UPPER ARUN HYDRO-ELECTRIC LIMITED

(A SUBSIDIARY COMPANY OF NEA)

Technical Specifications
For
Construction of Main Access Tunnel
of
Upper Arun Hydroelectric Project

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SECTION 1
GENERAL PROVISIONS

1 CHAPTER 1: GENERAL ADMINISTRATION

1.1 PROJECT MANAGEMENT

1.1.1 *Project Management Plan*

(a) The Contractor shall submit a Project Management Plan for the Engineer's Review and Approval within Twenty-Eight (28) days of the Commencement Date, which shall provide, but not limited to, the following information:

- a diagram showing the organisational structure for the management of the Contract, with associate organisations and SubContractors and show the lines of responsibility linking the various groups and describe interactions.
- a resource histogram and timeline of key personnel, Sub-Contractors and labour distribution; and
- a narrative describing the sequence, nature and inter-relationship of the Contract activities.

(b) The Engineer will review and approve the Contractor's Project Management Plan and shall have the right to require the Contractor to make amendments as deemed reasonably necessary by the Engineer. Any change proposed by the Contractor to the Project Management Plan shall be submitted for the Engineer's Review and Approval.

1.1.2 *Method Statements*

(a) The Contractor shall submit a method statement/s with its Bid which shall be updated as the Works progresses.

(b) The method statements shall be submitted for the Review and Approval for construction and erection of all Works, major Plant, equipment, and systems to the Engineer prior to such construction/erection being carried out on the Site.

(c) Two (2) hard copies and electronic copies of each method statement shall be submitted to the Engineer not less than Twenty-Eight (28) days prior to the commencement of the relevant activity.

(d) Method statements shall include, but not be limited to, a detailed account of how the works shall be carried out, sequence drawings or flow chart of activities, Temporary Work requirements, a risk assessment to identify potential hazards and the measures taken to remove or minimise those hazards, a program for the works covered by the method statement, required resources with respect to plant, material and labour, the effects on any interfacing or adjacent works and environmental compliance.

(e) In addition, the organisation structure with respect to supervision, health and safety, environmental and quality shall be included in the method statements.

(f) As part of the method statements, a Site utilisation plan for each worksite shall be submitted. The Site utilisation plan shall show, inter alia, proposed location of offices, sheds, temporary buildings, temporary

services, access roads, surface drainage, spoil dumps, temporary roads, fuel stores, explosives stores, etc.

(g) The Site utilisation plan shall include, but not be limited to, all land boundaries, extent of forestry management, existing roads and buildings, etc.

1.1.3 *Manuals*

1.1.3.1 General

(a) The Contractor shall provide Six (6) hard copies and electronic copies of the manuals as further detailed below, as well as any other manuals the Engineer may instruct the Contractor to produce, which the Engineer considers necessary for the satisfactory completion of the Works.

(b) The Contractor shall identify the delivery dates for each of the following manuals on the Program and shall monitor the ongoing status against this Program. The Contractor shall submit the monthly progress report to the Engineer latest by the 7th day of the following month. The monthly progress report shall include progress achieved during the month, packages completed, work programmed for the following period and any areas of concern.

1.1.3.2 Procurement

(a) The Procurement manual shall contain a single copy of all key and critical purchase requisition/orders, as agreed with the Engineer and any revision thereto. The Procurement manual shall include cross-references to all items of Plant, Materials and equipment included within the Contract. This manual shall be delivered to the Engineer within Twenty Eight (28) days of the Commencement Date, and shall be updated by the Contractor on a monthly basis.

1.1.3.3 Construction

(a) The Construction Manual shall contain all records of construction (erection fabrication, inspection, testing etc.), as - built drawings reflecting all aspects of the Works including any design changes agreed by the Engineer and waivers/concessions to specifications. This manual will also contain weld test and material traceability documentation.

(b) The format of the data included will be of two specific types; those documents that apply to the construction and commissioning activities for a single system, e.g. materials, tests, inspections etc. and those not system specific, i.e. welder certificates and procedures etc.

(c) The weld procedures, welder qualifications, non-destructive test (NDT) procedures etc., the levels of review for each shall be scheduled and included as part of the index.

(d) For all system - related documents the Contractor shall include a system/book index for the total submissions and inclusion within all manuals. This manual shall be delivered for the Engineer's Review and Approval within Twenty-Eight (28) days of the Commencement Date, and shall be updated by the Contractor on a monthly basis.

1.1.3.4 Health and Safety

The Health and Safety Manuals, policies, plans, guides etc, shall cover all aspects of Health and Safety and shall comply with the requirements set out in Chapter 2 – Health and Safety of the General Requirements.

1.1.3.5 Quality Control

The Quality Control Manuals, policies, plans, guides etc, shall cover all aspects of Quality Control and shall comply with the requirements set out in Chapter 3 – Quality Management of the General Requirements.

1.1.3.6 Environmental Management

The Environmental Management Manuals, policies, plans, guides etc, shall cover all aspects of Environmental Management and shall comply with the requirements set out in Chapter 4 – Environment of the General Requirements.

1.1.1.1 Operation and Maintenance Manual

The Operation and Maintenance Manuals shall cover all aspects of operating and maintaining the plant and equipment supplied and installed by the Contractor, and shall comply with the requirements set out in Chapter 3 – Quality Management.

1.2 ACCESS TO SITE

The project is accessible by the Koshi Highway starting from Khadbari, district headquarter road at a distance of 75 km to the Khadbari and could be reached in about 6 hours drive from Khadbari to Chongrak. The construction / upgradation of road between Khadbari to Chongrak site (almost 75 km) is under construction by the Government of Nepal. However, the access to the site may be disrupted during Monsoon season and the Contractor shall prepare each plan taking it into consideration.

The MAT portal is located approximately 200m from Chongrak and currently has no permanent road connectivity and requires river crossing access from Chongrak. Currently, there is a Ferry in operation to cross Arun River commissioned and owned by Access Road Contractor (GPL- KIBPL JV) which will not be in operation during Monsoon for 120 days. Construction Equipment and construction materials required for construction will be transported through Ferry. Sufficient storage facility shall be arranged for storage of at least 120 days (Ferry non-operation days during monsoon). The Contractor shall be responsible for coordination with the existing Access Road Contractor for the Ferry use. The cost of transportation including use of Ferry shall be included in the BoQ. The transportation of listed Equipment through Ferry shall be verified by the Engineer and paid in LS as per the schedule prescribed by the Engineer.

S.N.	Equipment	Unit	Quantity
1	Wheel Loader	Nos.	1
2	Compressor	Nos.	2
3	Shotcrete/Concrete machines	Nos.	1
4	Generator	Nos.	2
5	Dump truck	Nos.	2
6	Ventilation fan (including ducts)	Nos.	1
7	Grouting Machine	Nos.	2
8	Water pumps	Nos.	3
9	Workshop equipment	LS	1
10	Self-Loading Mixture	Nos.	2
11	JCB	Nos.	1
12	Miscellaneous	LS	1

Payment shall not be made if the transportation of equipment is not carried out in specified time (as specified in the approved schedule). The payment of transportation of material required for construction shall be under provisional sum.

There is an existing public suspension bridge in the project area, and the Contractor may use suitably. No additional payment shall be made for transportation of materials, whether by the suspension bridge or by any other method selected by the Contractor.

1.3 MATERIALS, PLANT AND WORKMANSHIP

The workmanship and all materials and plant incorporated into the Permanent Works shall, except where specified otherwise, comply with the latest issues of the Standards and Codes of Practice, as relevant and appropriate, published in the English language by the following organisations:

Acronym	Organisation
ISO	International Standards Organization
ASTM	The American Society for Testing and Materials
AASHTO	The American Association of State Highway and Transportation Officials
EN	European Standards
BSI	British Standards Institution
CEN	European Committee for Standardization
DIN	German Institute for Standardization
ICOLD	International Commission on Large Dams
IIW	International Institute of Welding

AWS	American Welding Society
USBR	United States Bureau of Reclamation
NS	Nepal Standard
IS	Indian Standard

The work shall, where relevant, comply with Nepalese Building Control Acts and the Nepalese Standard Specification of Materials and Workmanship for Building Contracts.

The Contractor shall keep at his site office a copy of all relevant standards and codes referred to in the Specifications.

Where the Contractor is not bound by the Contract to a particular standard or code, he shall, free of charge, furnish the Engineer with two English language copies of the Standard or Code of Practice according to which he intends to supply materials or carry out work. If not supplied by the Contractor in due time, Engineer may request such documents. The copies shall then be provided within 21 days of the request being made.

Where proprietary products are specified, similar products from other manufacturers will be permitted only if the Contractor demonstrates the product's equivalence to the specified product to the satisfaction of the Engineer.

Where required, the Contractor shall submit for the approval by the Engineer samples and test reports of proposed materials. Such samples shall be kept by the Employer for reference.

Materials or plant approved by the Employer shall not be replaced by other similar materials or plant from the same manufacturer or from other manufacturers or suppliers without the prior approval of the Engineer.

If in the judgement of the Engineer any materials or articles brought onto the Site are found to be of inferior quality to that required by the Contract or in any way unsuitable, such materials or plant shall forthwith be removed from the Site.

1.4 DRAWINGS AND DESIGN

The drawings issued are for the purpose of tendering. The design and drawings may change as per the site condition and as instructed by the Engineer. The Contractor shall carefully review all such drawings and shall advise the Engineer of any errors or omissions within 10 days of receipt after which time the Contractor shall be deemed to have accepted the drawings.

Certain temporary works shall be designed by the Contractor himself. This applies to:

- All temporary Site works, installations and facilities
- All temporary excavations (slopes, bracings etc)
- All temporary support works in tunnels

Contractor's design of such works shall be presented to the Engineer for approval at least 28 days before the work starts.

1.5 SITE MEETINGS

Site meetings will normally be held monthly but will be called when required by the Employer or the Engineer. The Contractor shall be represented at all meetings by Authorised Representative.

Minutes will be issued by the Engineer and submitted to the Contractor. If no comments are given in writing within 7 days from the receipt, the Minutes are deemed to be accepted by the Contractor.

