed until at least 28 days after concrete placement, unless otherwise directed by the Engineer.

In order to minimize possible damage to the membrane only vehicles necessary for construction, including the paver, will be permitted on the structure during and after the placing of the membrane system, and such vehicles shall be rubber tired or have rubber-covered treads.

The Contractor shall be responsible for maintaining the condition of the membrane system until covered with the bituminous concrete surface course overlay.

All methods employed in performing the work and equipment, tools, and machinery used for handling materials and executing any part of the work shall be subject to the approval of the Engineer before the work is started, and whenever found unsatisfactory, they shall be changed and improved as required. Equipment, tools, machinery, and containers used shall be kept clean and maintained in satisfactory working condition.



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Work shall not be performed during wet weather conditions. In addition, work shall not be performed when the concrete and ambient air temperatures are below 10° C. The concrete surface shall be thoroughly dry at the time of the application of the primer.

Concrete parapet surfaces and railing shall be protected to prevent their being defaced by primer or membrane material. Should defacement occur, the Contractor shall clean surfaces on the structure to the satisfaction of the Engineer.

Between the time the concrete is cleaned and prepared for primer and the time the membrane system is placed, no vehicles, including mechanical spreaders, shall be operated on the area being treated. Only the necessary personnel and equipment to perform the required work will be allowed on the treated surface, and only at such time and in such manner as approved by the Engineer. Care shall be taken to prevent sudden starts, stops, or turns by equipment. All other traffic shall be maintained on portions of the structure that are not being given the membrane protection.

Surfaces that are to be covered shall be thoroughly cleaned by the use of sandblasting, air jets, mechanical sweepers, hand brooms, or other approved methods, or as required by the Engineer, until the surface is free of sand, clay, dust, and loose or foreign matter. Water shall not be used to clean concrete surfaces unless authorized by the Engineer.

Any accumulations of oil or grease shall be scraped off the surface and cleaned with a strong caustic solution. The resulting residue shall be thoroughly flushed away with clean water. Cleaned areas shall be primed without delay as soon as they are dry. Dust and dirt shall be blown off with air jets immediately preceding application of primer.

Any sharp concrete protrusions on the concrete surface that would puncture the membrane shall be removed prior to application of the membrane.

The primer shall be applied to the cleaned concrete surfaces at the rate and in accordance with the procedure recommended by the membrane manufacturer. Surfaces to be covered by prefabricated membrane shall be uniformly coated with primer. Drying time prior to applying the membrane shall be as recommended by the manufacturer.

Unless otherwise approved by the Engineer, each phase of preformed waterproofing membrane construction shall begin at the low point of the surface to be waterproofed and shingled so that water will run over and not against any laps.

At culverts joints, the membrane shall extend to the edge of the joint opening as shown on the Drawings.

Prefabricated membrane shall be applied to the primed concrete surfaces by either hand methods or mechanical applicators. Prefabricated membranes shall be placed in such a manner that a shingling effect will be achieved, and any water that accumulates will drain toward the curb and the drainpipes. Each strip shall be overlapped a minimum of 10 cm.

An adhesive or a wide tipped torch shall be used, if necessary, to ensure a good seal of the prefabricated membrane joints. Hand rollers or other satisfactory pressure apparatus shall be used on the applied membrane to ensure firm and uniform contact with the primed concrete surfaces. Special care shall be used at the curb face to ensure that the membrane is uniformly and positively adhering to the concrete.

Prefabricated membranes shall be free of wrinkles, air bubbles, and other placement defects. Any torn or cut areas or narrow overlaps shall be patched using a satisfactory adhesive and by placing

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sections of the membrane over the defective area in such a manner that the patch extends at least 15 cm beyond the defect. The patch shall be rolled or firmly pressed onto the surface.

In the event protective covering is recommended by the prefabricated membrane manufacturer, a suitable compatible mastic or adhesive cement, as recommended by the membrane manufacturer, shall be used to adhere any protective covering material securely to membrane surfaces. Protective covering strips shall be butted tightly together at both longitudinal and transverse joints. Protective covering material shall be securely bonded to the membrane material and shall be essentially free of wrinkles, bubbles, and other placement defects.

After completion of the surface course, the waterproofing effectiveness of the membrane pavement system will be determined. The minimum electrical resistance shall be 500,000 ohms when tested in accordance with VTM-39. Areas designated by the Engineer as having a lower resistance reading than 500,000 ohms will be evaluated, and those areas determined by the Engineer to be detrimental to the effectiveness of the system shall be repaired at the Contractor's expense by removing the pavement and then replacing or repairing the defective membrane.

In the event more than 30 percent of the concrete area is shown defective by tests and is determined by the Engineer to be detrimental to the effectiveness of the system, the entire membrane system shall be removed and the deck cleaned in a satisfactory manner. The entire membrane-pavement system shall then be replaced in accordance with the requirements herein at the Contractor's expense.

### **33.4.4. Construction**

The Contractor shall employ qualified personnel experienced to complete the works..

#### Conformance Criteria

The Contractor shall provide formalized documentation, sealed and signed by the Engineer, who is responsible for each of the following construction phases and prior to commencement of each subsequent construction activity:

- Excavation
- Rock excavation reinforcement.
- Foundation base preparation (including replacing of foundation soil, where needed);
- Preparation of steel reinforcement and cast sequence;
- Backfill materials gradations and compaction requirements.

#### Material Storage

All construction materials, including top fill material, shall be covered and protected from rain, snow, dirt and ultraviolet light.

#### Excavation and foundation material replacement

The Contractor shall excavate to the lines and grades shown on the project grading plans. The Contractor shall take precautions to minimize over excavation. Over-excavation shall be filled with plain concrete, or as directed by the Engineer.

The Contractor shall report immediately to the Engineer any sub-soil conditions which he encounters during excavation which are likely to result in the bearing capacity required as shown on the Drawings not being achieved. Where the foundation soil locally encountered during excavation does not match with the mechanical characteristics assumed in the design phase, the contractor shall replace such material with plain concrete down to the underling rock material,

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preparing the interface surface with an adequate roughness. The procedure for material replacement shall be presented to the Engineer for Approval.

The Contractor shall verify location of existing structures and utilities prior to excavation. The Contractor shall ensure all surrounding structures are protected from the effects of wall excavation. Excavation support, if required, is the responsibility of the Contractor.

All underground service locations shall be clearly marked and protected during the course of construction. All damages to existing services resulting from the Contractor's operations shall be repaired at the Contractor's expense.

### **Foundation preparation**

Following the excavation, the foundation soil shall be examined by the Engineer to assure actual foundation soil strength meets or exceeds the design bearing strength. Soils not meeting the required strength shall be removed and replaced with plain concrete, as directed by the Engineer.

### **Backfill (except for Rockshed Structures)**

Soil test report for any source of selected fill shall be presented to the Engineer for approval. The backfill soil material should be well graded crushed and granular not Sub-rounded, and should conform to the following:

- i) Maximum particle size 100 mm
- ii) Uniformity coefficient greater than or equal to 4
- iii) Elastic Modulus  $M_E \geq 50 \text{ MN/m}^2$ .
- iv) Maximum unit weight of  $21 \text{ KN/m}^3$ , and in any case according to the design requirements.

Backfill shall be placed in such a manner as to avoid any damage or disturbances of installed structures. All materials that are damaged during backfill placement shall be removed and replaced at the Contractor's expense. Backfill should be compacted according to the Design Specifications .

### **Erosion Protection Measure at Culvers**

The discharge of each Culvert and each Pit on the valley side of the road shall be protected against erosion, adopting a rock protection armour with:

- i) Rock boulders: 1 - 3 m<sup>3</sup>
- ii) bed of plain concrete 0.50 m thickness

The Protection shall be envisaged also on the hill side, where a significant debris flow is expected. The extension of the erosion-protection works shall be determined according to a continuous hydrogeological survey during the construction.

## **33.5. Additional provisions for Rockshed**

### **33.5.1. General**

This specification is for the supply, fabrication and construction of the Rockshed structure. The works for Rockshed shall include, but not be limited to, excavation for the foundation, concrete levelling pads, installation of reinforcement, cast concrete, placing of the compacted granular backfill, placing of the Leca top filling, placing of drainage pipes complete with filter fabric sock, surface drains, cast-in-place secondary elements, etc.

#### **33.5.1.1 Qualification**

Shop drawings shall be stamped, signed and sealed by a professional engineer, registered to practice in Nepal.

The Contractor shall provide a complete set of drawings issued for construction and complete specifications for the approval of the Engineer prior to ordering materials to construct this structure.

The scope of work of the contractor shall include the following:

- a. Relevant geotechnical investigation for the design of the structure.
- b. Geotechnical review of bearing pressures applied to the foundation soils and overall stability, excavation, installation, supply, placement and compaction of the volume of fill.
- c. Replacement of the existing soils with a plain concrete, where the structure is not directly lying on rock material, to meet the requirements for stability (overall) and strength.

Design Calculations:

- d. The design of the Rockshed shall be based on the indications contained in the Design Basis (Technical Requirements, Section VI - Employer's Requirement (ERQ), Annex A) provided with this Tender Documents.

#### **33.5.1.2 Materials**

##### **Concrete Materials**

The fabrication of concrete shall conform to the requirements of Chapter 33.2 of these Specifications.

##### **Concrete Reinforcing Materials**

Reinforcing steel is to be in accordance with Chapter 33.3 of these Specifications. Reinforcing steel shall be Grade B500 C and comply with EN 10080.

##### **Backfill Materials**

Soil test report for any source of selected fill shall be presented to the Engineer for approval. The backfill soil material should be well graded crushed and granular not Sub-rounded, and should conform to the following:

- i) Maximum particle size 90mm
- ii) Uniformity coefficient greater than or equal to 4
- iii) Maximum 15% by mass passing the 75µm sieve, if not; 10% passing at 15µm sieve



### **33.5.1.3 Construction**

The Contractor shall employ qualified personnel experienced to complete this work. The LECA, or similar approved, Cushion (top filling) shall be installed in accordance with the supplier's recommendation. The supplier of the top-filling material shall provide a qualified representative on site to advise the contractor regarding construction procedures.

#### Conformance Criteria

The Contractor shall provide formalized documentation, sealed and signed by the Engineer, who is responsible for each of the following construction phases and prior to commencement of each subsequent construction activity:

- Foundation base preparation (including replacing of foundation soil, where needed);
- Preparation of steel reinforcement and cast sequence;
- Backfill and Topfill (LECA) materials gradations and compaction requirements.

#### Material Storage

All construction materials, including top fill material, shall be covered and protected from rain, snow, dirt and ultraviolet light.

#### Excavation and foundation material replacement

The Contractor shall excavate to the lines and grades shown on the project grading plans. The Contractor shall take precautions to minimize over excavation. Over-excavation shall be filled with plain concrete, or as directed by the Engineer.

The Contractor shall report immediately to the Engineer any sub-soil conditions which he encounters during excavation which are likely to result in the bearing capacity required as shown on the Drawings not being achieved. Where the foundation soil locally encountered during excavation does not match with the mechanical characteristics assumed in the design phase, the contractor shall replace such material with plain concrete down to the underling rock material, preparing the interface surface with an adequate roughness. The procedure (method of statement) for material replacement shall be presented to the Engineer for Approval two weeks before the execution of the works.

The Contractor shall verify location of existing structures and utilities prior to excavation. The Contractor shall ensure all surrounding structures are protected from the effects of wall excavation. Excavation support, if required, is the responsibility of the Contractor.

All underground service locations shall be clearly marked and protected during the course of construction. All damages to existing services resulting from the Contractor's operations shall be repaired at the Contractor's expense.