1.6 SITE REGISTER

The Contractor shall keep a Site register wherein full details of all work carried out each day shall be recorded. The register shall be available for inspection by the Engineer any time during normal office hours. At least the following details shall be included:

- location of the various works undertaken
- type and amount of work achieved
- number of employees and plant working
- tests carried out and results
- weather conditions
- inspections carried out by the Engineer
- visitors.
- others if any required

1.7 SUBMITTALS

1.7.1 *General Requirements*

1.7.1.1 General

The Contractor shall provide to the Engineer the minimum Contractor's Documents as described in this section. All reports, design drawings, detail drawings, working drawings, shop drawings, plans, as-built drawings, specifications, notes, annotations and information shall be provided by the Contractor in such sufficient format, detail, extent, size and scale and within such time as may reasonably be required to ensure effective execution of the Works. All dimensions shall be in metric units and all drawings shall be produced to adequate scale.

1.7.1.2 Identification

(a) The Contractor shall utilize and maintain an identification system acceptable to the Engineer for all project documentation for permanent inclusion in the Works, which shall enable the Contractor to control the documentation in the live phase of the Project. The Document Identification System shall be submitted to the Engineer as part of the Document Schedule.

(b) Provision shall be made by the Contractor to provide full training in the use of the identification system by the Engineer in readiness for handover of the Works.

1.7.1.3 Organisation of Documentation

All documentation shall be organized in a logical manner and all contents shall be properly indexed. A revision status record sheet at the front of each document shall facilitate recording of amendments in logical manner. Revision indication and issue dates shall also appear in each amended sheet. All submissions, except drawings, shall be housed in durable loose-leaf folders suitable for the addition of amendment data. The cover shall identify the contents, and carry the Contract reference number.

1.7.1.4 Quality

Paper used for documentation shall be suitable for long-term storage (minimum 80 g/m2) and all drawings shall be prepared on 80 g/m2. All drawings shall comply with the requirements of appropriate and recognized standards for drawings practice for Engineering drawings and Engineering diagrams.

1.7.1.5 Size

(a) With the exception of drawings and certain other forms such as certificates, all other documents shall be size A4. The preferred sheet size for drawings shall be size A1, and all lettering shall be legible when reduced to size A3, without magnification.

(b) Drawings for inclusion in technical manuals should be size A3, double folded to size A4, title visible with the drawing folded and bound along the left hand side. If drawings of size larger than A3 are required to facilitate clarity they shall be folded and

(c) placed into plastic wallets, with each wallet clearly identifying the enclosed drawing. The wallets shall be secured in the manual cover and permit easy access to the enclosed drawing.

(d) All vendor documents greater than size A3 must be capable of reduction to size A3 with no loss of symbol, lettering, legibility, or other forms of quality degradation. Such drawings shall also have a minimum left hand margin of 25 mm at size A3 to ensure that binding obscures no information.

1.7.1.6 Symbols

All symbols shall comply with the appropriate and recognized Indian, British, European, International or national standards as applicable.

1.7.1.7 Units and Scale Ratios

All design documents and drawings shall be supplied in SI metric units. Drawings shall be produced using one of the following scales 1:1, 1:2, 1:5, 1:10, 1:25, 1:50, 1:100, 1:200, 1:500, 1:1,000, 1:2,000 and 1:5,000 as desired by the Engineer. Where applicable, third angle projection shall be used throughout.

1.7.1.8 Number of Copies

Unless the Contract requires otherwise the Contractor shall submit Six (6) hard copies and electronic copies of each Contractor's Document for the use of the Employer.

1.7.1.9 Electronic Copies General

a) All information supplied to the Engineer by the Contractor shall be provided in electronic as well as hard copy format.

b) Word Processed text documents, manual, spread sheets, etc.

c) All word documents shall be handed over in software files compatible with those of the Engineer (latest version Microsoft Office Software). All spread sheet information shall be handed over in software files compatible with those of the Engineer. These disks shall be properly indexed both on the individual disks with the appropriate directory names, containing the data files, as well on a separate master directory disk, plus a separate list of all the documents concerned on paper. All relevant documents shall be in an uncompressed original format. All documents in this section shall also be presented in PDF format.

d) Drawing Files

e) All drawing files shall be handed over as current AutoCAD format software files (.dwg or .dxf). All documents in this section shall also be presented in PDF format.

f) Document Images, Computer Aides and Graphic Files

g) All non-word processed and spread sheet documents, such as photographs, videos, maps, graphic document files, data sheets and likewise shall be handed over electronically or more or of the following file formats, as appropriate.

1.7.2 *Specific Information*

1.7.2.1 Construction Schedule:

The construction program shall include the mobilization period, construction camp, workshop Site establishment, Temporary facilities and administrative procedures for available job sites in advance of the commencement of operation. The duration should include explosive storage arrangement along with main construction works.

1.7.2.2 Document Schedule

(a) The Contractor shall provide a detailed schedule of documents including drawings (the "Document Schedule") to be produced during execution of the Works pursuant to the Contract for submission to the Engineer. The Document Schedule shall indicate, by generic type, those supplied for review and comment (design reports, procedures, etc) and those for information. The Contractor shall submit this Document Schedule for the Engineer's Review and Approval within Twenty-Eight (28) days of the Commencement Date and monthly thereafter as part of the monthly progress report the Conditions of Contract.

(b) The Document Schedule shall also indicate to the Engineer those specific design, safety and related elements required for third party verification and, where possible and required, the proposed third party.

1.7.2.3 Purchase Information

(a) The Contractor shall, at a minimum, submit copies of the following as part of the Procurement Manual:

- Unpriced key and critical external supply purchase orders.

- Subcontract packages.
- Subcontract information.
- Expediting and inspection reports.
- Shipping schedule for major items of Contractor's Equipment, estimated dates of shipment and arrival and dutiable value of goods, to be provided two months in advance of shipment.

1.7.2.4 Construction and Procurement Records

(a) The Contractor shall generate records as required by the Contract and the project specific Quality Plan, Chapter 3 – Quality Management of the General Requirements.

(b) All records including those generated by SubContractors or suppliers, shall be concisely compiled, indexed and uniquely identified with the Contract reference number clearly identifiable to the individual parts and assemblies to which they refer.

(c) The Contractor shall ensure that all Site and Works documentation is maintained and stored in accordance with the Quality Plan, Chapter 3 – Quality Management of the General Requirements.

(d) For items of Plant, Materials or Contractor's Equipment that are being delivered to the Site, the Contractor shall ensure that all records required by the Engineer pertaining to such items arrive at Site with the relevant Plant, Material or equipment. Such records shall include all traceable records, including reports and certification in respect of any components.

(e) The compilation and storage of records during the term of the Contract shall be controlled to ensure adequate security, verification and traceability prior to taking over of the Works by the Engineer. The storage conditions shall maximize resistance to damage and deterioration.

(f) The Contractor shall retain copies of all records generated during the course of the Contract by the Contractor, its SubContractors and suppliers for a period of five years from the Date of Completion. These records shall be made available to the Engineer on request.

(g) The Contractor shall submit a monthly Documentation Schedule for the Engineer's Review and Approval as part of the monthly progress report for review by the Engineer and shall maintain the Documentation Schedule throughout the project to show the up-to-date status and revision of each document. The transfer of this information should be achieved by electronic transfer from the Contractor's central system.

(h) The Contractor shall submit documents to the Engineer in accordance with the Documentation Schedule and the quality requirements, quality procedures and Quality Plan. Prior to issue of the Taking-Over Certificate, final documentation shall be handed over by the Contractor to the Engineer in Six (6) hard copies and electronic copies.

1.7.2.5 Electronic Document

a. Emergency Contingency Planning and Recovery

At all times during the performance of the Contract, the Contractor shall have in place a valid and working emergency contingency plan, recovery procedures and appropriate means, facilities, methodology and personnel to deal with emergencies. The emergency contingency plan and recovery procedure should come into action if and when any of the communication, hardware, software, or services are terminated or interrupted as a result of events such as, but not limited to: storm, flood, fire, earthquake, sabotage, accident, computer system or component failure (hardware or software).The Contractor shall review the contingency plan monthly and shall update it as necessary. The Contractor shall have in place a draft emergency plan.

from the Commencement Date and shall submit the draft emergency plan to the Engineer for Review and Approval within Twenty-Eight (28) days of the Commencement Date.

b. Storage at Site

The Contractor shall provide permanent library facilities for the hard copies and the software and hardware for electronic format information. All the stored information shall be kept within the permanent site offices in an area that is sufficiently protected and equipped with viewing facilities and a copying facility up to A3 and printing facility up to A1 size.

The atmospheric storage conditions within this area shall be such as to prevent deterioration of the information. The Contractor shall back up all types of information, data, records, manuals, and photographs and documents on paper or electronically, on a regular basis and store a copy safely both on and off site. These shall include commissioning, testing and take-over phases of the Plant. The area shall provide secure storage of the information.

The Engineer shall be granted full and unrestricted access to this facility and to the information stored therein, excluding commercially sensitive information relevant to the Contractor.

1.7.2.6 Certification Schedule

The Contractor shall be required to develop and maintain a current certification schedule for any items of Plant and Contractor's Equipment requiring periodic inspection/testing in accordance with the respective mandatory codes, applicable standards and laws (e.g. pressure vessels, rigging and lifting appliance, pressurized systems etc).

(a) When documents in the Contract contain particular specifications or more restrictive standards than required as specified above, the documents in the Contract will always prevail. In case of lack of precise requirements in the Employer's Requirements and even if no reference to any Standard or Code is made, the Standards and Codes listed above shall be used as reference.

1.7.2.7 Standards for the Works

(a) All materials and Works shall be designed, erected or installed and tested in conformance with the latest issues of the relevant Indian Standards (IS) and where IS codes are not applicable, other international recognised Standards shall be followed with the approval of the Engineer. However, any specific

requirement of the documents in the Contract shall prevail.

(b) All plant and equipment supplied under this Contract shall be proven in service and/or references from users of similar plant and equipment shall be made available to the Engineer by the Contractor, if so required.

1.8 MEASUREMENT AND PAYMENT

No separate payment shall be made for General Administration unless specifically provided in the BOQ. The cost of all General Administrative activities shall be deemed to be included in the Contract /Bid Price.

2 CHAPTER 2: HEALTH AND SAFETY

2.1 GENERAL REQUIREMENTS

(a) This section comprises the Employer's minimum general health and safety requirements that, in accordance with the Conditions of Contract, shall be observed by the Contractor at all times, with a very high degree of diligence and care.

(b) The Contractor shall take full responsibility for the prevention of unhealthy or unsafe conditions and practices and for the promotion, implementation and control of healthy and safe working procedures and practices for all phases of the Work and shall provide a safe working environment for its employees, employees of SubContractors, visitors, and Employer's and Engineer's personnel at its own cost.

(c) Nothing specified herein shall relieve the Contractor of any obligation or responsibility in this regard. The Engineer shall not be obliged to attend inspections of work areas if the required or approved safety measures have not been implemented and such works shall not be approved to proceed. Any delay to the Works so caused shall be the full responsibility of the Contractor.

(d) The Contractor shall also provide security to the site so that the health and safety of members of the public is not compromised.

(e) The Contractor shall carry out the Works in a safe, workmanlike manner, in accordance with good working practice to a recognized code of practice and in compliance with requirements set out in the Contract. Tunnelling works shall, at a minimum, comply with the requirements of the International Tunnelling Association (ITA) - Guidelines for Good Tunnelling Practice, Good Industry Practice and any applicable standards.

(f) Approved safety equipment shall be worn by all persons at all times whilst on the Works. Suitable clothing, high-visibility reflective vests, footwear, helmets, cap lamps, waterproofs, safety glasses, ear protectors, gloves, goggles, harnesses, breathing apparatus, etc. appropriate to the work being undertaken, shall be issued to and worn by all workmen. The workmen shall be trained in the use of all such equipment before entering working areas.

2.2 HEALTH AND SAFETY POLICY

(a) The Contractor shall, in the form of a Health and Safety Policy Statement, state his target, commitment and strategy with regard to safety on the Project.

(b) The Health and Safety Policy Statement shall be signed by the Chairman or Board of Directors of the Contractor.

(c) The Health and Safety Policy Statement shall be displayed in a prominent position within the Contractor's offices on each worksite.

(d) The Contractor shall implement the health and safety policy, which shall be in force throughout the duration of the Contract. Without in any way limiting the Contractor's responsibility for health and safety, for the purpose of implementing the health and safety policy, the Contractor shall prepare a Site Health and

Safety Manual, in accordance with the Conditions of Contract. The Contractor shall also constitute a Health and Safety mechanism, which shall include, but not be limited to:

- The Safety Officer (accident prevention officer in accordance with the Conditions of Contract) and his deputy who shall be fully engaged for health and safety aspects of the project;
- Representatives of supervisory staff; and
- Representatives of the various categories of workmen.

(e) The arrangements for implementing the health and safety policy shall be not less than those required by the Laws and Regulations of Nepal and will include, but not be limited to:

- The duties of the Safety Officer and his Deputy;
- Implementation and monitoring of compliance with the Site Safety Manual and updating of its contents as deemed necessary;
- Notification, investigation and recording of accidents;
- Codes of practice to be used to ensure healthy and safe working conditions and the management of hazardous conditions;
- The arrangements for the frequency and occasions of routine and special meetings of the Health and Safety Committee, the keeping of records, rights and access to information; and
- The arrangements for disseminating information, training and supervision to ensure the codes of practice are conformed with.

(f) The code of practice shall be based on a recognised international standard and shall be of no less a standard than Laws and Regulations of the Nepal.

2.2.1 *PROJECT HEALTH AND SAFETY MANUAL*

(a) The Contractor shall submit for Engineer's Review and Approval, a Health & Safety Manual (the Project Health and Safety Manual) and Health & Safety Plan, which shall address the matters described in this Chapter 2.

(b) The Contractor must submit to the Engineer, the Health and Safety Manual for the Engineer's Review and Approval within Twenty-Eight (28) days of the Commencement Date.

(c) Each Health and Safety Document shall:

- incorporate any directions or requirements from the Engineer, including those in respect of the earlier draft of that Health & Safety Document;
- address health and safety subjects in greater depth where working methods and sequences have been developed or changed since the previous draft of the Health & Safety Document; and
- identify Works, by area or subject and the persons responsible for supervising those on Site.

(d) Only after the Project Health & Safety Manual is approved by the Engineer, it will become the Project Health & Safety Plan, for the purposes of this Contract.

(e) The Contractor shall manage the Project Health and Safety Plan and shall review the plan on a regular basis and it may be updated or revised, at the Contractor's own cost, with the Engineer's Review and

Approval, or as instructed by the Engineer in order to ensure that the plan continues to give guidance during the life of the Contract,

(f) The Engineer may monitor and review the Contractor's health and safety performance and may undertake formal safety audits of the Contractor's performance.

(g) Non-compliance with the health and safety Laws shall be considered a major Contractor's default.

(h) In the event of non-compliance with agreed health and safety rules or procedures the Contractor shall impose sanctions according to its Health and Safety Sanctions Procedure.

2.2.2 *SAFETY PROCEDURES*

(a) The Contractor shall develop and update as necessary a set of safety procedures that shall be submitted for the Engineer's Review and Approval.

(b) The procedures shall include the necessary forms to be completed for various events. The procedures shall include, but not be limited to:

- immediate reporting and formal investigation and reporting of accidents;
- immediate reporting and formal investigation of dangerous occurrences;
- the emergency evacuation of worksites, in particular underground works and deep excavations;
- the storage of Materials, in particular, explosives, chemicals, flammable materials and gas bottles;
- the transport of Materials, in particular explosives, gas bottles and large or heavy materials;
- the use of Materials, in particular those that may cause injury, illness or require special Personal Protective Equipment (PPE);
- the use of PPE;
- working at height;
- working in a confined space;
- the use, maintenance and storage of lifting equipment;
- electrical, systems and appliances;
- Permits to work;
- safety training and task training;
- the operation of a powerhouse and switchyard;
- fire prevention and fire fighting;
- health, welfare and hygiene; and
- security and access control through means of identification cards, site passes, security checks, booking systems etc.

(c) The procedures shall be developed and updated as the Contract progresses for the Engineer's Review and Approval.

(d) The procedures shall be transmitted to the workforce during safety inductions, tool box talks, safety

presentations, method statements and supervisors instructions.

2.2.3 *GENERAL RULES AND APPLICABLE LAWS*

(a) The Contractor (including its employees, subContractors or manufacturers) must fully comply with, and establish an efficient management to put in practice, all Laws, relevant general rules and specific procedures relating to health, safety and environmental issues (as amended from time to time by the relevant authority). The Contractor must also comply with all written and verbal instructions (later confirmed in writing) given by the Engineer or by the relevant Governmental Agency during the Works if they are in accordance with Law and/or the Health and Safety Plan.

(b) For the purposes of the Project Health and Safety Plan, a reference to the Contractor includes its employees, subContractors, subContractors' employees, advisors, consultants, vendors, suppliers and visitors or any other person or entity which is in relation with the Contractor.

(c) The Project Health and Safety Plan shall be applicable for any facility and premises of the Works.

(d) The Project Health and Safety Plan may be amended by agreement between the Employer and the Contractor if operational circumstances, or risks of accident so require, so as to comply with all applicable Laws and Good Industry Practice. All amendments will be notified by the Contractor to the Engineer and the Contractor must comply with these amendments at its own cost.

(e) All communications, permitting, applications, etc., to or with Government Agency and/or their representatives must be notified and approved beforehand by the Engineer.

(f) The Health and Safety Manual, the Health and Safety Plan as well as any health and safety document (including their drafts) must demonstrate and specifically deal with all applicable Laws, regulations, codes, rules and any amendments thereto, including, but are not limited to the following:

- Labour Act, 2048 (1992)
- Labour Rules, 2050 (1993)
- Labour and Employment Policy, 2062 (2006)
- Bonded Labour (Prohibition) Act, 2058 (2002)
- Child Labour (Prohibition and Regulation) Act, 2056 (2000)
- Child Labour (Prohibition and Regulation) Rules, 2062 (2006)
- Electricity Act, 2049 (1992)
- Electricity Rules, 2050 (1993)
- Fire Services Rules and Regulations
- Building Regulations and Codes
- Work Permit Requirement (Immigration Department Requirement) for foreign workers;

2.2.4 *Health And Safety Plan*

(a) Without limiting any other provision of the Contract, the Project Health and Safety Plan must meet the

requirements of Good Industry Practice, all applicable Laws, rules, regulations, international norms or procedures as well as all of the obligations of the Contractor under the Contract, and shall systematically address all aspects of the Work engaged.

(b) The Health and Safety Plan must itemise the specific plans and programs in an agreement with the health and safety requirements. The Health and Safety Plan may be a collection of documents and manuals (for example: emergency plans, training manuals, data sheets, etc.).

(c) The Contractor shall fulfil and comply with the Health and Safety Plan.

(d) The Engineer's and/or the Contractor's Health and Safety Department has the right to stop any work, if there is imminent danger to him or others, if the person stopping the work honestly believes that the work being done is unsafe.

(e) Without limiting the Conditions of Contract, the Health and Safety Plan including Health and Safety personnel once accepted must not be changed without prior consultation with and acceptance by the Engineer.

(f) All personnel of the Contractor and any subContractor must receive training and induction by the Contractor on the Health and Safety Plan to ensure that all personnel are aware of the requirements that pertain to their job functions.

(g) The Health and Safety Plan shall demonstrate that the management and commitment of the Contractor for health and safety is an integral part of Contractor's management process and will be established in a planned, systematic and documented manner.

(h) The Health and Safety Plan shall cover and detail the following health and safety requirements as a minimum in order to comply with all applicable Laws, standards, norms or regulations and Good Industry Practice:

- The Contractor's health and safety Policy Statement;
- The Contractor's Organization Chart;
- The Organization Chart of the health and safety Area;
- Health and Safety Sanctions
- Medical examinations;
- Induction Program, training and skill building;
- Objectives and goals and performance indicators;
- Definition of Health and Safety roles and responsibilities for each position occupied by persons in the Contractor's organization;
- Applicable standards, law and guidelines to be adopted;
- Governmental permits, approvals and licenses for the Project;
- Issue of an Health and Safety Hand book guide to all personnel;
- Work program for the Worker-Management Joint Health and Safety Committee;
- Risk identification, analysis and control;

- Behaviour observation program (safe and at risk behaviours), which will require minimum number of workers, should be developed;
- Implementation of Program to control High Risk activities;
- program of Health and Safety activities for Contractor's front line Supervisors visiting the site as well as for, the Management Health and Safety staff visiting the construction site;
- Occupational Health Program, including respiratory tract and hearing protection, hygiene, alcohol and drugs, health and physical condition, protection from sunlight, restriction of smoking, asbestos, first aid and access to medical treatment, lighting, vibrations, etc.;
- Monitoring of the exposure of workers to noise, dust and other potentially hazardous pollution or substances;
- Accident/Incident investigation and reports;
- Health & Safety record-keeping;
- Internal and external audits;

- Those persons within the Contractor's parent and Site organisations who will be responsible for coordinating and monitoring the Contractor's health and safety performance on Site and reporting these matters to the Contractor's board of directors;
- The proposed level of Site safety surveillance together with the nomination of safety supervisors and a safety officer who will have an overview of all Site safety matters. The responsibilities, qualifications, training and experience of those nominated shall be specified;
- The Contractor's procedures for reporting and investigating accidents, dangerous occurrences and occupational illness;
- The Contractor's procedures for identifying hazards, assessing risk and eliminating potential site hazards. Reference shall also be made to mitigating measures which include procedures for the identification of the need for and the provision of personal protective equipment (PPE), permits systems, safety rules and safety training;
- Safety procedures for working with major items of plant such as, excavators, overhead cranes, tunnelling equipment, etc;
- The Contractor's procedures for assessing the suitability of Sub-Contractors with respect to health and safety; and
- The Contractor's procedures for ensuring that his personnel are medically fit for tasks they are carrying out. The procedures shall take into account working hours and environment.