#### Foundation preparation

Following the excavation, the foundation soil shall be examined by the Engineer to assure actual foundation soil strength meets or exceeds the design bearing strength. Soils not meeting the required strength shall be removed and replaced with plain concrete, as directed by the Engineer.

#### Backfill and Topfill

Backfill and Topfill materials shall be in accordance with Chapter 33.5.1.2 of these Specifications.

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Backfill shall be placed in such a manner as to avoid any damage or disturbances of the rockshed materials. All materials that are damaged during backfill placement shall be removed and replaced at the Contractor's expense. Backfill should be compacted according to the Specifications, to obtain the required internal friction angle and unit weight.

### **33.6. Finishing and drainages**

All finishing (drainages, painting, filling,..) shall comply with requirements and dimensions provided in the **Employer's Requirement (ERQ), TECHNICAL REQUIREMENTS – Annex A and B and Drawing Sections** of Contract Document, as well as in "Standard Specifications for Road and Bridge Works – 2073(2075 Amendment) ", where relevant.

## **34. UNDERGROUND WORKS**

### **34.1. General**

The purpose of this Technical Specification for Civil Works is to recall and extend, where necessary, the general requirements set forth in the "Standard Specifications for Road and Bridge Works - 2073(2075 Amendment)", Government of Nepal, Ministry of Physical Infrastructure and Transport - Department of Roads, with reference not only to the underground works, but also to material and testing of materials (section 600), earthworks (section 900), pipe drains (section 700), formworks (section 1800) and concrete (section 2000) . For all not written in following articles, general requirements by "Standard Specifications for Road and Bridge Works - 2073(2075 Amendment)" hold.

### **34.2. Rock excavations with hammer**

With its offer, the Contractor shall provide all the technical specifications of the operating machines intended to be used for rock excavations with hammer.

The use of other mechanical excavation systems will be retributed according to the same conditions as per mechanical excavation with hammer.

Anyway, the Engineer could oblige the Contractor to use explosives instead of mechanical means, without any additional costs apart from what is due according to the Contract.

The Contractor shall excavate according to excavation profiles shown on the project plans. The Contractor shall take precautions to minimize over excavation. Over-excavation shall be filled with shotcrete and additional anchors and wire meshes may be required. No additional costs can be claimed by the Contractor in case of over-excavation.

The Contractor shall verify location of existing structures and utilities prior to excavation. The Contractor shall ensure all surrounding structures are protected from the effects of rock excavation.

#### **34.2.1. Excavation material management**

Excavation material management shall be described in a detailed plan, that the Contractor must provide with its offer, according to Nepalese standards, and is considered as included in his prices.

Rock excavation material should be preferably reused or recycled.

### **34.3. Rock excavations with explosive**

According to the excavation profiles for the different tunnel support classes, the Contractor shall provide with its offer the blasting parameters (drilling schemes, type of explosives and explosives quantities, blasting sequence, etc.).

All works with explosives lie under responsibility of the Contractor.

Over-excavation shall be limited as much as possible. Over-excavation shall be filled with shotcrete and additional anchors and wire meshes may be required. No additional costs can be claimed by the Contractor in case of over-excavation. Any additional blasting that should be necessary to reprofile the excavation contour won't be retributed.



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Within first 100 m from the portals, the Engineer could oblige the Contractor to use mechanical excavation (by hydraulic hammer or ripper) instead of explosives, without any additional costs apart from what is due according to the Contract. Basically, the Contractor must excavate with a full face advance, except for the invert section. In case the Contractor needs to partialize the excavation face, a proper motivation and the relevant excavation scheme shall be provided.

Before any advance blasting phase, the Contractor must present to the Engineer for approval the blasting plan intended to be used.

After any blasting phase, a complete blasting protocol must be provided by the Contractor, with date, time, tunnel chainage, blasting scheme, blasting result and, in case, changes with reference to the blasting plan.

### **34.3.1. Excavation material management**

Excavation material management shall be described in a detailed plan, that the Contractor must provide with its offer, according to Nepalese standards, and is considered as included in his prices.

Rock excavation material should be preferably reused or recycled.

### **34.3.2. Safety measures**

Explosives shall be carefully used and stored accordingly to relevant Nepalese standards; particularly in the vicinity of existing structures and traffic at the south and north portal. Explosives could cause projection of stones and small pieces of rock towards working people, pedestrians, vehicles and buildings.

The excavation face must be covered at a certain distance with proper devices and both workers and machineries must be kept in a safe area during blasting operations.

During blasting at the portals, it could be necessary to temporarily interrupt the traffic in front of the working sites (north and south portals) and stop vehicles and pedestrians at a safe distance from the blasting zone. The stop of the traffic shall be limited to no more than 5 minutes during the blasting; hence, proper protection shall be installed to avoid projection of material on the road. The Contractor is responsible to prepare and submit with its offer a safety report with all the safety measures intended to be used during blasting in proximity of the portals and underground.

The Contractor is responsible for the application of the safety plan.

The Contractor must implement all signage works inside and outside the working sites to inform pedestrians and vehicles of the blasting risk in proximity of the working sites.

The Contractor must also implement acoustic and lighting devices to inform peoples in the surrounding area about the beginning of a blasting procedure.

The Contractor is responsible for any damage to people and existing structures due to blasting and induced vibrations.

### **34.3.3. Noise reduction measures**

As the South Portal is adjacent to existing buildings and a temple, the Contractor shall implement and submit to the Engineer for approval a plan of measures to minimize the noise disturbance around the South tunnel Portal during the excavation of the tunnel, such as noise protection walls and/or cover outside the portal, demonstrating to keep an acceptable noise level according to Nepalese standard at the temple during construction and/or quantify activity when noises too high and how to manage such situations.

**34.4. Shotcreting (50 to 350mm thick)****34.4.1. Shotcrete type**

<i>Characteristic</i>	<i>Requirements</i>
Maximum size of Coarse Aggregate	≤ 8 mm
Compressive strength class (EN 206-1)	C25/30
Minimum characteristic cube strength	30 MPa
Minimum exposure classes	XA1, XD1
Maximum chloride content, % by weight of cement	0.2
Initial resistance class according to SIA 198	J2
Minimum compressive strength after 3 h (cylindric $f_c$ )	1 MPa
Minimum compressive strength after 24 h (cylindric $f_c$ )	5 MPa

**34.4.2. Shotcrete execution**

Basically wet-mix underground application shall be preferred to dry-mix application. In case of dry-mix application, the Contractor must prove effectiveness and provide all safety measures to prevent dust propagation and to maintain a sound air quality. Alkali-free accelerator shall be used in the shotcrete mixture: no silicate based accelerator can be used.

All voids and fissures must be completely filled, as well as wire meshes must be completely covered by shotcrete (inside and outside). Wire meshes shall be placed and fixed so that, during, shotcreting, they will not vibrate and can be completely wrapped by shotcrete.

**34.4.3. Preliminary tests**

Preliminary tests shall be provided by the Contractor.

For each shotcrete production cycle, at least 10 cylindric samples ( $\phi$ 50 mm, height 50 mm) shall be tested: 5 compressive strength tests after 7 days and 5 compressive strength tests after 28 days. Reference shall be made to EN 12 390-3 and EN 12 504-1.

**34.4.1. Contractor Qualification and Obligations**

The Contractor shall provide certificate stating the admixture used for the shotcrete, as well as documentation regarding aggregate origin and composition; moreover, shall provide all relevant tests results demonstrating that minimum requirements as above described are fulfilled, following relevant standards and "Standard Specifications for Road and Bridge Works – 2073(2075 Amendment)".

Projection of concrete shall be done in layers of 5 cm thickness: to avoid shade effect, shotcrete behind wiremesh shall be projected before wiremesh installation. All void due to excavation face irregularities shall be filled before to place the wiremesh and cast the final shotcrete layer.

The Contractor shall consider as included in his prices all component, activity and safety measure needed to provide and install the shotcrete layers

### **34.5. Steel Fibers for Shotcrete**

Steel fibres reinforced shotcrete must be systematically used at the tunnel contour as a primary lining and at the tunnel face wherever necessary.

#### **34.5.1. Steel fibres type**

WIRAND MACCAFERRI FS7 or similar.

Diameter/Length: 0.55 mm/33 mm

L/D aspect ratio: 60

Tensile strength: > 1100 MPa

Elongation at break: < 4%

Dosage: 50 kg/m<sup>3</sup>

#### **34.5.2. Contractor Qualification and Obligations**

Contractor shall produce technical sheet of proposed type of steel fibers, demonstrating it satisfies the above requirements.

### **34.6. Wire mesh for Shotcrete**

#### **34.6.1. Wire mesh type**

φ 5 mm, pattern 10 cm x 10 cm.

K196 Ruwa Matten or similar.

#### **34.6.2. Material Types**

Min. B500 A (according to European standards).

#### **34.6.1. Contractor Qualification and Obligations**

Contractor shall produce technical sheet of proposed type of steel fibers, demonstrating it satisfies the above requirements.

The Contractor must guarantee adequate fixing of the wiremesh to the shotcrete support (3 fixing every 1 m<sup>2</sup> is suggested) and a minimum overlap between wire mesh sheets of at least 50 φ.

### **34.7. Steel ribs**

#### **34.7.1. Profiles type**

HEB 180 profiles are foreseen.

#### **34.7.1. Other steel ribs components**

The Contractor must design all steel ribs components, such as connection plates, base plates, welding of components and connection bars between steel ribs.

The steel rib foot must be designed so that a regular and flat base, without asperities and roughness, is guaranteed. A shotcrete or lean concrete layer could be used to level the ribs base.

#### **34.7.2. Material Types**

Structural steel S355. Structural steel shall comply with EN10025.

Repair of steel plates or rolled shapes by welding at the producing mill is not permitted.

Bolts, screws and nuts shall comply with the European Standards.

### **34.7.1. Contractor Qualification and Obligations**

Contractor shall produce certificates regarding the material of the adopted profile.

The Contractor shall provide before construction to the Engineer, and get approved, proper construction drawings of steel ribs with all details of connections and welding with attached a comprehensive static report demonstrating all connection and details are designed to withstand relevant design loads (as by design basis and construction design).

The Contractor must avoid shade effect during shotcrete execution around steel ribs as well as voids between shotcrete and steel ribs. Steel ribs must be completely wrapped by shotcrete.

## **34.8. Lattice girders**

### **34.8.1. Profiles type**

JB-3-Gurt Gitterträger or similar:

- 3G-70/26/34 or similar
- 3G-130/20/30 or similar
- 3G-70/18/26 or similar

P230-36 or P230-30 or similar

### **34.8.2. Material Types**

Steel grade S500, according to European standards.

Lattice girders foot must be designed so that a regular and flat base, without asperities and roughness, is guaranteed. A shotcrete or lean concrete layer could be used to level the lattice girders base.

### **34.8.3. Contractor Qualification and Obligations**

Contractor shall produce certificates regarding the material of the adopted profile.

The Contractor shall provide before construction to the Engineer, and get approved, proper construction drawings of steel ribs with all details of connections and welding with attached a comprehensive static report demonstrating all connection and details are designed to withstand relevant design loads (as by design basis and construction design).

The Contractor must avoid shade effect during shotcrete execution around lattice girders as well as voids between shotcrete and lattice girders. Lattice girders must be completely wrapped by shotcrete.