(i) The Health and Safety Plan must also address as a minimum the following matters which are exposed in more detail in the following sub-sections:

- Safety during construction;
- Personal protective equipment;

- High risk Areas and zones;
- Health and Safety Induction;
- Health and Safety Inspections;
- Health and Safety Audits;
- Job Safety Analysis (JSA) Requirement;
- Excavations;
- Work Permits;
- Emergency Response Plan;
- Evacuation Training;
- Emergency Equipment.

2.2.5 *SAFETY DURING CONSTRUCTION*

2.2.5.1 General

(a) The Contractor shall advise the Engineer of all accidents, occurrences or incidents in a format to be agreed prior to the commencement of work on Site.

(b) In addition to any record the Contractor is required to keep under legislation, the Contractor shall keep at the Site offices an accident report book and maintain proper records therein. The accident report book shall be available for inspection at all reasonable times by the Engineer. The Contractor must communicate all serious incidents to its workers.

2.2.5.2 Electrical

(a) The Contractor shall give at least fourteen (14) working days' notice to the relevant authority with a copy of the notice to the Engineer, before starting any work under any overhead lines, with consideration given to the possible revision to the route of the Works or method, to avoid Works under power lines. This is to be subject to the agreement of the Engineer which shall not be unreasonably withheld. If this option is not viable then investigation into the possible temporary disconnection of electricity supply should be investigated. If this option is not viable then provision should be made to ensure that all equipment that can extend to exceed the safe working headroom is fitted with limiters that will provide safe working headroom or other alternatives shall be investigated.

2.2.5.3 Health and Safety Reporting

(a) The Contractor shall provide the following information on a weekly and monthly basis as part of the weekly and monthly progress reports of the Conditions of Contract):

- number of hours actually worked;
- number working days lost due to injury;
- number and nature of lost time injuries;
- accident frequency & accident severity;
- number and nature of near misses;
- current status of any injured personnel, damaged property or environmental damage;

- status of the implementation and outcomes of corrective actions undertaken as a result of health & safety inspections, risk assessments, lost time injuries and near misses; and
- status of Occupational Health and Safety (OHS) management system audits undertaken and audit reports.

(b) The Contractor shall report all accidents and incidents to the Employer/Engineer as soon as any accident or incident occurs followed by a formal accident/incident investigation report in a format acceptable to the Employer/Engineer within 24 hours of any accident or incident occurring. More detailed reports may be required by the Employer/ Engineer depending on the nature of the accident/incident.

2.2.5.4 Health and Safety Procedures

(a) The Contractor shall develop and update as necessary a set of safety procedures that shall be submitted for the Engineer's Review and Approval. The procedures shall include the necessary forms to be completed for various events.

(b) The procedures shall be developed and updated as the Contract progresses for the Engineer's Review and Approval.

(c) The procedures shall be transmitted to the workforce during safety inductions, tool box talks, safety presentations, and method statements and supervisors instructions.

(d) The Contractor shall develop and update as necessary specific procedures as a minimum measures for the following non-exhaustive items:

- Driving and maintenance of light vehicles;
- Inspection, operation and maintenance of equipment and machinery;
- Lock-out/tag-out of equipment and machinery;
- Electrical wiring, cables and extension cords;
- Handling of hazardous materials;
- Elevated work;
- Rigging and lifting manoeuvres, lifting equipment, the use, maintenance and storage of
- Excavations and trenches;
- Confined spaces;
- Internal Health and Safety Work permits;
- Hot work;
- Assembly and disassembly of scaffolding;
- Reinforcing steel work and concrete forms;
- Erection work;
- Use of hand tools;
- Use of and inspection of electrical tools, electrical, systems and appliances;
- Use of personal protective equipment;
- Safe commissioning procedures;
- Operation, transportation and storage of radioactive equipment;

- Work instruction sheets;
- Handling of wastes and residues;
- Findings of archaeological remains;
- Handling of used oil and oil filters;
- Handling of fuels;
- Handling of concrete remains and debris;
- Prevention and control of spills (Solids and liquids);
- Environmental closure and jobsite demobilization;
- Control of particulate matter;
- Supply and consumption of potable water;
- Supply and maintenance of chemical toilets;
- Use of elevated work platforms suspended from cranes (e.g., work baskets and work buckets);
- Work safety risk analysis;
- Ladders and stairs;
- Use of explosives;
- Surface drilling;
- Underground Emergencies;
- Underground Drilling;
- Underground Loading of explosives;
- Underground Scaling;
- Underground Rock bolting (mechanical, resin, concrete, etc.);
- Underground Reinforcement with Shotcrete;
- Underground Surveying;
- underground geological face mapping
- Underground marking of the face;
- Underground mucking of the face;
- Underground Blasting;
- Surface Blasting;
- Blasting tools;
- Cutting tools;
- Sandblasting;
- Flushing;
- Fire prevention;
- Work surfaces;
- Transportation of personnel;
- Communications of policies;
- Change in Management

- First aid;
- Emergencies, the emergency evacuation of worksites, in particular underground works and deep excavations;
- Immediate reporting and formal investigation of accidents;
- Safety training and task training; and
- Interruption of traffic (including its management);
- Temporary facilities and/or construction camp (including handling potable water, toilets, cleaning, refrigeration, air-conditioning; smoke detectors etc.);
- The Contractor's safety proposals for compressed air working;
- An outline program for safety tours and detailed safety inspections.

2.2.6 *PERSONAL PROTECTIVE EQUIPMENT*

(a) The Contractor and Contractor's Supervisor must provide training and enforce the use of personal protective equipment (PPE) and related compliance with international or official Nepalese standards on Health and Safety for regulation of protective equipment.

(b) Notwithstanding the aforesaid, the Works may require the use of other specific types of personal protective equipment for certain works in accordance with the corresponding risk analysis done by the Contractor.

(c) The Contractor shall provide free of charge and well maintained following personal protective equipment's, to all of its personnel, its Sub-Contractor's personnel, as well as the Employer's and Engineer's Personnel and their Visitor's (in accordance with the activities to be performed);

- High visibility, reflective vest or shirt
- Safety helmet and Miner's Safety helmet only for underground personnel
- Safety footwear (Rubber or leather Boots or Shoes with protective steel toe caps and steel sole inserts, or Fibre Reinforced Plastic (FRP) toe for electricians)
- Ear Protectors
- Dust Masks
- Safety gloves (in accordance with the activities to be performed)
- Respirators with filters, in accordance with the pollutants existing at the jobsite (when applicable)
- Self-rescuers for all workers underground or alternatively provision in a container box close to the working faces and along the tunnels or as otherwise agreed.
- Safety goggles with UV and impact protection (dark lenses for daytime use)
- Work suit or work clothes.
- Two piece rubber suit for underground tunnelling
- Sun block protection for all surface workers exposed to daily UV radiation
- Exposure to hand/arm vibration or whole body vibration is to be controlled by the choice of equipment, installation of dampening pads or devices, and by limiting the duration of exposure.

- The use of chemical hazards shall be minimised by the use of alternative materials or by the implementation of measures to avoid or control their use and release into the working environment. Where chemical hazards or irritant or toxic substances may come in contact with the skin or clothing, the Contractor's

personnel shall be provided with and wear appropriate protective clothing, gloves, aprons, splash suits, face shields, goggles, etc.

- Contractor's personnel involved with welding or hot work shall be provided with and wear appropriate protective clothing, gloves, welder goggles, etc. A welding/hotwork permit system shall be implemented and enforced.
- Contractor's personnel working on steep slopes or otherwise subject to possible falls from height shall be subject to fall prevention/protection measures, which include the installation of guardrails, mid-rails and toe boards; proper use and training in the use of scaffolding and ladders; and
- the use of full body safety harness with shock absorbing lanyards, restraints or lifelines.
- Types of contracts or activities (such as office administrative personnel etc.) may exist that do not require the use of some or all of the aforesaid personal protective equipment. In such cases, the exemption from any use of PPE must be notified by the Contractor and approved by the Engineer. Personal protective equipment must always be kept in good working condition and replaced when necessary.
- If the Contractor fails to provide such Personnel Protective Equipment, the Employer shall be entitled to provide the same and recover any and all costs from the Contractor.

2.2.7 *AREAS AND ZONES*

(a) At the start of any job or work, all Contractors must familiarize themselves with the hazards and risks present in each area, zone or workplace involved and perform a risk analysis.

(b) The Contractor must install hard protections or fences or equivalent at jobsites and workplaces whenever working in excavations, limiting lifting manoeuvres, and work at heights.

(c) Contractor and Contractor's sub-Contractors personnel may only travel through or enter those specifically authorized areas and zones, authorized by the Engineer and for the purpose of the Project.

(d) All work that the Contractor is to perform in an area other than the Construction Site designated by contract must be coordinated by the Engineer.

2.2.8 *HEALTH AND SAFETY INDUCTION*

(a) Health and Safety Induction is the formal presentation, in the form of a course of study, of the Health and Safety practices and procedures that must be honored and

obeyed by all employees of all the Contractors, Sub-Contractors and Suppliers working on the Project.

(b) The Contractor must impart to all the Contractor's employees and employees of its Sub-Contractors, a formal Health and Safety Induction process. These courses must be imparted by Contractor personnel or

by such third parties as the Contractor must designate and constitute a prerequisite for access to the project premises. Compliance with this obligation must be accredited by Contractor, by means of exhibiting and submitting the related attendance records, and proof of mark (test result) that are to be issued for each Health and safety Induction.

2.2.9 *HEALTH AND SAFETY INSPECTIONS*

(a) At least one person of the Contractor management Team shall make at least one inspection per week in which Contractor shall check on the state of the construction work and report thereon to the Engineer. The Engineer, acting alone or jointly with the Contractor, may also inspect the construction works at any time.

(b) All substandard conditions detected during these inspections shall be documented and informed to the Engineer, and corrected as soon as possible or by specific deadline set by the Contractor, which shall be recorded in the inspection format used for each inspection.

2.2.10 *HEALTH AND SAFETY AUDITS*

(a) The Engineer will perform at least two Health, Safety and Environmental (HSE) audits per year on the Contractor.

(b) The first audit will be performed any time after the first 30 days from the start of Contractor's performance in the field or whenever the Engineer deems appropriate.

(c) All nonconformities found during the conduct of these audits shall be documented and corrected as soon as possible or by a reasonable deadline set by the Engineer, which shall be recorded in a memorandum drawn up for such purposes at the time of each audit.

(d) The auditing process will be aimed at determining the degree of adequate compliance with the performance standards and requirements defined and set out in the "Health and Safety Plan", Applicable work procedures, and a Compilation of all relevant Nepalese regulations and relevant international practices.

2.2.11 *RADIOACTIVE SOURCES*

(a) The Contractor shall maintain up-to-date records of people and sources, to ascertain that valid permits and authorizations for the movement, installation and handling of radiation sources in accordance with current standards and law, are in place at all times.

(b) The Contractor, prior to any movement, installation or handling of each radioactive source, shall submit to the Engineer copies of all permits issued by the authority or agency having jurisdiction.

2.2.12 *JOB SAFETY ANALYSIS (JSA) REQUIREMENT*

(a) For all critical work to be performed, the Contractor shall elaborate a documented Job Safety Analysis before starting the work.

(b) If the work must continue into the night or as conditions change, the changes involved must be noted as a step or stage. The risks associated with working at night must be specified, and the related risk controls must be implemented.

(c) The JSA can be amended during the work shift by attaching an appendix to the original JSA and

identifying the changes.

(d) During the development of the JSA, the employees who are to participate in the work must be informed accordingly.

(e) Contractor's Supervisor including the workers involved, are to complete the Job Safety Analysis (JSA), and sign the completed sheet.

(f) The Contractor is responsible for completing the JSA forms, for using the process to identify the steps, the evaluations and control and for giving the approval prior to the start of work.

2.2.13 *EXCAVATIONS*

(a) Without limiting any obligation under the Contract, the Contractor, when undertaking excavation works shall comply with the relevant laws, regulations, rules and codes of practice applicable to such excavation works.

(b) Before proceeding with excavations or trenches, the Contractor shall investigate and establish if any of the following exist in the ground:

- Buried or underground pipelines.
- Components of cathodic protection systems, grounding grids, etc.
- Sewer pipes and conduits.

- Buried electric cables.
- Overhead electric lines

2.2.14 *INTERNAL HEALTH AND SAFETY WORK PERMITS*

(a) Internal Health and Safety Work permits consist of a system designed to protect workers, the environment and property. The following types of work permits will be applicable at the Project and shall be considered in their respective procedures.

- Heavy lifts and lifts in tandem
- Entry into confined spaces
- Hot work
- Energizing of electrical equipment
- Work at heights
- Handling of radioactive material and work with radiography and gamma radiography
- Other specific activities as determined by the Project Health and Safety Team.

2.2.15 *EMERGENCY RESPONSE PLAN*

(a) The Contractor shall, within Twenty Eight (28) days from the Commencement Date, submit for approval a comprehensive Emergency Response Plan, in accordance with the general requirements of the "Performance Standards on Social & Environmental Sustainability, Performance Standard 3" published by the International Finance Corporation.

(b) The Emergency Response Plan shall be revised and/or updated as necessary, or, without relieving the

Contractor of any of his obligations or responsibilities, as instructed by the Engineer. Revisions and/or updates of the Emergency Response Plan shall be submitted not later than Twenty Eight (28) days from the date deemed necessary or from the date of the Engineer's instruction.

(c) The Emergency Response Plan shall detail procedures and plans which the Contractor intends to implement, and shall demonstrate that the Contractor has the facilities and personnel required to implement the approved Emergency Response Plan.

(d) The emergency response plan shall cover, but not be limited to the following:

1. Medical emergencies
2. Rescue procedures
3. Evacuation procedures,(medical, civil unrest, etc.)
4. Fire and fire fighting
5. Hazardous materials
6. Biological hazards
7. Radiological hazards
8. Natural disasters,
9. Epidemics
10. Pollution prevention (from any source)
11. Waste
12. Coffer dam overtopping
13. Collapse of tunnels and underground excavations

And shall include:

- Procedures for immediate actions;
- Procedures for reporting incidents to the Engineer, the local and national authorities and health authorities
- Complete list of equipment available for use in emergency situations.
- Procedures for informing neighbours and downstream users in cases of release of hazardous substances and/or pollutants
- Procedures for reporting irregular events.
- Procedures for dealing with the instance/s
- Program for training of key staff in emergency responses. The training will be based on various emergency scenarios.

(e) The Contractor is responsible for the proper instruction and training of Contractor's personnel according to the Emergency Response Plan. Events and/or Circumstances as identified in the Health and Safety Plan under the Contractor's working area should be integrated and coordinated with the Engineer's Emergency Response Plan.

(f) The Contractor has the ultimate responsibility in case of an emergency for properly stopping the

construction activities at the affected areas and under Contractor's supervision, the subsequent evacuation to Emergency Meeting Points (EMP). The performance of headcounts of personnel following the evacuation, and the submission of the related notes to the person in charge of the emergency situation is also the Contractor's responsibility.

2.2.16 *EVACUATION TRAINING*

(a) The Contractor shall carry out with the Employer / Engineer, emergency drills for purposes of training as frequently as specified as the corresponding Emergency Response Plan.

(b) The Contractor must provide support for the preparation and execution of the evacuation training that will be of use for the safety of all employees.

2.2.17 *EMERGENCY EQUIPMENT*

(a) Emergency equipment consists of the key equipment for the prevention, detection, mitigation, recovery and rescue associated with emergency and includes personal protective equipment and other safety equipment related with the areas and types of work performed by the Contractor.

(b) The Contractor must ensure that all emergency equipment is regularly tested, and that it is always in working condition and its personnel is trained and, whenever required, certified in the use of that equipment.

2.2.18 *REPLACEMENT OF UNSATISFACTORY WORKERS*

(a) The Contractor shall remove immediately any of the Contractor's workers if after the corresponding investigation is evident that such worker does not meet the requirements or the necessary skills, his conduct is harmful for the performance of the Works or commits acts that are against his own safety or the safety of other workers.

2.2.19 *CONTRACTOR'S STAFF AND PERSONNEL OBLIGATIONS*

2.2.19.1 List of Intolerable Acts and Omissions

(a) The following is a non-exhaustive list of acts and omissions that are not tolerable and shall not be done and will lead to the application of Contractor's Health and Safety Sanctions Procedure:

- non-reporting of any accidents or injuries;
- non-use of the safety harness and fall arrest systems when working at heights;
- being in an unauthorized or restricted area without authorization;
- not obeying Health & Safety lock-out procedures for personnel & equipment;
- overriding, removing or elimination of safety devices;
- using lifting equipment beyond the range of their design criteria;
- operating or working on equipment without authorization and appropriate certification;
- being on the construction site or working under the influence of alcohol, drugs or prohibited substances;
- being located underneath suspended loads;
- not using basic Personnel Protective Equipment (PPE); and

- handling of hazardous material by unauthorized personnel.

2.2.19.2 Delegation

(a) The Contractor may delegate the Contractor's authority and obligations, to other members of the Contractor's organization. Such a person on whom authority has been delegated, shall be identified (name, position, items under his responsibility) on a detailed list that shall be submitted to the Engineer prior to the start of the Contractor's Site mobilization.

2.2.19.3 Roster of Workers

(a) The Contractor shall maintain at the Site, an up-to-date roster (list) of all of the Contractor's workers with the following information for each individual:

- Name;
- Identification card number;
- Age;
- Position or job assigned;
- Starting date;
- Area where working; and
- Induction training course certificate.

2.2.19.4 Co-ordination of Staff

(a) The Contractor is required to coordinate the participation of the Health and Safety staff of the Engineer, in all agreed joint inspections to be made by the Contractor and SubContractors to their respective working areas.

2.2.19.5 Safety Specialist – Accident Prevention Officer

(a) In accordance with of the Conditions of Contract, as part of the Contractor's safety policy, the Contractor shall appoint a safety specialist (licensed, certified and qualified) or approved equivalent, according to International Recognized Standards with at least five (5) years of experience, to assist in the construction of the Works.

(b) Together with the Accident Prevention Officer, the Contractor shall appoint sufficient Deputy Safety Officers who shall be responsible for ensuring that the safety procedures, safety policy, applicable laws and codes of practice are adhered to.

(c) The Accident Prevention Officer or one of his deputies shall be available on a 24 hour basis and shall carry out regular and random checks of all parts of the Site where work is taking place.

(d) Particular attention shall be given by the Safety Officers to aspects such as lighting, handrails, especially around all dangerous openings, access stairs, toe plates, ventilation of enclosed spaces, blasting procedures, removal of construction rubble, orderly storing and stacking of construction equipment and material

(e) s and general cleanliness of the Works.

(f) The Accident Prevention Officer and his deputies shall have the authority to stop work if, in their opinion the work is being carried out in an unsafe manner.

2.2.19.6 Submission of Reports

(a) The Contractor shall submit to the enforcement authorities and as applicable according to provisions of current law all reports required by such provisions. These reports shall be first submitted to the Engineer for Review and Approval.

2.2.19.7 Internal Health and Safety Regulation

(a) The Contractor shall distribute to everyone of its workers a copy of its Internal Health and Safety Regulation as required by labour law.

2.2.19.8 Health and Safety Supervision

(a) The Contractor is required to facilitate the following in connection with the Health and Safety supervision responsibilities of the Engineer:

- All stoppages or suspensions of work demanded by the appropriate authorities shall be informed immediately and further confirmed in writing and submitted to the Engineer.
- The Engineer shall have access to the construction site log.

2.2.20 *HAZARDOUS SUBSTANCES*

(a) The Contractor shall identify and keep records of all hazardous equipment, materials, or other substances and any other health hazards in his undertaking of the Contract. Newly created hazards or new hazardous equipment, materials or other substances brought on to Site shall be added to the record. The Contractor shall draft codes of practice appropriate to the said hazards. The Engineer shall be granted access to such records at all times.