**34.9. Swellex rock bolts****34.9.1. Bolts type**

Swellex rock bolt Pm 16 type or equivalent

<b>Characteristic Pm16</b>	<i>Requirements</i>
Minimum breaking load (expanded profile)	160 kN
Minimum yielding load (expanded profile)	140 kN
Minimum elongation	10%
Profile diameter	36.5 mm
Material thickness	≥ 2 mm
Drilling diameter	≥ 50 mm
Expansion pressure	240 bar

Swellex rock bolt Pm 24 type or equivalent

<b>Characteristic Pm16</b>	<i>Requirements</i>
Minimum breaking load (expanded profile)	240 kN
Minimum yielding load (expanded profile)	200 kN
Minimum elongation	10%
Profile diameter	37 mm
Material thickness	≥ 3 mm
Drilling diameter	≥ 50 mm
Expansion pressure	300 bar

**34.9.2. Other components**

The Contractor must design all other components, such as redistribution plates, and the relevant costs must be included in the rock bolt rates.

**34.9.3. Tension / Pull-out tests**

The Contractor shall demonstrate that swellex bolts are properly anchored to the rock by performing suitable pull out tests. The pull-out tests shall demonstrate that the characteristic external resistance of the bolts reaches at least the characteristic internal resistance of the bolt.

Pull-out tests shall be performed following relevant rules provided by Eurocodes for this type of tests and the indications provided in relevant design documents attached to the tender; the following minimum number of tests shall be performed:

- At least 3 for each type of rock mass (where a type rock mass is defined as characterized by a certain percentage of mudstone or other erosive and sandstone or rock type, admitted range +/- 10% at the tunnel face, and a certain Q-Value/RMR/GSI, admitted range +/- 5 points);
- However, at least 3 every 100 m of tunnel for each type of bolt (if applied).

In case during the tests the bolt shall show plastic behaviour or is pulled out, it shall be replaced. Bolts used for pull-out tests shall not be considered as resistant bolt in the support system.

**34.9.4. Contractor Qualification and Obligations**

Contractor shall produce technical sheet of proposed type of bolts and get approval by the Engineer before construction. The Contractor shall produce for every bolt:

- Drilling record, with indication of length, diameter, drilling system and type of excavated material;
- Expansion procedure record, with description of adopted pressure and injected quantity

Moreover, the Contractor shall produce a layout with bolts numbering in order to let the Contracting authority understand to which bolt every document is referred to. Finally, the Contractor shall produce for every performed test a report with description of testing device and procedure and results, accordingly to relevant eurocodes.

**34.10. Injected rock bolts, incl. injections****34.10.1. Bolts type**

Belloli Belcem M33 or equivalent

<b>Characteristic M33</b>	<b>Requirements</b>
Minimum breaking load (Ftk)	460 kN
Minimum yielding load (Fyk)	364 kN
Profile diameter	32 mm
Drilling diameter	≥ 60 mm
Steel Grade	B550B or superior

Belloli Belcem M27 or equivalent

<b>Characteristic M27</b>	<b>Requirements</b>
Minimum breaking load (Ftk)	350 kN
Minimum yielding load (Fyk)	280 kN
Profile diameter	25 mm
Drilling diameter	≥ 60 mm
Steel Grade	B550B or superior

Belloli Belcem M24 or equivalent

<b>Characteristic M24</b>	<b>Requirements</b>
Minimum breaking load (Ftk)	250 kN
Minimum yielding load (Fyk)	200 kN
Profile diameter	22 mm
Drilling diameter	≥ 60 mm
Steel Grade	B550B or superior

Length of bolts range between 4 and 7 m, according to design drawings.

All devices needed to provide a proper injection of the bolts (chamfering, injection pipes, cement itself, pumps and other devices) are to be included in the bolts rate.

**34.10.2. Cement based grout**

The injection procedure shall be able to guarantee continuous and full anchorage between the bolt and surrounding rock. The cement based grout shall comply to the following minimum requirements. However, independently by compliance to them, the Contractor is required to demonstrate proper anchorage of the bolts by suitable tension tests.

<i>Characteristic</i>	<i>Requirements</i>
Type	High strength, non-shrink cementitious construction grout with aggregate size suitable for the effective pouring thickness
W/C (max)	0.5
Plasticizer	1% - 2% on weight
Strength (cylindric)	5MPa after 48h, 25MPa after 28d

**34.10.1. Tension / Pull-out tests**

The Contractor shall demonstrate that injected bolts are properly anchored to the rock by performing suitable tension tests. The tests shall demonstrate that the external resistance of the bolts reaches at least the characteristic internal resistance of the bolt.

The tests shall be performed following relevant rules provided by Eurocodes for this type of tests and in a number of:

- At least 3 for each type of rock mass (where a type rock mass is defined as characterized by a certain percentage of mudstone or other erosive and sandstone or other rock type, admitted range +/- 10% at the tunnel face, and a certain GSI, admitted range +/- 5 points);
- However, at least 3 every 100 m of tunnel for each type of bolt (if applied).

In case during the tests the bolt shall show plastic behaviour or is pulled out, it shall be replaced. Bolts used for pull-out tests shall not be considered as resistant bolt in the support system.

**34.10.1. Other components**

The Contractor must design all other components, such as redistribution plates, and the relevant costs must be included in the rock bolt rates.

**34.10.2. Contractor Qualification and Obligations**

Contractor shall produce technical sheet of proposed type of bolts and get approval by the Engineer before construction. The Contractor shall produce for every bolt:

- Drilling record, with indication of length, diameter, drilling system and type of excavated material;
- Injection record with description of injection system, adopted pressure and injected cement volume;

Moreover, the Contractor shall produce a layout with bolts numbering in order to let the Contracting authority understand to which bolt every document is referred to. Finally, the

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Contractor shall produce for every performed test a report with description of testing device and procedure and results, accordingly to relevant eurocodes.

### 34.11. Spiles

#### 34.11.1. Self-drilling bolt type

Minova MAI SDA R51L or equivalent self-drilling cemented bolt

<i>Characteristic MAI SDA R51L</i>	<i>Requirements</i>
Minimum breaking load (Ftk)	550 kN
Minimum yielding load (Fyk)	450 kN
Outer diameter	51 mm
Inner diameter	33.3 mm
Drilling diameter	≥ 60 mm
Steel Grade	B550B or superior

#### 34.11.2. Cement based grout

The injection procedure shall be able to guarantee continuous and full anchorage between the bolt and surrounding rock. The cement based grout shall comply to the following minimum requirements. However, independently by compliance to them, the Contractor is required to demonstrate proper anchorage of the bolts by suitable tension tests.

<i>Characteristic</i>	<i>Requirements</i>
Type	High strength, non-shrink cementitious construction grout with aggregate size suitable for the effective pouring thickness
W/C (max)	0.5
Plasticizer	1% - 2% on weight
Strength (cylindric)	5MPa after 48h, 25MPa after 28d

All devices needed to provide a proper injection of the bolts (chamfering, injection pipes, cement itself, pumps and other devices) are to be included in the bolts rate.

#### 34.11.3. Tension / Pull-out tests

The Contractor shall demonstrate that injected bolts are properly anchored to the rock by performing suitable tension tests. The tests shall demonstrate that the external resistance of the bolts reaches at least the characteristic internal resistance of the bolt.

The tests shall be performed following relevant rules provided by Eurocodes for this type of tests and in a number of:

- At least 3 for each type of rock mass (where a type rock mass is defined as characterized by a certain percentage of mudstone or other erosive and sandstone or other rock type, admitted range +/- 10% at the tunnel face, and a certain GSI, admitted range +/- 5 points);
- However, at least 3 every 100 m of tunnel for each type of bolt (if applied)



**34.11.4. Other components**

The Contractor must design all other components, such as redistribution plates, and the relevant costs must be included in the rock bolt rates.

**34.11.5. Contractor Qualification and Obligations**

Contractor shall produce technical sheet of proposed type of bolts and get approval by the Engineer before construction. The Contractor shall produce for every bolt:

- Drilling record, with indication of length, diameter, drilling system and type of excavated material;
- Injection record with description of injection system, adopted pressure and injected cement volume;

Moreover, the Contractor shall produce a layout with bolts numbering in order to let the Contracting authority understand to which bolt every document is referred to. Finally, the Contractor shall produce for every performed test a report with description of testing device and procedure and results, accordingly to relevant eurocodes.

**34.12. Forepoling umbrella****34.12.1. Steel pipes**

<i>Characteristic</i>	<i>Requirements</i>
Steel grade	S355
Outer diameter	>100 mm
Thickness	≥ 16 mm

Expected length of the pipes is 15 m, according to design drawings.

Steel pipes shall be provided by valves every meter in order to allow selective injection by every valve meter by meter.

**34.12.2. Cement based grout**

The injection procedure shall be able to guarantee continuous and full anchorage between the bolt and surrounding rock. Injection shall be performed through all the valves, by selective injection system (double packer) in order to guarantee full injection of the hole and main rock fractures. The cement based grout shall comply to the following minimum requirements. However, independently by compliance to them, the Contractor is required to demonstrate proper anchorage of the bolts by suitable tension tests.

<i>Characteristic</i>	<i>Requirements</i>
Type	High strength, non-shrink cementitious construction grout with aggregate size suitable for the effective pouring thickness
W/C (max)	0.5
Plasticizer	1% - 2% on weight
Borehole diameter	≥ 60 mm
Strength (cylindric)	5MPa after 48h, 25MPa after 28d

All devices needed to provide a proper injection of the bolts (chamfering, injection pipes, cement itself, pumps and other devices) are to be included in the pipes rate.

**34.12.3. Contractor Qualification and Obligations**

Contractor shall produce, and get approval by the Engineer before construction, certificates demonstrating steel quality and supplier of the steel pipes as well as adopted cement, demonstrating it satisfy requirements. The Contractor shall produce for every pipe::

- Drilling record, with indication of length, diameter, drilling system and type of excavated material;
- Injection record with description of injection system, adopted pressure and injected cement volume;

Moreover, the Contractor shall produce a layout with pipes numbering in order to let the Contracting authority understand to which bolt every document is referred to. Finally, the Contractor shall produce for every performed test a report with description of testing device and procedure and results, accordingly to relevant eurocodes.

The Contractor shall consider as included in his prices all component, activity, tests and safety measure needed to provide and install the pipes.

**34.13. Fiberglass dowels/bolts**

**34.13.1. Fiberglass dowel type**

It is foreseen to use fiberglass pipes to be injected from inside. Minimum characteristics as follows.

<i>Characteristic</i>	<i>Requirements</i>
Minimum breaking load (Ftk)	800 kN
Outer diameter	60 mm
Inner diameter	40 mm

Length is according to tunnel support classes (see design drawings)

**34.13.2. Cement based grout**

The injection procedure shall be able to guarantee continuous and full anchorage between the bolt and surrounding rock. The cement based grout shall comply to the following minimum requirements. However, independently by compliance to them, the Contractor is required to demonstrate proper anchorage of the bolts by suitable tension tests.

<i>Characteristic</i>	<i>Requirements</i>
Type	High strength, non-shrink cementitious construction grout with aggregate size suitable for the effective pouring thickness
W/C (max)	0.5
Plasticizer	1% - 2% on weight
Borehole diameter	≥ 60 mm
Strength (cylindric)	5MPa after 48h, 25MPa after 28d

All devices needed to provide a proper injection of the bolts (chamfering, injection pipes, cement it self, pumps and other devices) are to be included in the bolts rate.

### **34.13.3. Tension / Pull-out tests**

The Contractor shall demonstrate that injected bolts are properly anchored to the rock by performing suitable tension tests. The tests shall demonstrate that the external resistance of the bolts reaches at least the characteristic internal resistance of the bolt.