(b) The Contractor shall regularly check the storage areas for Contractor's Equipment, transport vehicles and hazardous materials, for spillages and leaks. The Contractor shall make adequate provisions, to the satisfaction of the Engineer, to prevent such spillages of toxic materials from entering natural streams or areas outside the Site.

(c) Maintain an inventory of all hazardous materials stored on site. A Material Safety Data Sheet (MSDS) shall be available at the construction office for each hazardous material.

(d) Locate hazardous material/waste storage facilities at least 50 m from any perennial stream or intermittent stream channel.

(e) All hazardous material/substances shall be stored on site in a manufacturer recommended container, within a covered or enclosed structure, with an impervious liner (e.g., concrete pad or plastic liner), that is secure (e.g., fenced, locked, and/or with security guard and restricted entry), and with appropriate secondary containment sufficient to store the volume of the largest hazardous material container.

(f) Hazard signs indicating the nature of the stored materials (MSDS) shall be displayed on the storage facility or containment structure and kept on file at the site office.

(g) The Contractor shall arrange maintenance staff with appropriate protective clothing to clean up the spilled material. This may be achieved through covering the area with sawdust (if the quantity of spillage/leakage is small), or sandbags (if the quantity is large), and/or using a shovel to remove the topsoil (if the spillage/leakage occurs on bare ground. Spilled hazardous materials must not be flushed to local surface drainage systems. Instead, government approved clean-up and disposal procedures shall be carried out.

2.2.21 *FIRST AID*

(a) The Contractor shall institute and operate a basic first aid training programme to ensure that each foreman or work crew leader in control of 20 or more workmen is trained in first aid and possesses a certificate to that effect issued by the Red Cross Society of Nepal, or equivalent qualification within 3 months of his appointment.

(b) The Contractor shall provide and maintain in ready condition boxes of first aid materials together with stretchers at prominently marked locations within 100 meters of each working place or as required by the E m p l o ye r / Engineer. The contents of the boxes must be available in emergencies without use of a key. The contents of each first aid box shall include but not be limited to:

wound cleaner (500 ml)
wounds
padding (250 g)
sterile gauze (5 packets)
(for splinters)
1 pair scissors (100 mm)
2 cards of 6 safety pins -
24 triangular bandages
splints sterile eyewash -
6 roller bandages (80 mm x 5 m) swabs for cleaning
6 roller bandages (100 mm x 5 m) cotton wool for
2 rolls elastic adhesive (25 mm x 3 m)
2 anti-allergenic adhesive strip (25 mm) 1 pair forceps
2 packets adhesive dressing strips
6 large dressings (975 mm x 100 mm)
6 shell dressings (150 mm x 200 mm)
4 straight
eye pads 3 pairs disposable gloves

(c) The first aid boxes shall be checked every week and any items that are used must be replaced immediately.

2.2.22 *LIGHTING AND POWER*

2.2.22.1 General

(a) All power and lighting circuits are to be fitted with earth leakage systems. Any circuit where the earth leakage system is malfunctioning shall be repaired immediately or removed from the working area.

2.2.22.2 Lighting

(a) The Contractor shall provide and maintain during the execution of the Works an adequate lighting system both for the working and for the transit areas as approved by the Engineer.

(b) In the areas where works are in progress, mobile or stationary flood-lights or equivalent type of lights shall be installed so that the activities can be executed with safety and accuracy.

(c) Lighting cables and their fittings shall be installed and maintained during the execution of the Works in the

best safety conditions and in accordance with the regulations in force in Nepal

(d) Unless different lighting levels are otherwise specified, the lighting system during construction shall have minimum intensity of 50 lux in transit areas and 200 lux in working areas.

2.2.22.3 Grounding and Control of Electric Discharge

(a) All equipment and appliances shall be electrically grounded/earthed, and the effectiveness of such grounding/earthing shall be periodically checked by the Contractor's specialized personnel.

(b) Energised electrical equipment, appliances and lines are to be clearly labelled with warning signs.

(c) Locking out and tagging out devices shall be used during servicing or maintenance.

(d) All electrical leads, cables and hand-held power tools are to be checked regularly for frayed and exposed cables and replaced if damaged.

(e) Power leads, cables, extension leads, junction boxes and distribution boxes shall be protected from damage, including damage from traffic, and replaced if damaged.

(f) Establish and maintain "No Approach" zones around or under high voltage power lines.

(g) Where electrical blasting is used, equipment shall be installed to control possible electric discharges in the ground due to storms, electrical motors, etc. Whenever electrical discharges are experienced which could affect the safety grade of

detonators, electrical blasting operations shall be interrupted and fuse blasting shall be resorted to instead.

2.2.23 *SIGNAGE, LABELING AND HAZARD CODES*

(a) Hazards and areas forming a danger to the safety of all personnel shall be clearly marked and labelled. Labels and signs shall be clear.

(b) Copies of Hazard coding system shall be displayed at all entrances to the site, site working areas, office areas and accommodation areas.

2.2.24 *FIRE PRECAUTIONS*

(a) The Contractor shall provide, equip and maintain adequate fire fighting facilities.

(b) The Contractor shall organize a fire brigade equipped for the fighting of any fires which may break out at the Site.

(c) The Contractor shall provide and ensure that an adequate number of fire extinguishers are available at all times at the various working areas and camps at the Site and are maintained in satisfactory working order. The quantity, type and location of fire extinguishers shall be subject to the approval of the Engineer.

(d) Fire protection facilities which are provided shall be of the gas, dry power or other approved chemical type and/or pump water type.

(e) Fire hazard areas shall be clearly defined, with appropriate signs and labelling.

2.2.25 *STORAGE OF FLAMMABLE MATERIALS, LIQUIDS AND GASES*

(a) Flammable materials, liquids and gases shall be in suitable and approved storage facilities, remote from entry and exit points into the site works, offices and other buildings.

(b) Flammable materials, liquids and gases shall be kept away from sources of naked flames or other sources of ignition, as well as away from ventilation intakes of vents.

(c) The storage facilities shall have spark proof fittings and fixtures, with natural or passive floor and ceiling level ventilation and explosion venting.

(d) The storage facilities shall be equipped with fire extinguishing devices, and made of materials which can withstand flame impingement.

(e) Containers shall be bonded and grounded, with the addition of mechanical floor level ventilation.

(f) Personnel in charge of or handling flammable materials shall have specific training in handling flammable materials, and in fire prevention and suppression.

2.2.26 *WORKER HEALTH AND LIVING CONDITIONS*

The Contractor is responsible for ensuring safe working conditions for its employees and shall include the following elements:

a. Provide education and training to the workers on basic personal hygiene; the prevention of diseases, including respiratory diseases, water and food borne diseases such as diarrhea, and communicable diseases such as tuberculosis; and on HIV/AIDs symptoms, counselling, and treatment services.

b. Implement an awareness program for workers and local communities on the prevention, detection, screening, and diagnosis of sexually transmitted diseases, especially with regard to HIV/AIDS. The program shall also include

c. information on alcohol abuse, GBV, SEA, and human trafficking.

d. The workers' camp facilities shall be autonomous, adequate for the number of workers in each camp, and not rely on local/public facilities for accommodation, healthcare, sanitation, cooking, recreation, and other infrastructure or services

e. Workers' accommodation and living conditions shall meet at least the minimum requirements. These standards include building construction; housing; general health, safety, and security; fire safety; electricity, plumbing, water, and sanitation; general living facilities e.g., drainage, heating, ventilation, and air conditioning [HVAC], water, wastewater, and solid waste); rooms/dormitory facilities (e.g., bed arrangement, storage facilities); sanitary and toilet facilities (e.g., toilet facilities, showers/bathrooms and other sanitary facilities); canteen, cooking, and laundry facilities; medical facilities; and leisure, social and telecommunication facilities. The Contractor shall provide basic hygiene supplies to all workers (e.g., soap, laundry detergent).

f. Separate accommodation, toilets, and shower/bathroom facilities shall be provided for men and women. Notices shall be displayed outside each block of latrines and urinals, in the language understood by the majority of the workers stating "For Men Only" or "For Women Only", as the case may be. Such facilities shall be conveniently accessible and kept in a clean and hygienic condition. Latrines shall also be constructed in areas that are likely to be visited frequently by the construction workers. Latrines shall be located at a distance of at least 50 meters away from residential areas and watercourses. If septic tank systems are used for any residential labor camps, the seepage pits shall be located at a safe distance from water sources to avoid contaminating them. Wastewater shall not be disposed of into water bodies without treatment.

g. Appropriate areas shall be designated for smoking. NO SMOKING signs shall be placed in areas where smoking is prohibited, for example, in the dormitories and medical facilities.

h. Workers' facilities for the Main AccessTunnel Contractor:

- Water – The Contractor shall supply water to each of the workers' camps without impacting on the water supply to nearby villages. Raw water will be tested and treated as necessary to meet Nepal's potable water quality standards. Water lines shall be extended to serve major work areas.
- Wastewater – Each workers' camp will be served by a wastewater treatment facility (e.g., treatment plant or large septic system) approved by UAHEL and which shall be designed to meet Nepal wastewater effluent standards and sized to meet the camp's wastewater flow.
- Cooking and meals – Meals shall be nutritious and take into account ethnic, religious, and cultural differences of the workforce. The Contractor shall not purchase or serve to workers any fish caught in the Arun River or its tributaries or any wild/bush meat.
- Medical facilities – Each workers' camp will have a separate clinic room headed by a nurse with adequate medical supplies, an ambulance, and helicopter evacuation available in the case of emergency. The Contractor must have an agreement with the nearest available hospital for the treatment of emergency cases.
- Recreation and leisure facilities – The Contractor shall provide adequate recreational opportunities for its workforce, including access to phones/Internet facilities for free or at affordable rates that allows workers to interact with their families and friends.

2.2.27 *WORKER SAFETY AND WORKING CONDITIONS*

The Contractor is responsible for ensuring safe working conditions for its employees and shall include the following elements:

- Provide all personnel, including day laborers, with the proper personal protective equipment (PPE), such as safety boots, safety glasses, helmets, hearing protection, gloves, dust masks, and/or respirators, and enforce their use.
- Carry out health screening and fitness tests for all workers at the time of recruitment. This health screening shall be undertaken in keeping with the work profiles of the workers. The fitness test shall screen for

communicable diseases and any health risks that may create issues in undertaking the task assigned. In addition to this, regular annual health check-ups shall be undertaken for all workers.