The tests shall be performed following relevant rules provided by Eurocodes for this type of tests and in a number of:

- At least 3 for each type of rock mass (where a type rock mass is defined as characterized by a certain percentage of mudstone or other erosive and sandstone or other rock type, admitted range +/- 10% at the tunnel face, and a certain GSI, admitted range +/- 5 points);
- However, at least 3 every 100 m of tunnel for each type of bolt (if applied)

### **34.13.4. Contractor Qualification and Obligations**

Contractor shall produce technical sheet of proposed type of bolts and get approval by the Engineer before construction. The Contractor shall produce for every bolt:

- Drilling record, with indication of length, diameter, drilling system and type of excavated material;
- Injection record with description of injection system, adopted pressure and injected cement volume;

Moreover, the Contractor shall produce a layout with bolts numbering in order to let the Contracting authority understand to which bolt every document is referred to. Finally, the Contractor shall produce for every performed test a report with description of testing device and procedure and results, accordingly to relevant eurocodes.

## **34.14. Waterproofing system: composite drainage layer**

### **34.14.1. Description**

Groundwater, coming from the surrounding rock mass, is collected at the foot of the tunnel vault, thanks to the drainage and waterproofing layers around the tunnel. The tunnel waterproofing system consists of the following package of layers (in setting sequence, from top to bottom): geocomposite drainage layer; waterproofing layer; protection layer.

### **34.14.2. Composite draining layer**

As drainage layer a geocomposite sheet type Enkadrain shall be used or equivalent, made of two layers of geotextile tissue with interposed a three-dimensional structure to guarantee drainage. Equivalent system can be applied if the Contractor can demonstrate that same drainage properties are guaranteed.

Before to apply the drainage layer, the temporary lining surface shall be accurately checked (visual inspection by Contractor together with representative of the Owner) and smoothed in order to have a regular surface on which to place the waterproofing system. Where smoothing is necessary, it is to be performed by application of an additional shotcrete layer.

**34.14.3. Waterproofing layer**

Groundwater, coming from the surrounding rock mass, is collected at the foot of the tunnel vault, thanks to the drainage and waterproofing layers around the tunnel. The tunnel waterproofing system consists of the following package of layers (in setting sequence, from top to bottom): geocomposite drainage layer; waterproofing layer; protection layer.

As waterproofing layer, a PVC-P membrane or Spraying Membrane (type SIKAPLAN WP 2110-21HL or equivalent) shall be used, which shall fulfil following minimum requirements:

<b>Characteristics</b>	<b>Minimum requirements</b>
Thickness	2 mm
Resistance to punction	≥ 2.85 kN (accor. to Swiss Norm SIA272, SN EN ISO12236)
Tensile resistance	16.5 N/mm <sup>2</sup> (accor. to Swiss Norm SIA272, SN EN ISO527)
Max Elongation	≥ 300 %
Shoch resistance	≥ 900 mm (accor. to Swiss Norm SIA272, SN EN ISO12691 system A)

The different strips of PVC membrane shall be welded together by a two parallel continuous welding lines, in order to get a continuous and waterproof membrane. The welding shall be tested by inflating air pressure within the two weld a verifying that a pressure over 100 kPa can be maintained.

No structural or supporting elements that pass through the membrane are allowed. The PVC membrane shall be fixed at the outer lining by proper systems that will be fixe to the membrane itself by welding.

**34.14.4. Protection layer**

Between the waterproofing layer and the inner lining, a protection sheet shall be placed, in order to protect waterproofing during installation of reinforcement bars and during casting of inner lining. As protection sheet, an additional protection membrane shall be used (type SIKAPLAN WP Protection Sheet 20H or equivalent).

<b>Characteristics</b>	<b>Minimum requirements</b>
Thickness	2 mm
Max Elongation	≥ 150 %
Impact resistance	≥ 900 mm (according to Swiss Norm SIA272, SN EN ISO12691 system A)

**34.14.5. Contractor Qualification and Obligations**

Contractor shall produce to the Engineer, and get approved before construction, technical sheet of all the elements (composite draining layer, waterproofing layer and protection layer) which shall demonstrate they satisfy all requirements.

The Contractor shall moreover provide for approval to the Engineer before construction the procedure he plan to use to install and weld the waterproofing layer in order to get waterproof connections.

The Contractor shall provide to the Engineer after construction reports of the waterproof tests performed on welded connections.

**34.15. Inner lining****34.15.1. Description**

The inner lining shall be realized partly by plain concrete and partly by reinforced concrete, accordingly to design and static verifications.

A minimum 50 mm concrete cover must be guaranteed.

Before casting the inner lining, the waterproofing system shall be installed and checked in accordance to Owner's representative.

Casting of concrete shall be made by movable formworks, with length between 10 and 12 m, that allow to cast the lining block in one phase, i.e. without longitudinal construction joints above the final road surface. It is allowed to cast in advance a footing on both sides, in order to provide a support for formwork and a base for the main casting phase.

**34.15.2. Concrete**

The concrete mixture shall comply with following minimum requirements.

<b>Characteristic</b>	<b>Requirements</b>
Minimum cement or combination [1] content	300 kg/m <sup>3</sup>
Maximum water cement ratio [1]	0.45
Maximum size of Coarse Aggregate	≤ 32 mm
Consistency class (EN 206-1)	S4 - S5
Minimum average bulk density of fresh concrete	2400 kg/m <sup>3</sup>
Compressive strength class (EN 206-1)	C30/37
Minimum characteristic cube strength	37 MPa
Minimum average Flexural strength (EN 12390-5)	2.4 MPa
Minimum average Splitting tensile strength (EN 12390-6)	2.0 MPa
Exposure class	XC4 / XD1 / XF1
Other requirements	Resistant to AAR

**34.15.3. Reinforcement**

As concrete reinforcement, ribbed steel bars shall be used satisfying following minimum requirements.

<b>Characteristic</b>	<b>Requirements</b>
Steel grade	B500B
Yielding stress (Fyk)	500 MPa

**34.15.4. Contractor Qualification and Obligations**

As for all other requirements, regarding for example (but not only) concrete production, documentation and testing, formwork and curing, the Contractor shall refer to indications and requirements provided in "Standard Specifications for Road and Bridge Works - 2073", Government of Nepal, Ministry of Physical Infrastructure and Transport - Department of Roads, referred to "concrete for structures – section 2000" and section 1800

### **34.16. Inner Finishing and drainages**

All inner finishing (drainages, painting, filling,...) shall comply with requirements and dimensions provided in the **Employer's Requirement (ERQ), TECHNICAL REQUIREMENTS Annex A and B and Drawings of the Contract Documents**, as well as in "Standard Specifications for Road and Bridge Works – 2073(2075 Amendment)", where relevant.

### **34.17. Instrumentation And Monitoring**

Instrumentation and monitoring are considered as an integral part of the NATM tunnelling for verification of the design assumptions on the interactions between the surrounding ground and the initial tunnel support systems induced during excavation process. Works described herein are subsidiary obligations of the Contractor.

#### **34.17.1. Method of Monitoring**

Monitoring of ground movement is the mandatory activities to assure that the tunnel centre remains in the alignment.

The monitoring of the ground movement aims to detect the displacement and settlement of the initial tunnel support systems -- particularly the shotcrete lining -- and the ground surface while they are still small and to enable early support system modifications.

**These monitoring shall consists of the following observations/surveys.**

#### **(a) Visual Examination of the Tunnel Opening and Ground Surface**

##### **(i) Geologic mapping of the face after each round.**

Geologic mapping of the tunnel face and the round periphery is an important element for determining initial support systems.

Information typically included in these face maps include:

- The station location for the cross-section; the date and time the face mapping was prepared;
- The name of the individual who prepared the face map;
- Classification of each type of material observed; the location of interface boundaries between these materials;
- Rock jointing including orientation of principal joints and joint descriptions;
- Shear zones;
- Observed seepage conditions and their approximate locations on the face, walls, or roof;
- Observed ground behaviour noting particularly the location of any instability or squeezing material at the face;
- The location of any boulders or other obstructions; and
- Any other significant observations.

In rock tunnels where the perimeter rock is left exposed, sketches presenting similar information can be prepared for the tunnel walls and roof. All mapping shall be prepared by an experienced

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geologist or geological engineer of the Contractor knowledgeable of tunnelling and with soil and rock classification.

Mapping of the face, walls and roof shall occur for every excavation round and formally documented and signed off by both the Contractor and the Engineer in the format acceptable to the Engineer.

- (ii) Groundwater inflow, if observed.

The quantity of observed seepage shall be recorded and monitored on a daily basis for all groundwater inflow including seepages in the previous rounds as well. The method of measuring inflow quantity shall be subject to the Engineer's approval.

- (iii) Deformation of initial support systems after each round.

Ground movement along the tunnel alignment will be the primary cause of displacement or buckling of initial support systems. Amongst others, displacement, buckling and subsidence (settlement) of steel ribs, integrity of shotcrete with wire mesh/steel ribs and rock face, and potential damage to or loosening of rock bolt components, shall be visually checked by the Contractor's geologist or the geological engineer before using the survey instruments. Information thus obtained shall be recorded and presented to the Engineer for review before next excavation.

- (iv) Ground surface settlement along the tunnel centre

The Contractor is required to make close observation on potential anomalies such as surface cracking, tilting of trees, changes in stream water flow direction, displacement of the existing boulders, and other unusual phenomena. The Contractor shall record any such anomalies with each excavation cycle, and submit such records as soon as possible but well before next excavation takes place.

The Engineer may instruct the Contractor to lay surface settlement markers and/or benchmarks for observation of ground movement.

### (b) Lateral and Vertical Displacement

As for the lateral movement of the tunnel opening, distance between the shotcrete surfaces shall be measured at the points illustrated in Fig-34.17.1 for full-face excavation profile and Fig-34.17.2 for top-heading and bench excavation shown below.

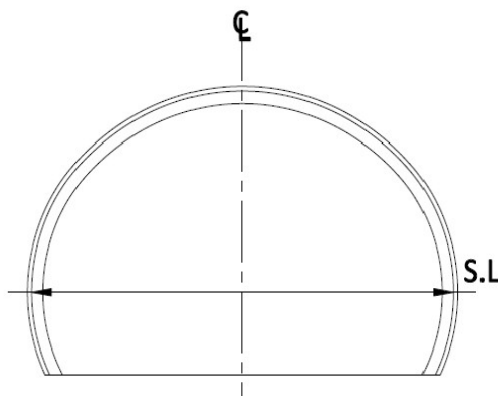


Fig-34.17.1: Full-face excavation excavation

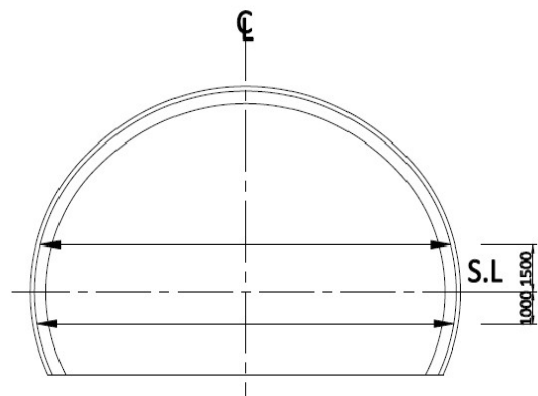


Fig-34.17.2: Top-heading and bench excavation

Vertical displacement of the tunnel cross-section shall also be monitored by surveying level of the crown.

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Lateral displacement shall be measured at the spring lines for full-face excavation sections (Fig-34.17.1), and if tunnel is excavated sequentially, i.e. top heading ahead of bench, measurement shall be taken first at 1.5 meters above the spring line (Fig-34.17.2) for every top heading round.

Once bench excavation starts after the top heading excavation, the Contractor shall measure the displacement again at 1.5 meters above the spring line (Fig-34.17.2) and at 1.0 meter below the spring line (Fig-34.17.2) after each bench excavation round.

In unstable ground, which is vulnerable to excavation-induced stress relief such as or tunnel sections near the portals under shallow overburden -- say less than about twice the tunnel width measured along the spring line -- additional measurements shall be taken along a pair of symmetrical lines between the points connecting the crown and points at 1.5 meters above the spring line (Fig-34.17.3).

In tunnel domains where any of or a combination of (i) excavation-induced sharp unsymmetrical pressure, (ii) settlement of steel rib, or (iii) ground heaving is likely to occur, the Engineer may instruct the Contractor to take further measurements along a pair of the symmetrical lines (indicated in dashed lines in Fig-34.17.3) that connect the point at the crown and points at 1.0 meters below the spring line.

In case where the magnitude of the unsymmetrical pressure, settlement of steel ribs, or the ground heaving is considerable in the Engineer's judgement, the Engineer may instruct the Contractor to take readings of the vertical displacement at two off-set points from the crown in addition to the settlement reading of the crown level.

The number of survey points will be determined at the Engineer's discretion and the Contractor shall provide such survey points according to the Engineer's instructions given orally or in writing.

### (c) Surface settlement above the centreline near the tunnel portal

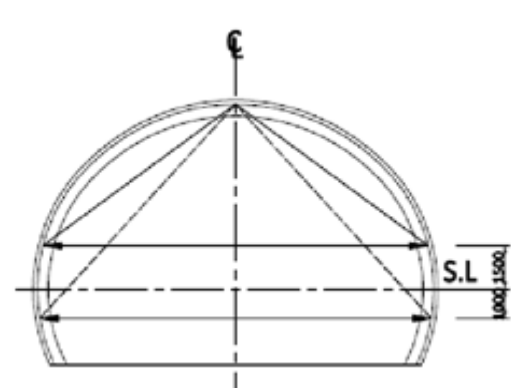
Geological anomalies observed on the ground surface above tunnels, such as surface cracking, tilting of trees, changes in stream water turbidity and its flow direction, displacement of the existing boulders, and other unusual phenomena, shall be monitored and recorded in a format acceptable to the Engineer.

The Engineer may determine shorter intervals of survey points which are normally selected along the tunnel centre despite the normal intervals given in Table-34.1 below. Survey points may be increased on the ground surface at the Engineer's discretion in case readily noticeable movement is detected.

**Table-34.1: Depth of Overburden and Intervals of Survey Points**

Depth of Overburden	Intervals
Not exceeding D	5 m
Exceeding D and less than 2D	10 m

*D: Tunnel diameter at spring line.*



**Fig-34.17.3: Lateral Displacement Survey Points for Top Heading & Bench Excavation**



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### 34.17.2. Monitoring Frequency and Interval of Distance

Lateral and vertical displacement of the tunnel opening shall be monitored at the frequencies indicated in Table-34.2, and at the intervals shown in Table-34.3.

**Table-34.2: Parameters of Monitoring Frequencies**

Monitoring Frequency <sup>(*1)</sup>	Factors Controlling Monitoring Frequency <sup>(*1)</sup>	
	Distance from Face	Rate of Lateral/Vertical Movement
2 times / 1day	0 – 0.5 D	Exceeding 10 mm / day
1 time / 1day	0.5 – 2.0 D	5 – 10 mm / day
1 time / 2 days	2.0 – 5.0 D	1 – 5 mm / day
1 time / 1 week	5.0 D or more	Not exceeding 1 mm / day

(\*1): Monitoring frequency will be determined by either the distance from face or rate of movement whichever effectuate higher frequency.

**Table-34.3: Intervals of Survey points**

Excavation Profiles	Interval of Survey points <sup>(*2)</sup>			
	Within 50 m from Portal	50 – 200 m from Portal	Over 200 m from Portal	Overburden not exceeding 2D
All Class	10 m	20 m	30 m	10 m

(\*2): The intervals will be determined by the Engineer based on the ground conditions encountered.

#### **Surveying Requirements**

- (a) The Contractor shall use a total station for all surveys for accurate data collection. Thus, the Contractor shall submit to the Engineer for his approval details of the total station he proposes to use.
- (b) All survey shall be conducted and controlled by a qualified professional surveyor having a minimum 3 years tunnel survey experiences using a modern total station.
- (c) The required surveying accuracy is  $\pm 2$  mm for both lateral and vertical directions in any survey unless otherwise instructed by the Engineer. The surveying instruments shall be packaged with the minimum reading function not more than  $\pm 0.1$  mm.
- (d) The lateral and vertical movement of the tunnel supports (and ground surface as well) shall be surveyed immediately after mucking is completed. It is recommended that the survey is conducted within 3 hours after completion of mucking. For synchronicity of the survey data between ground surface movement and the tunnel supports movement, the Contractor shall simultaneously carry out tunnel survey and ground survey unless otherwise the Engineer agrees.
- (e) No excavation will be permitted unless all required survey data is collected.
- (f) The data processing software shall be subject to the Engineer's approval.

#### **Survey Reference Points**

- (a) Permanent reference points shall be continuously located and installed along the tunnel route, no later than one day after installation of the tunnel support system.
- (b) The maximum spacing of the reference points shall be not more than 100 meters along straight sections of the tunnel, and no more than 50 meters along curved sections.
- (c) The installation of the reference points shall be to the satisfaction of and/or as required by the Engineer. The location of the reference points shall not conflict with other parts of the work, and

## **Employer's Requirements : Technical Specification**

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- (d) Reference points shall be rechecked and verified at one-kilometre intervals in conjunction with the completion of the tunnel support systems.

### **Longitudinal Profile Survey**

The Contractor shall perform (and provide to the Engineer) longitudinal profile survey of the tunnel lining, by means of closed traverse, upon completion of the tunnel works.

### **Submittal**

- (a) The Contractor shall submit for the Engineer's approval the following information within 28 days after the date of commencement of the Works.
- Format of geologic mapping, and method of measuring quantity of groundwater inflow,
  - Details of the total station, and
  - Data processing software.
- (b) Other documents (reporting formats) which should be submitted before next excavation are as follows.
- A report notifying geological anomalies observed during visual inspection of tunnel supports and ground surface above the tunnel alignment.

### **34.17.3. Thresholds**

#### **Convergence thresholds (Rock Class upto III):**

- Expected maximum vertical displacement 6 mm - 10 mm (lay-by) - 1 mm (bypass);
- Alert threshold, vertical displacement 10 mm;
- Alarm threshold, vertical displacement 15 mm;
- Expected maximum horizontal displacement 2 mm;
- Alert threshold, horizontal displacement 5 mm;
- Alarm threshold, horizontal displacement 10 mm.

#### **Convergence thresholds (Rock Class IV):**

- Expected maximum vertical displacement 8 mm;
- Alert threshold, vertical displacement 10 mm;
- Alarm threshold, vertical displacement 15 mm;
- Expected maximum horizontal displacement 2 mm;
- Alert threshold, horizontal displacement 5 mm;
- Alarm threshold, horizontal displacement 10 mm.

#### **Convergence thresholds (Rock Class V):**

- Expected maximum vertical displacement 8 mm;
- Alert threshold, vertical displacement 10 mm;
- Alarm threshold, vertical displacement 15 mm;
- Expected maximum horizontal displacement 6.5 mm;
- Alert threshold, horizontal displacement 10 mm;
- Alarm threshold, horizontal displacement 15 mm.

## **35. ROCKFALL PROTECTION MEASURES**

### **35.1. General**

The purpose of this Technical Specification for Civil Works is to recall and extend, where necessary, the general requirements set forth in the "Standard Specifications for Road and Bridge Works – 2073(2075 Amendment)", Government of Nepal, Ministry of Physical Infrastructure and Transport - Department of Roads, with reference to the rock protection measures and earthworks. For all not written in following articles, general requirements by "Standard Specifications for Road and Bridge Works – 2073(2075 Amendment) hold.

### **35.2. Lightweight Expanded Clay for Rockshed Cushion layer**

Within the following articles of this Technical Specification, the minimum technical requirements for ROCKshed Cushion Layer

#### **35.2.1. Applicable Codes and Documents**

Applicable Code is the latest edition of relevant Eurocode

#### **35.2.2. Contractor Qualification and Obligations**

The Contractor shall prove

#### **35.2.3. Articoli specifici**

Testo

### **35.3. Rockfall barriers**

Within the following articles of this Technical Specification, the minimum technical requirements for providing and installation of Rockfall Barriers to withstand falling boulders with different levels of impact energy are given: 2000 KJ, 3000kJ and 5000 KJ with wire Ø 3mm, Ring Ø 350mm, Rope Ø 16-22mm, HEA post type with spacing of 8-12m, with barrier ht. ranging between 4 and 5 m as per design and specification including the construction of all required foundations, support system, braking system all complete, and use of helicopter or the crane, whichever is feasible & equivalent to Geobrugg RXE 2000-3000-5000 Rockfall barrier.

#### **35.3.1. Barrier types**

Depending on required energy adsorption, three types of rockfall barriers has been considered with the following general requirements:

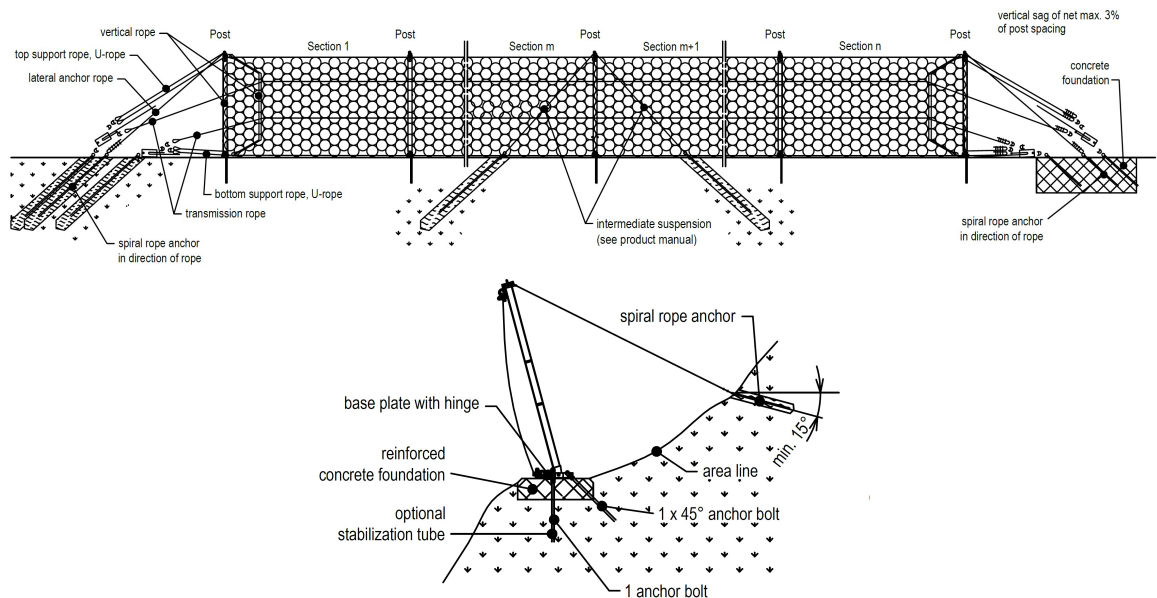
- Design barrier type GEOBRUGG RXE 2000 or similar  
Absorption capacity 2000 kJ  
Energy class EOTA 5  
Height 4 m  
Post spacing 8-12 m (average 10 m)
- Design barrier type GEOBRUGG RXE 3000 or similar  
Absorption capacity 3000 kJ  
Energy class EOTA 6  
Height 4 m

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- Post spacing 8-12 m (average 10 m)
- Design barrier type GEOBRUGG RXE 5000 or similar
- Absorption capacity 5000 kJ  
Energy class EOTA 8  
Height 5 m  
Post spacing 8-12 m (average 10 m)

Adequacy of the position, energy absorption and height to the local conditions shall be verified and confirmed or adapted by the Contractor performing an independent rockfall analysis. Exact location of the rockfall barriers shall also be defined based on such analysis.