- Provide safety training, regular refresher training, and daily "tailgate" talks on safety issues. The Contractor shall maintain records for each employee to document the H&S training that they have received.
- Notify and provide training to all appropriate personnel of any changes to the OHS Plan as per the Management of Change process.
- During heavy rains, accidents, or emergencies of any kind, all work aboveground shall be suspended.
- Underground work and electrical/mechanical equipment shall be braced to withstand seismic events during the construction.
- MSDSs shall be maintained for each hazardous material present on the worksite.

Special requirements:

- Workers working in the following situations shall receive specialized training H&S training:
  - Underground or confined spaces
  - Working at heights
  - Working with explosives
  - Working with hazardous materials
  - Working in or over watercourses
- This specialized training shall ensure that workers are aware of the potential hazards of working in these areas, understand the safety precautions required, and understand the proper use of any specialized PPE.
- The Contractor is responsible for providing appropriate safety measures, including proper lighting and ventilation of underground works and monitoring of gases, stabilization of tunnels, and prevention of rock-fall.

2.2.28 *TRANSPORT OF LABOUR*

(a) The Contractor shall be responsible for, and make provision for, the safe vehicular transport of all labourers between the labour camps and/or established collection points and their work areas, and vice versa. The Contractor shall provide sufficient transport, properly fitted out for the safe transport of labour in a form acceptable to the Engineer.

(b) The transport shall provide for safe entry and egress, prevent persons jumping or climbing over the sides, and be fitted with seating. Under no circumstances shall labour be transported on flatbed trucks, rail or similar vehicles which do not comply with the requirements. Weatherproof covers shall be available for use at all times following the onset of the rains until such time as the Employer agrees that the provision is no longer required. The Contractor shall prevent overloading of vehicles, and suitable crush barriers shall be provided at main loading points.

2.2.29 *SAFETY OF THE PUBLIC*

(a) Where the public could be exposed to danger by any of the Site activities the Contractor shall close off such access and erect suitable warning and "no trespassing" signs in English and Nepali, all to the approval of the Engineer.

(b) Where shown on the Drawings or instructed by the Engineer the Contractor shall provide alternative safe access routes for the public. The cost of such alternative accesses shall be borne by the Contractor.

(c) To conduct mandatory health check-up of in-migrant workers to identify pre-existing contagious diseases before th

(d) ey come to the workers camps.

(e) Provide medical/health/first aid centers at each workers' camp so as to not place any additional burden on local health posts. Only workers with emergency conditions that exceed the capability of project medical facilities will use public facilities (i.e., hospitals in Khandbari and Kathmandu).

(f) UAHEL will have a gender/GBV specialist to manage and coordinate gender/GBV and SEA/SH issues related to the project.

(g) Develop a communicable disease (e.g., COVID-19) management plan that describes safety precautions, requirements for worker testing before coming to the workers' camps and periodically thereafter, visitor testing requirements and safety requirements, and procedures to put in place in the event a worker tests positive for COVID-19 or another communicable disease.

(h) Install safety fencing and warning signage to control public access at high risk areas, including the tunnel and cavern portals, quarry, power plants, crusher and batching plants, and spoil disposal areas.

(i) Provide adequate night-time lighting around the Contractor workers' camps.

(j) Install a perimeter security fence around the Contractor workers' camps with guards to restrict public access.

2.2.30 *USE, HANDLING AND STORAGE OF EXPLOSIVES*

(a) In the use, handling and storage of explosives, the Contractor shall comply with the guidelines given in the ICI Nobel's Explosives Company Blasting Practice Handbook and with all statutory regulations of Nepal.

(b) The handling or use of explosives shall be discontinued during the approach and progress of a thunderstorm. All persons shall be removed from danger areas to a place of safety during such periods.

(c) The Contractor shall engage an approved shot-firer as per the requirements of the Regulation.

2.2.31 *WARNING OF BLASTING*

(a) Prior to a surface blasting event (i.e., excluding underground blasting), water shall be sprayed on the surface of the blast area to increase its moisture content, and blasting mats (constructed from truck tires bolted together), wire mesh, gunny sacks, and/or sandbags shall be used on top of the blast area at each shot to prevent flying rocks and dust. Blasting shall not be carried out in adverse weather conditions. Spraying shall be conducted after the blast to control fugitive dust.

(b) The Contractor shall install and operate a siren of sufficient volume to be easily heard above the general Site noise from all points within a radius of 1.0 km of surface blasts, including those persons operating construction vehicles and machinery.

(c) The Contractor shall provide notification to any occupants of surrounding land at least one day prior to any surface blasting activity and shall address any concerns that they may have. The Contractor shall also issue a warning siren 20 minutes before the blast, again about 1 minute before the blast, and an "all clear" siren shortly after the blast, which can be heard up to approximately 1 kilometer from the surface blast site.

(d) Hand operated sirens will not be accepted.

(e) The Contractor shall submit details of his blasting procedures to the Engineer for consent and shall ensure that such procedures are adhered to at all times. The procedures shall be coordinated with all other organizations in the area which may also be undertaking blasting or be affected by blasting.

(f) Relevant aspects of the procedures shall be agreed with the local civil and military authorities and disseminated as widely as practicably possible amongst the local population.

2.2.32 *SCAFOLDING, FALSEWORK AND FORMWORK*

(a) Scaffolding, falsework and formwork are to comply with relevant International applicable standards.

(b) Portable and access ladders shall be wooden or steel ladders sufficiently strong and with suitable size for the use intended, and are to comply with relevant applicable standards. Wooden ladders shall have the steps fixed to the longitudinal posts by assembly. The use of ladders with steps nailed or wired along the longitudinal posts is not permitted.

2.2.33 *BIOLOGICAL HAZARDS*

(a) The Contractor shall introduce and maintain a strict regime for measures to control biological agents or hazards which exist on, or are introduced to the site, as required by Government or the local and international health, medical or sanitary authorities.

2.2.34 *SANITARY AND HYGIENE MEASURES AND EPIDEMICS*

(a) The Contractor shall comply in all respects with the rules, regulations and instructions of the relevant Government and health authorities as regards sanitary and hygiene requirements in connection with the Works.

(b) The Contractor shall implement an educational programme and awareness campaign covering sanitary & hygiene, contagious diseases, sexually transmitted diseases (STDs), and HIV/AIDS.

(c) In the event of any outbreak of illness of an epidemic nature, the Contractor shall immediately report such occurrence to the Employer and the relevant authorities, and shall comply with and carry out such regulations or orders and requirements as may be made by the government or the local and international health, medical or sanitary authorities for the purpose of dealing with, and overcoming same.

2.2.35 *RADIOLOGICAL HAZARDS*

(a) The Contractor shall introduce and maintain a strict regime of measures for the prevention and control of exposure to radiation which exists on, or are introduced to the site, as required by the Government or international authorities.

2.2.36 *TRAFFIC MANAGEMENT AND SAFETY PLAN*

(a) In accordance with the Employer's Traffic Management and Safety Policy, the Contractor shall, within Twenty Eight (28) days from the Commencement Date, submit a comprehensive Traffic Management and Safety Plan prepared specifically for the Site, covering all aspects of traffic management and safety.

(b) The traffic management and safety plan proposed by the Contractor shall be subject to the Engineer's Approval.

(c) The Traffic Management and Safety Plan shall cover, but not be limited to:

- Scheduling of vehicle movements.
- Travelling in convoys
- Qualifications of drivers/operators
- Vehicle inspections and testing
- Vehicle maintenance
- Spare parts purchasing and storage
- Emissions and emission control
- Speed limits and speed controls
- Fines procedure
- Procedure to ensure compliance
- Training and education
- Signposting
- Monitoring

(d) Trucks/dumpers loads shall be covered (e.g., tarpaulin sheets) during offsite transportation.

(e) The Contractor is responsible for the costs associated with repairing any damage caused to local roads and bridges due to the transportation of excessive loads.

2.2.37 *RESCUE TEAMS*

(a) Prior to the commencement of construction, the Contractor shall organize and train Rescue Teams composed of his employees. The Rescue Teams shall be capable to render help after accidents at work.

(b) The Rescue Teams shall be organized in such a way that a sufficient number of members are ready for action at any time and shall be effective for the whole duration of the Works.

(c) The Rescue Teams members shall be instructed and trained for their task by qualified and experienced

persons.

(d) Each Rescue Team member shall be skilled in giving first-aid, dealing with the appliances for artificial respiration and fire fighting equipment, and shall possess a good local knowledge.

(e) The Contractor shall submit the details of the proposed rescue team organization to the Engineer for Approval.

2.2.38 *SECURITY MEASURES*

(a) The Contractor shall be responsible for the security of the project sites and shall provide and maintain an adequate security force to fulfil this obligation. This will include the provision of identification badges for access to work sites and clear marking of all project vehicles.

(b) Security personnel shall keep 24 hours watch and control work sites and camps and stop all attempts of illegal activities including drunken driving.

(c) In the case that a third-party security service provider is engaged by the Contractor, the Contractor shall ensure that the private security agency complies with the Companies Act of Nepal, and the Labour Act of Nepal.

(d) Keep unauthorized persons off the construction site.

(e) Authorized persons shall be limited to the Contractor's and the Owner's personnel or other individuals approved by the Contractor or Owner. The Contractor shall implement a sign-in/sign-out procedure for site visitors. Visitors shall receive a safety briefing and only be allowed into the construction site with a project escort.

(f) Establish security checkpoints to confirm the identity and purpose of each individual seeking to enter the construction area.

(g) Obtain permission for visitors and relatives of the camp residents to enter the camp. This permit shall be approved by the construction camp manager.

2.2.39 *ADDITIONAL HEALTH AND SAFETY REQUIREMENTS FOR UNDERGROUND WORK*

2.2.39.1 General

(a) In addition to the minimum general health and safety requirements contained in Section 2, additional requirements are to be complied with when undertaking activities underground, which include, but not limited to the following :

- US Bureau of Mines regulations, standards and codes;,
- USBR – Construction Safety Standards;

and which form part of the Contractor's obligations, duties and responsibilities in accordance with the Contract.

2.2.39.2 Lighting

(a) Tunnels shall be illuminated with electric lamps with adequately insulated branch circuits. A voltage in excess of 110 volts shall not be permitted for underground illumination. Emergency lighting with a

minimum intensity of not less than 10 lux shall be provided in case of a power failure.

(b) Lighting cables shall be installed on one side of the tunnels, and telephone or communication system wires shall be laid on the opposite side. All cables installed in underground shall be firmly fixed on sidewalls with supports and insulators of adequate design and capacity, and their installation shall be made so that they cannot be damaged by the equipment operating in tunnel.