An example of the rockfall barrier hereby considered is shown in the following figure (Geobrugg AG). See tender drawings for more details.



### 35.3.2. Technical requirements

The Contractor must refer to the rockfall barriers supplier for all system details.

The reference supplier for the present design is GEOBRUGG AG. Similar suppliers could be chosen by the Contractor.

Structural elements of the barrier shall fulfil the following minimum requirements.

Minimum diameter of a single net wire shall be 3 mm and coating thickness min.150 g/m<sup>2</sup> to encounter potential erosion and weathering processes and reduce maintenance. The nets shall be made in such a way that if there is a rupture, the failure area should be closely limited and not propagate through the protection surface.

For safety reasons, brake elements shall be placed at the ends of the corresponding support ropes only.

Brake elements activation force has to be  $\geq 50$  kN, to avoid activation during installation or triggered by snow other temporary loads.

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Hot dip galvanization of energy dissipating (deforming) elements is not allowed to avoid rusting after partial brake elements activation.

All connections of ropes to posts and anchors must be detachable, to allow mesh exchange without taking down support or middle ropes in order to guarantee fast and economical maintenance.

All assembly components shall be hot dip galvanized to provide at least the same corrosion resistance as the main elements (posts, ropes, net).

Anchors shall fulfil the following general requirements:

- Rope anchorage with a flexible head section which allows a movement of min. 30° off the anchor axis without reduction of the nominal load capacity;
- Double corrosion protection at anchor head of rope suspensions.

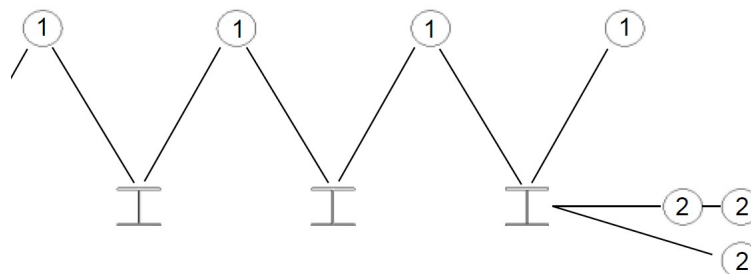
Moreover, anchorages, depending on the type of rock barrier required at each location, shall satisfy individual minimum requirements as resulting by proper calculations under the effect of the design impact energy and accordingly to the supplier of the adopted system.

All elements of the adopted rockfall barriers shall guarantee a service life not lower than 50 years.

### 35.3.3. Technical requirements on anchors for Geobrug RXE 2000 or equivalent

Anchors with following minimum requirements shall be provided (to be verified in accordance with supplier specifications):

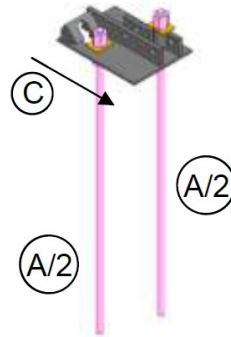
- Upslope anchors (1) retaining ropes  
Characteristic load 315 kN (tensile)  
Anchor type permanent spiral rope anchor GEOBRUGG type III 18.5 mm or similar  
Drilling diameter  $\geq 110$  mm  
Length  $\geq 5.5$  m
- Lateral anchors (2) support and lateral ropes  
Characteristic load 285 kN (tensile)  
Anchor type permanent spiral rope anchor GEOBRUGG type III 18.5 mm or similar  
Drilling diameter  $\geq 110$  mm  
Length  $\geq 5.0$  m



***RXE 2000 typical rope scheme***

- Posts foundation
 

Characteristic load	310 kN (A = compression) / 85 kN (C = shear)
Anchor type	2x permanent micropiles GEWI 32 mm or similar (steel grade B500B)
Drilling diameter	≥ 110 mm
Length	≥ 4.5 m



***RXE 2000 post foundation***

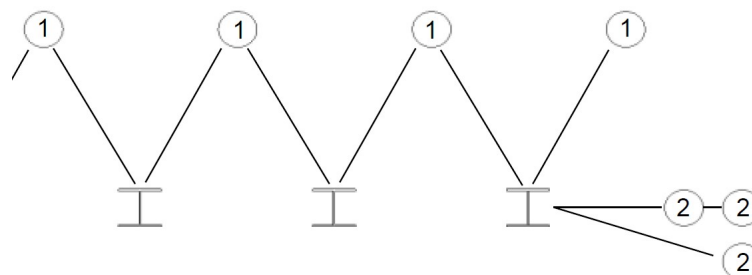
**35.3.4. Technical requirements on anchors for Geobrugg RXE 3000 or equivalent**

Anchors with following minimum requirements shall be provided (to be verified in accordance with supplier specifications):

- Upslope anchors (1) retaining ropes
 

Characteristic load	230 kN (tensile)
Anchor type	permanent spiral rope anchor GEOBRUGG type III 18.5 mm or similar
Drilling diameter	≥ 110 mm
Length	≥ 4.0 m
- Lateral anchors (2) support and lateral ropes
 

Characteristic load	280 kN (tensile)
Anchor type	permanent spiral rope anchor GEOBRUGG type III 18.5 mm or similar
Drilling diameter	≥ 110 mm

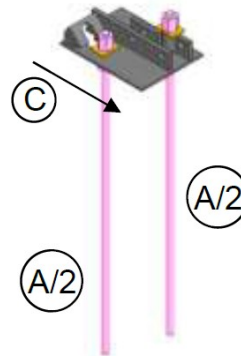


***RXE 3000 typical rope scheme***

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- Posts foundation
 

Characteristic load	270 kN (A = compression) / 150 kN (C = shear)
Anchor type	2x permanent micropiles GEWI 32 mm or similar (steel grade B500B)
Drilling diameter	≥ 110 mm
Length	≥ 4.0 m



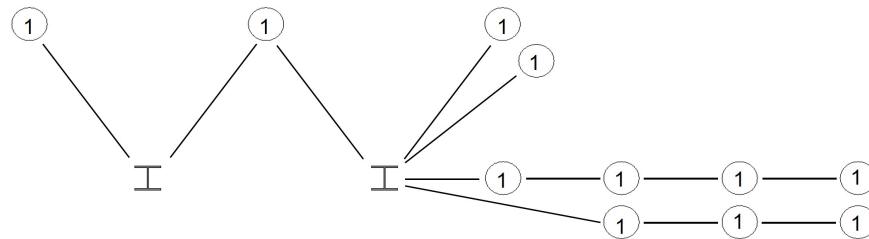
**RXE 3000 post foundation**

### 35.3.5. Technical requirements on anchors for Geobrugg RXE 5000 or equivalent

Anchors with following minimum requirements shall be provided (to be verified in accordance with supplier specifications):

- Upslope/Lateral anchors (1) retaining/support/lateral ropes
 

Characteristic load	290 kN (tensile)
Anchor type	permanent spiral rope anchor GEOBRUGG type III 18.5 mm or similar
Drilling diameter	≥ 110 mm
Length	≥ 5.0 m



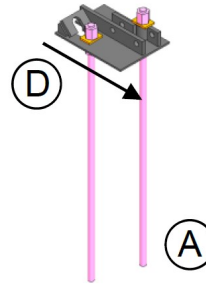
**RXE 5000 typical rope scheme**

## Employer's Requirements : Technical Specification

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- Posts foundation

Characteristic load	300 kN (A = compression) / 265 kN (D = shear)
Anchor type	2x permanent micropiles GEWI 40 mm or similar (steel grade B500B)
Drilling diameter	≥ 110 mm
Length	≥ 7.5 m



***RXE 5000 post foundation***

### 35.3.6. Onsite tests

In order to verify that spiral rope anchors and micropiles meet the design requirements, suitable pull out/load tests shall be provided before rockfall barriers installation.

In each homogeneous rock formation or ground condition and for each rocknet, at least 3 tests shall be provided for each designed anchor type. The design of the tests (location, pulling and loading system, etc.) shall be provided by the Contractor according to Eurocodes. The tests shall be performed up to a load level useful to guarantee that external resistance is at least equal to characteristic internal characteristic resistance of the anchors. The tests shall be performed before to start construction and the results shall be made available and approved by the Engineer.

### 35.3.7. Contractor Qualification and Obligations

The Contractor shall demonstrate to make use of specialized personnel with experience in installation of rack barrier of the same supplier as adopted.

The Contractor shall produce a safety plan and a risk assessment for the construction phase, which show all safety measures that he is going to install in order to exclude the risk of falling rocks and materials on the existing road during installation of rocknet. Only after approval by the Engineer, construction can start.

The Contractor shall also prove to have installed the rocknet accordingly to supplier requirements. For this purpose, the Contractor shall produce a certificate provider by the supplier of the system testifying that the rock net has been installed correctly in order to work properly.

The Contractor shall moreover provide the following documentation being crucial for correct installation and guaranteeing results obtained during certification procedure:

- Product manual showing all the barrier's details, installation steps and details of solutions for special cases (e.g. intermediate suspension).
- Maintenance manual explaining inspection procedures, conditions proving correct barrier performance and eventual repair methods.
- Anchor forces table showing characteristic forces (max. forces measured during tests).

The Contractor shall consider as included in his prices all component, activity and safety measure needed to provide and install the adherence mesh in the proper way and position, including all redistribution plates, bolts and wire bolts, drilling activities, use of helicopter, safety measures and protection barrier to allow to keep the H10 in service at least with reduced width (alternate traffic).



### 35.4. Wiremesh Systems

Supply and installation of Wiremesh system as per design and specification including the construction at site, and use of helicopter or the crane, whichever is feasible & equivalent to Geobruigg TECCO G65/4 high tensile steel wire mesh.

#### 35.4.1. Technical requirements

The Contractor must refer to the adherence wiremesh system supplier for all system details.

The reference supplier for the present design is GEOBRUGG AG. Similar suppliers could be chosen by the Contractor.

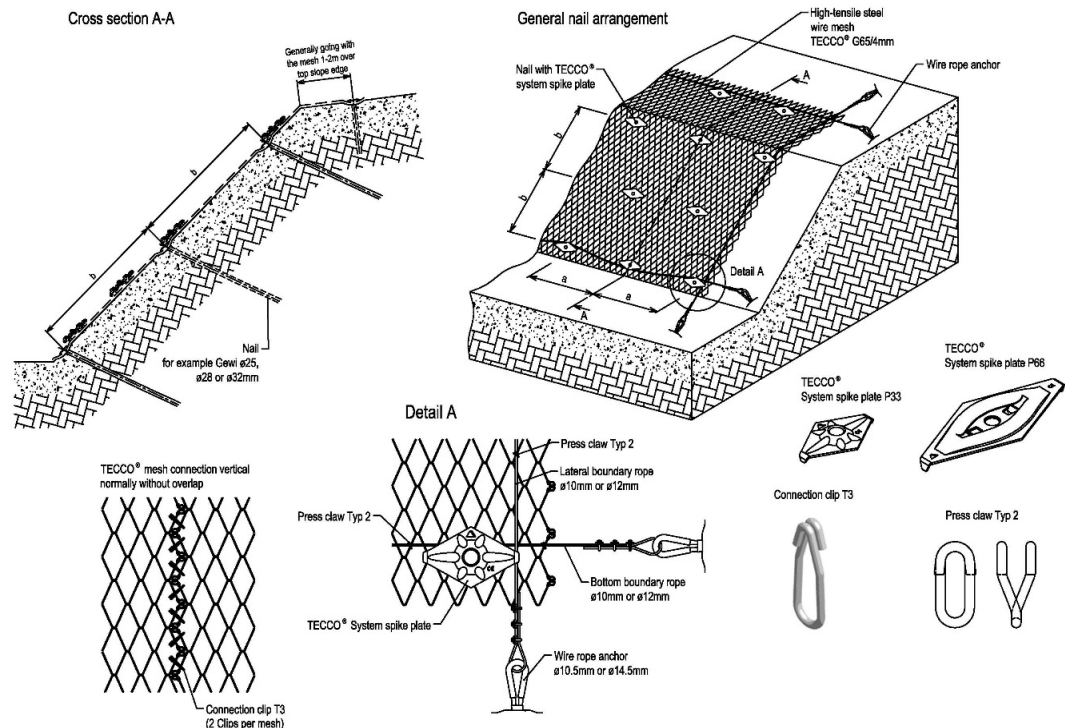
The adopted surface net shall be made of high-tensile steel wire mesh type Geobruigg TECCO G65/4 or similar, with P66 redistribution plates (spike plates, steel quality S355J) or similar. Anchorage of stabilization nets will be provided by grouted bolts GEWI 32 mm or similar (steel grade B500 B), with a pattern with maximum step 2.5 m x 2.5 m, having a minimum drilling diameter equal to 110 mm. As the bolts are used as permanent bolts, a sacrificial steel layer of at least 2 mm around the whole bar shall be assumed as a consequence of rusting during service life. As alternative, bolts with double protection shall be adopted, accordingly to relevant Eurocodes. Minimum requirement on characteristic resistance of the bolt during service life (i.e. considering section reduction due to rusting) is:

- axial resistance  $\geq 300$  kN;
- shear resistance  $\geq 170$  kN.

Along the border of the net, a lateral border rope and wire rope anchors shall be provided as by supplier indications.

All element of the adopted adherence mesh shall guarantee a service life not lower than 50 years.

The above described adherence mesh is shown in the following figure (Geobruigg AG).



### **35.4.2. Onsite tests**

In order to verify that wire rope anchors and micropiles meet the design requirements, suitable pull out/load tests shall be provided before adherence net installation.

In each homogeneous rock formation or ground condition, at least 3 tests shall be provided for each designed anchor type. The design of the tests (location, pulling and loading system, etc.) shall be provided by the Contractor according to Eurocodes. The tests shall be performed up to a load level useful to guarantee that external resistance is at least equal to characteristic internal characteristic resistance of the anchors. The tests shall be performed before to start construction and the results shall be made available and approved by the Engineer.

### **35.4.3. Contractor Qualification and Obligations**

The Contractor shall demonstrate to make use of specialized personnel with experience in installation of adherence net of the same supplier as adopted.

The Contractor shall produce a safety plan and a risk assessment for the construction phase, which show all safety measures that he is going to install in order to exclude the risk of falling rocks and materials on the existing road during installation of rocknet. Only after approval by representative of the Owner, construction can start.

The Contractor shall also prove to have installed the adherence net accordingly to supplier requirements. For this purpose, the Contractor shall produce a certificate provider by the supplier of the system testifying that the rock net has been installed correctly in order to work properly.

The Contractor shall moreover provide the following documentation being crucial for correct installation and guaranteeing results obtained during certification procedure:

- Product manual showing all the net's details, installation steps and details of solutions for special cases (e.g. intermediate suspension).
- Maintenance manual explaining inspection procedures, conditions proving correct barrier performance and eventual repair methods.
- Anchor forces table showing characteristic forces (max. forces measured during tests).

The Contractor shall consider as included in his prices all component, activity and safety measure needed to provide and install the adherence mesh in the proper way and position, including all redistribution plates, bolts and wire bolts, drilling activities, use of helicopter, safety measures and protection barrier to allow to keep the H10 in service at least with reduced width (alternate traffic).

## **35.5. Permanent Shotcrete with bolts for erosion protection of mudstone or other erosive layers (150 mm thick)**

Where erosion of mudstone or other erosive layers with thickness larger than 20 cm can be expected with consequent risk of instability of upper sandstone blocks, a shotcrete layer shall be applied to protect it by erosion and stabilize superficial unstable blocks.

Wherever mudstone or other erosive or other erosive with a thickness ranging between 20 and 50 cm, the following system shall be applied:

- execution of a permanent shotcrete C30/37 layer, 15 cm thick, with a wire mesh  $\phi 6/10 \times 10$ ;

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- the shotcrete layer shall have a minimum high of 1 m (to cover the whole mudstone or other erosive or other erosive layer and overlap mudstone or other erosive or other erosive for at least 20-30 cm);
- wire mesh shall have everywhere at least 5 cm cover and 30 cm overlapping;
- in the centre of the shotcrete layer, a row of bolts with horizontal step 2 m shall be placed and the heads covered by at least 5 cm concrete, accordingly to design drawings.
- Above shotcrete layers and its bolts, where foreseen, Tecco net will be installed with its own bolts, as by previous point, to keep continuity of the Tecco intervention above and below the mudstone or other erosive or other erosive layer;
- before shotcrete execution, scaling of unstable blocks;
- if a mudstone or other erosive or other erosive layer is eroded (presence of step between sandstone layer above and mudstone or other erosive or other erosive layer), the step shall be filled with shotcrete in order to level it and give a foot to the above sandstone layer, before installing the final shotcrete layer and bolts.

Wherever a mudstone or other erosive or other erosive layer has a thickness > 50 cm, the following measures shall be applied:

- same system with protective shotcrete layer as for thinner mudstone or other erosive or other erosive layers, but with at least 2 rows of bolts fixing the shotcrete layer with horizontal and vertical step not larger than 2 m;
- Above shotcrete layers and its bolts, Tecco net will be installed with its own bolts, as by previous point;
- scaling and filling with shotcrete in case of erosion as for thinner layers of mudstone or other erosive or other erosive .

For relevant requirements regarding shotcrete type, characteristic and admixture, wiremesh type, bolts types and characteristics, execution process, preliminary tests on shotcrete, pull-out, tension and corrosion tests on bolts and Contractor qualifications and obligations, reference shall be made to points 10.2, 10.3 and 10.4 and to "Standard Specifications for Road and Bridge Works – 2073(2075 Amendment)".

### **35.6. Scaling of unstable blocks**

Within the following articles of this Technical Specification, the minimum technical requirements for scaling procedure of unstable blocks shall be defined.

#### **35.6.1. Applicable Codes and Documents**

Relevant document is **Employer's Requirements-Drawing** of the contract Documents, where potential unstable boulder are shown as available observed by orthophotos. This document shall be considered as a starting base to evaluate the areas where scaling shall be needed; however, the Contractor shall perform an independent survey to record position of boulders, evaluation of their risk of instability and, hence, update map of boulders to be removed.

#### **35.6.2. Contractor Qualification and Obligations**

The Contractor shall provide to the Engineer for approval its own independent evaluation on the areas where scaling is needed and a plan describing them, before to start activity. Moreover, Contractor shall submit for approval to the Engineer, prior to start activity, a proper procedure to proceed on removal of unstable blocks, guaranteeing safety of adjacent areas that shall be kept in service, at least with reduced width (alternate traffic); the procedure shall include all necessary protection to guarantee safety of traffic and pedestrian. Moreover, all activity shall be performed guarantee safety conditions to workers themselves.

After activity has been concluded, the Contractor shall produce a plan where he record all boulders that has been removed and all boulder that has been checked but considered stable in the short and long term.

## **36. EXPLOITATION AND SAFETY EQUIPMENT (ESE)**

### **36.1. General**

The detail-degree of all the systems listed here below has been harmonized with the project phase and with the procedural situation (tender for **DB/EPC contract**), therefore no executive details are provided where it is not considered essential for the outcome of the works. It was therefore assumed that the executive details will be defined with the general contractor, by the client or by a representative of the same, during the execution phase of the project.

The reference standards and requirements for the following systems have been defined:

- Energy supply system
- Lighting system
- Ventilation system
- Signage system
- Surveillance systems
- Communication network and Tunnel control system
- Cabling system
- Secondary installations

**Refer Employer's Requirement (ERQ), TECHNICAL REQUIREMENTS Annex C and D.**

## **37. Installation and pre-commissioning**

Once the plants/Equipments have arrived at the site, they can be installed according to the detailed planning provided by the contractor.

The activities will have to be harmonized and optimized to reduce the installation time without this being detrimental to the quality of the work. The installation sequence of the systems must follow a logical order and must be harmonized with the execution of the civil engineering works.

They should be avoided:

- rework
- disassembly of plants or parts of plants already assembled and tested.

Progressively, with the installation of the plants, the general contractor will have to monitor the quality of the execution of the works, and intervene promptly in the event that it is not satisfactory.

The progressively assembled plants, and also their parts, will be progressively tested in their basic functions. These tests will be informal and will be conducted by the general contractor.

The installation period will end with a pre-commissioning phase that will take place on site.

In the pre-commissioning, Contractor shall arrange and carry out all inspections in accordance with the Contract requirement. Where the third party inspection is required, Contractor shall ensure that all third party inspection conform with the Contract requirements and Contractor shall furnish Contracting Authority with the copies of records for all inspections.

Contractor's scope of inspections prior to pre-commissioning shall include, but not be limited to, the following:

- All materials and Works are subject to visual inspection for surface defects.
- Visually inspection and verification that the installations conform with the drawings.
- Conduct inspections of all equipment, check nameplate, check electrical connection data, layout and ensure conformity to specification.
- Inspection on safety features and earthing system of electrical equipment.
- Visual inspection and ensure correct assembly of all equipment.

Contractor shall perform testing and pre-commissioning in accordance with Contract requirement for all Contractor and Contracting Authority supplied equipment and system.

Contractor shall prepare the detailed testing and pre-commissioning procedure and submit to Contracting Authority for review and **approval three (3) months** before testing and pre-commissioning activities commencement. The procedure shall include, but not be limited to, the following:

- Pre-commissioning execution plan, critical path network, bar charts.
- Pre-commissioning scope of work of each system, equipment testing procedures of each system.
- Check sheets overview, reinstatement test pack, list of equipment to be used.
- Pre-commissioning manpower level and organisation.
- Schedule for equipment vendor representative(s) mobilisation for both Contracting Authority and Contractor supplied equipment.
- Listing of consumables required.

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All testing and pre-commissioning shall be thoroughly recorded and documented. These documents shall be approved by Contracting Authority and eventually be included in the Final Documentation.

No testing or pre-commissioning shall be undertaken until the appropriate verification and check have been satisfactorily completed and agreed upon in writing by Contractor.

In all cases, the relevant equipment manufacturer's instruction manual and vendor data must be carefully read and understood before any testing and pre-commissioning started.

Non-conformance of any equipment discovered during testing and pre-commissioning shall be rectified, re-tested and re-commissioned by Contractor to the satisfaction of Contracting Authority at Contractor's own cost.

Contractor shall provide all consumable necessary for the testing, pre-commissioning and operation of the process equipment. Contractor shall use vendor recommended consumable for the equipment and take due cognisance of the manufacturer's recommendations and the overall intent of Works.

Contractor shall provide the services of vendor representatives, as required, for the pre-commissioning period for Contractor supplied equipment at Contractor's own cost.

The PLANT AND SYSTEM SCOPE OF WORK of the present contract will be considered as mechanically complete when the following requirements have been met:

- The PLANT AND SYSTEM SCOPE OF WORK have been constructed, and pre-commissioned in accordance with the approved drawings, specifications, Quality Plan and procedures, including inspection/witnessing and acceptance by Contracting Authority prior to introducing the process and utility feedstock into the system.
- All the installed equipment have been functionally tested, all SPIRs have been submitted by Contractor and accepted by Contractor.
- All utility systems and plant buildings have been commissioned.
- All design modifications have been noted and modifications incorporated into Data and Documentation mark ups with As- Built mark ups within system dossiers. All operating instructions, documentation and drawings necessary for prudent and safe operation of the facility have been submitted and accepted by Contractor.
- Mechanical Completion Certificate have been issued by Contractor, upon fulfilment of all the above stated requirement by Contractor.

## **38. COMMISSIONING**

### **38.1. General**

The additional requirements contained in this section shall apply to PLANT AND SYSTEMS (ESE) works, as defined Employer's Requirement Section.

Contracting Authority is responsible to perform the commissioning

Contractor shall execute all activities required for commissioning and start-up of the Exploitation and Safety Equipment, i.e. checking, putting into operation and operating the utilities systems required for commissioning the process and other facilities, and all verifications required to demonstrate that the Exploitation and Safety Equipment are ready for start-up.

### **38.2. Commissioning requirement**

Contractor shall note that Commissioning shall generally include the following activities and such activities are to be completed prior to opening the tunnel to traffic.

The commissioning phase shall end at least two months before the tunnel is put into service. In the following two months the tunnel shall be allowed to operate without traffic to check for any problems before opening to traffic.

All tests must be documented and signed by those present.

Major commissioning Activities are (non-exhaustive list):

- Testing and certification, in accordance with current legislation, of the entire low-voltage electrical distribution system, including the UPS network and including verification of all grounding and lightning and surge protection. Where required by law, the tests must be accompanied by the necessary certifications
- Testing of all control algorithms of the lighting (lighting level adjusted according to the values of the luminance probes, etc.) and testing of the manual control of all parts of the lighting system.
- Testing of all control algorithms of the ventilation (ventilation level adjusted according to the values of the sensors, etc.) and testing of the manual control of all parts of the ventilation system.
- Test of a software simulated fire and consequent reaction of the ventilation system.
- Testing of all possible signage conditions (all OCs - operating conditions – and transitions between them). In particular, the emergency closure of the tunnel shall be tested.
- Test of the detection carried out by the fire detection system: both thermal detection (fibre-optic cable) and smoke detection (smoke sensors).
- Test live images from all cameras: display in control centre, recording.
- Testing of all auxiliary systems, such as pumping systems.
- Testing and verification of the fibre-optic infrastructure.
- Testing and verification of universal structured cabling.
- Test the Ethernet communication network of the gallery, including the redundancy of the main switches.
- Testing of the entire tunnel control system (SCADA): appearance of the graphic pages, sending of commands, acknowledging the execution of a command, tracking in the system log, alarm messages, control algorithms at SCADA level, control

algorithms at the level of the operator panels and their graphic appearance, control algorithms at the level of the PLCs, etc.

Every single SCADA variable (tag) must be tested. The redundancy of the SCADA server must be tested. All response values (times) of the system must be tracked to future memory. The export of historical data (log) must be tested.

The verification of the graphic aspect of the man-machine interface must take place in the presence of the final operators who will use the systems, who will have the possibility to request modifications or adaptations.

- Testing of the radio system in the tunnel in the presence of emergency services such as police, fire brigades or ambulances. The effectiveness of the radio communication system shall be officially confirmed by the emergency services.
- Testing of the emergency telephone system (calls), including texts of fire extinguisher pick-up.
- Testing of all installations inside buildings, such as electrical sockets, room lighting, fire detection, telephony, etc. Where required by law, the tests must be accompanied by the necessary certifications.
- Accurate testing of all automatic safety reactions (document 695013-D-A-E-K-002, volume 5). The individual events triggering the reactions may be either real or simulated. All implant reactions should be logged and attached to the test documents as proof to future memory.
- Test of the functioning of the tunnel equipment in the presence of two fires. For this purpose, two fires will have to be simulated, at different times, using smoke generators suitably placed inside the tunnel at particularly significant points according to the ventilation designer. The reaction of all tunnel installations should be evaluated according to document 695013-D-A-E-K-002. The reaction of the ventilation system (activation, delays, sense of smoke evacuation, etc.) should be evaluated and confirmed by the ventilation designer. The tests must be carried out in the presence of the emergency services, which may use this opportunity for a drill (arrival at the tunnel, manoeuvres, communication between the services, entrance to the tunnel in the presence of smoke, rescue of people - figurants - involved, clearing of the area, etc.). The text may also serve as an exercise for the operators of the control room. The tests will have to be filmed. All reactions of the installations, tracked in the log of the tunnel control system, must be saved to future memory.

### **38.3. Contractor Commissioning Responsibility**

Contractor's responsibilities include, but are not limited to the following:

- Provision of a team of suitably experienced and qualified personnel including management, supervision, labour, and the necessary assistance by Sub-Contractor's / Vendor's commissioning specialists, for commissioning as per approved plans, schedules and procedures, including the appointment of a Commissioning Manager.
- Preparation of interface and commissioning co-ordination procedures together with supporting documentation. Contractor shall prepare and submit Commissioning Manual to Contracting Authority for approval, six (6) weeks in advance.
- Preparation of safety audits and recording of all approved safety audit items to ensure the required safety.
- Provision of all commissioning spare parts and consumables and ensuring their availability at Site at least two (2) weeks prior to commissioning of facility.



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- Maintenance of all documentation and records of Commissioning Activities including execution and documentation of performance tests of commissioning systems.
- Maintenance of records of all design changes for updating the operating manuals.
- Provision of mechanical, electrical and instrumentation test and measuring equipment and special tools and accessories necessary to carry out calibration, testing, trouble shooting and repair to ensure timely completion of commissioning activities.
- Preparation and issue of the Commissioning dossier of the individual systems.
- Identification of commissioning activities including definition electrical and instrumentation test systems, definition of commissioning systems and definition of performance test program.
- Ensuring adequate and timely operator involvement in the preparation of the commissioning activities, and close liaison and co-ordination with Contracting Authority Operations, Maintenance and Safety.
- Provision of a detailed commissioning plan, procedures, schedules and reports which shall be submitted to Contracting Authority for approval. Ensuring documented recording and reporting.
- Submission of operating and maintenance manuals for Contracting Authority approval, six (6) weeks prior to commissioning.
- Obtaining and complying with the necessary permits and approvals.

## **39. TRAINING OF CONTRACTING AUTHORITY PERSONNEL**

The additional requirements contained in this section shall apply to PLANT AND SYSTEMS (ESE) works, as defined Employer's Requirement Section.

With an objective to ensure continuous, efficient and trouble free operation and maintenance of the road tunnel plants and systems, after hand-over to Contractor and before tunnel opening to traffic (desired: 1 month), Contractor shall undertake a training program for Contracting Authority personnel. The training of Contracting Authority operations and maintenance personnel is a key Contractual requirement, which will be fulfilled by Contractor, in agreement and to the satisfaction of Contractor.

Training shall be provided in both, a formal 'classroom' environment and also 'hands on training' at site during installation and commissioning stage.

Training requirements of Contracting Authority personnel shall cover as a minimum:

- a) General operation of the road tunnel
- b) Operation of the road tunnel in emergency conditions
- c) General maintenance requirements of all the equipment.

The training for operation and maintenance shall be carried out at site, by continuous involvement of assigned Contracting Authority personnel, during installation, pre-commissioning and commissioning stage.

Training must also be provided for emergency services (police, fire brigade, ambulance):

- general description of the tunnel and its facilities
- closure of the tunnel
- functioning of the ventilation
- risk factors in tunnel intervention
- the way it interacts with the control room.

In particular, account must be taken of the fact that those who intervene on site in the event of an emergency must be adequately trained to give instructions to the operators of the control room (switch off the ventilation, act on the signs, act on the lighting, etc.).

Contractor shall prepare a detailed training program, in consultation with vendors and submit to Contractor, for approval at least 6 months before the opening of the tunnel to traffic.

The general requirements related to training are as below:

- All training shall be conducted using the Nepalese and English Language and during the normal operational working hours.
- Services of suitably experienced and qualified instructors shall be utilized by Contractor for training. The instructors must have perfect mastery of the tunnel facilities.

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- All training equipment including training aids, special training equipment etc shall be organized by Contractor. Also considered here are the equipment necessary for real fire tests (smoke generators, respirators, beakers).
- Reference manuals including vendor data books, training/maintenance/operating manuals and other technical literature, as necessary for the training shall be supplied in the required number of sets in advance by the Contractor. The language of these documents will be English and Nepalese.
- Class-room training shall be followed by field demonstrations.
- Training program shall cover the following aspects :
  - General system familiarization.
  - System/operation
  - System/operation in emergency situations
  - Automatic safety reactions
  - System maintenance
  - Troubleshooting – in operations as well as maintenance
  - Preventive maintenance requirements
  - Periodical cleaning and inspection.
- Contractor shall ensure that the program of vendor representatives' site visit for field assistance, is informed to Contractor, in advance to enable Contracting Authority personnel to participate with Contractor/Vendor's staff during the installation and commissioning of such equipment/system.
- Contractor shall maintain a complete record of training and submit to Contractor, along with one set of complete training literature, manuals etc. on successful conclusion of training program.

## **40. PROJECT DOCUMENTATION**

Project documentation requirements for Contract execution, as explained below, shall be complied by the Contractor.

### **40.1. Documentation During Engineering, Procurement, Construction Phase**

The documents and drawings, which are to be submitted to Contractor, for review and approval or review, shall be identified by Contracting Authority as a part of approval of Technical Document Register (TDR), during early part of project. The balance documentation in TDR shall be forwarded to Contractor, for information. Contractor shall submit three (3) sets of the required documentation for Contracting Authority review.

Contracting Authority approval / review cycle shall be 30 calendar days from the receipt of the document. Contractor shall plan and schedule all related project activities, taking into account the 30 calendar days' Contracting Authority approval cycle. Contracting Authority shall, however, endeavour to review critical documents on priority, with shorter approval cycle, to the extent possible.

### **40.2. Final documentation**

After successful completion of the defect liability period, within 1 month, Contractor shall hand-over the Final project Documentation to Contracting Authority as outlined below:

- a) The number of sets of Final Documentation to be handed over shall be:
  - Hard Copy - 6 Sets
  - Electronic Copy - 2 Sets

Hard copies shall be handed over as properly hard-cover bound volumes, with complete documentation index in each volume, in addition to the index of the respective volume.

Electronic copies shall be on DVD or USB pen-drive with proper labels and List of Contents.

- b) The Final Project Documentation, shall include, but not limited to, the following:
  - Start-up and Operation Manual.
  - Maintenance Manual
  - Final Vendor Documentation
  - As-Built Drawings.
  - Project Design Dossier (will cover an updated Design Basis, Design Philosophies, and Calculations, which formed basis for engineering).
  - Detailed, definitive and exhaustive wiring diagrams.
  - Complete set of Approved SPIRs
  - Construction Documentation and Records

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- Commissioning Records.

Vendor documentation shall be well organized and compiled. It shall have the following three separate sections:

- Design section – Technical Documents, specifications, data sheets and drawings
- Manufacturing records
- Operation and maintenance manual

Contractor shall transmit this requirement to the vendors during inquiry stage and check vendor's compliance with this requirement upon receipt of the vendor documentation.

Contractor shall include copies of his purchase orders for the terms, in his final documentation.

Un-priced purchase orders for all items and bulk items will also be included in final documentation.

The above purchase orders shall not be subject to any review, audit or reimbursement and shall be submitted for Contractor's future reference only.

- c) Final Acceptance Certificate shall be issued by Contractor, only after hand-over of complete Final Documentation by Contractor to Contractor's satisfaction.