(c) Where in the Engineer's opinion it is impracticable to place and use electrical cable at the excavation face of the tunnels, pneumatic or carbide lamps shall be used.

2.2.39.3 Ventilation

2.2.39.4 Quality of Air

(a) The air in tunnels shall contain at least 19 % of oxygen at all time and the concentration of contaminants such as gases, vapours, and dust shall never exceed the limits established for the workmen's health, taking into account the effects of time, temperature, humidity and the cumulative effects of contaminants.

(b) Without prejudice to the adoption of such lower figures as may be required by the Employer, the air breathed by workmen and other persons in tunnels shall not contain more than 5 p.p.m. of nitrous fumes (measured as NO2) for longer than 10 minutes after each blast and 30 p.p.m. of carbon dioxide as an absolute maximum.

(c) Concentrations of fumes in excess of 5 p.p.m. of nitrous fumes, 50 p.p.m. of carbon monoxide, 10 p.p.m. of hydrogen sulphides and 5,000 p.p.m. of carbon dioxide shall be allowed within a maximum distance of 3 m of the point of discharge of fumes from internal combustion engines provided that no plant operator or other persons stay within this distance.

(d) Concentrations of methane shall not exceed one and one-half percent (1.5%) at the heading and one percent (1%) in the general tunnel atmosphere.

(e) Concentrations of other flammable gases shall not exceed forty percent of the lower explosive limit at the heading, and twenty percent of the lower explosive limit in the general tunnel atmosphere. The lower explosive limit for some gases that might be found in underground works are listed below:

- Benzene 1.3%
- Butane 1.8%
- Carbon Disulfide 1.3%
- Carbon Monoxide 12.0%
- Ethane 3.0%
- Fuel Oil 0.7%
- Gasoline 1.4%
- Kerosine 0.7%
- Methane 5.0%

- Propane 2.1%

(f) Dust hazardous to health in the size range from 5 microns to 0.2 microns in effective diameter shall be kept to a minimum by effective ventilation, wet drilling and abstraction at or adjacent to the source when drilling or by any other means.

2.2.39.5 Internal Combustion Engines

(a) Underground use of internal combustion engines burning gasoline or liquefied petroleum gases, propane, butane propylene and butylenes is forbidden.

(b) The Contractor shall obtain proof from prospective suppliers of diesel-powered equipment for use in underground that the proposed equipment conforms to the requirements of the U.S. Bureau of Mines Circular No. 8183, "Mobile Diesel-powered Equipment for Non-coal Mines Approved by the Bureau of Mines," and supplements thereto.

(c) The Contractor shall maintain all such diesel equipment in safe operating condition, insuring compliance with the requirements of the above circular. In the event the Engineer is of the opinion that these requirements are not being met, the Contractor shall perform at his own costs all required tests as specified in U.S. Bureau of Mines Report of Investigations RL 5616.

2.2.39.6 Minimum Quantity of Air

(a) A minimum amount of 4.25 m3/min of fresh air for each person working underground excavation shall be provided.

(b) In addition to the requirements above for personnel, if diesel-powered equipment is used, then an additional minimum quantity of fresh air of 2.5 m3/min for each kW at work inside the tunnel shall be supplied.

2.2.39.7 Ventilation System

(a) The ventilating system for the underground works shall be of sufficient capacity to maintain an adequate supply of uncontaminated air at all points in the tunnels.

(b) The Contractor shall design a ventilating system that shall, during tunnel driving, allow a continuous flow of air at the face of the heading. The design of the ventilation system shall be calculated according to the size and capacity of all equipment to be used and the number of personnel working in the specific underground work.

(c) The ventilating pipe or fan line shall terminate no more than 30 m away from the face of heading.

(d) For at least the first 20 minutes after each blast, the fan shall be run to exhaust smoke and dust and to remove from the face dynamite fumes and fine silicates to the satisfaction of the Engineer.

(e) When necessary to reduce the amount of dust, all rock surfaces and blasted rock at the working faces shall be kept wet. During mucking, muck piles shall be watered down to prevent dust hazards.

(f) If during the execution of the work the Engineer realizes that the capacity of the ventilation system is inadequate for the good health of the workers and for removing possible noxious gases, the Contractor

shall install additional fans and take all necessary measures to obtain the required safety conditions at no additional cost.

(g) The Contractor shall submit the detailed design, equipment specifications and operation plan of the proposed ventilation system to the Engineer for Approval not later than forty (40) days before beginning installation. The details shall show pipe size, pipe material and type of joints, type and capacity of fans, suspension devices, power supply and distribution system and any other data required by the Engineer.

2.2.39.8 Control of Noxious Gases

3.1.1.2 Testing Instruments and Equipment

(a) The Contractor shall provide and operate proper apparatuses and equipment for detecting possible noxious (toxic and flammable) gases in tunnel. The instruments shall be approved by the Engineer before placing the purchase order or being transported to the Site.

(b) The Contractor shall obtain and maintain a gas detector at the heading for determining the presence of methane and other flammable gases. The Contractor shall also obtain an approved type portable oxygen indicator for measuring concentrations of oxygen within the range of 0 to 25 percent, by volume.

(c) Monitoring concentrations of carbon monoxide, carbon dioxide, nitrogen dioxide, hydrogen sulphide, methane, other noxious or flammable gases, as well as oxygen content of tunnel atmosphere shall be carried out by the Contractor at specific locations at regularly scheduled intervals on each shift, and a record of readings shall be maintained and submitted to the Engineer.

3.1.1.3 Suspension of Construction Activities

(a) Should the concentrations of carbon monoxide, nitrogen dioxide, hydrogen sulphide, methane, or other noxious or flammable gases exceed the permissible limits or should the oxygen content in the tunnel be below the limit, all operations shall be immediately suspended and the personnel shall be moved to a safe area. Any additional cost incurred for the above shall be borne by Contractor.

(b) Further, should concentration of flammable gases exceed the permissible limits, all sources of ignition shall be extinguished or removed and all equipment, with exception of ventilation and exhaust equipment, shall be shut down until the concentration of gas is brought within the permissible limits.

(c) The Contractor shall in no case resume work without having previously taken all necessary safety measures.

(d) Should exploding gases be detected, the Contractor shall provide the construction equipment with explosion-proof electric motors, exhaust pipes of fuel type engines with proper spark absorber and any other accessory and device necessary for assuring the required safety in underground. The provision of such safety measures shall not be construed by the Contractor as a basis for additional compensation over the stipulated unit and lump sum prices.

2.3 MEASUREMENT AND PAYMENT

No separate payment shall be made for Health and safety works unless specifically provided in the BOQ. The cost of all HS staffing, Mitigation, Management and Monitoring activities, Compliance, including preparation of reports shall be deemed included in the Contract /Bid Price.

3 CHAPTER 3: QUALITY MANAGEMENT

3.1 GENERAL

(a) The Contractor shall establish, implement and maintain a Quality Management System which shall, as a minimum, meet the requirements set out in ISO 9001: 2000. The Quality Management Plan shall cover all aspects of the Works to be performed under the Contract and shall be used: 1) as an aid to achieve compliance with the Contract and to document such compliance; and 2) by the Employer/Engineer to monitor the application and compliance with the approved procedures throughout the Contract period. Wherever possible, diagrams, charts and organogram should be used in preference to lengthy descriptions.

(b) The Quality Management System shall provide procedures for the design, construction and handover of the Works and for the testing, review and procurement of Materials to be used in the Works and shall cover all aspects of the Works whether on or off Site.

(c) The Quality Management System shall provide documentary evidence that the tests and inspections specified have been undertaken and that the specified test results have been achieved.

(d) Within Twenty-Eight (28) days of the Commencement Date and in any event prior to any work proceeding, the Contractor shall submit for the Engineer's Review and Approval a Preliminary Quality Plan.

(e) The preliminary Quality Plan shall include, but not be limited to, the following information:

- Identification and scope of certifying authority involvement;
- Summary of the Project requirements including all proposed quality activities;
- Contractor's Organization Chart;
- All quality assurance and quality control procedures proposed by the Contractor for its use in the execution of the Works;
- Responsibilities of quality assurance personnel;
- Description of procedures for quality control of documentation;
- Description of identification, segregation, return or rectification of non-conforming Works and Materials;
- Description of document control procedures;
- Description of procedures for handling site information requests;

- Proposed list of all the codes of practice, standards and specifications that the Contractor is to apply to its work;
- Description of the Contractor's internal and sub-Contractor quality assurance audits;
- A statement detailing the records that the Contractor proposes to keep, the time during which they shall be prepared and the subsequent period and manner in which they shall be stored and submitted to Employer/Engineer, and
- Scope of inspection and test plans for every activity requiring inspection. The scope shall describe the

plans required, level of inspection and who is responsible for releasing an activity from a "hold point".

(f) Within Fourteen (14) days of the Engineer's Approval of the Preliminary Quality Plan, the Contractor shall provide the Employer/Engineer with a detailed Quality Plan for the Engineer's Review and Approval taking into account any directions or requirements from the Employer/Engineer on the Preliminary Quality Plan. The detailed Quality Plan shall include but not be limited to, the following additional information:

- Descriptions of the following interfaces:

  - Between the Contractor and the Employer/Engineer;
  - Within the Contractor's project team including design consultants;
  - Between the Contractor, SubContractors and suppliers;
  - Between the Contractor and local and statutory authorities; and
  - Between the Contractor's internal quality management personnel and project personnel.

- All quality assurance and quality control procedures proposed by the Contractor for its use in the execution of the Works, including but not limited to:

  - Procedures for quality control of documentation;
  - Procedures for identification, segregation, return or rectification of non-conforming Works and Materials;
  - Procedures for document control;
  - Procedures for handling site information requests.

  - Inspection and test plans for every activity requiring inspection. The plans shall describe the level of inspection and who is responsible for releasing an activity for a "hold point"; and
  - Contractor's internal and sub-Contractor quality assurance audits.

- A statement detailing the records that the Contractor proposes to keep, the time during which they shall be prepared and the subsequent period and manner in which they shall be stored and submitted to the Employer/Engineer.

(g) The detailed Quality Plan shall be updated as required, to incorporate all changes to the Contractor's procedures that have been approved by the Engineer.

(h) The Quality Plan shall make reference (where appropriate) to other documents issued by the Contractor to illustrate the main tasks within the Project, their subdivision and the reporting structure to be established for the Project.

(i) The Contractor shall prepare all charts, submission schedules and the proposed content and format of all quality control certification systems to demonstrate that the Contractor will meet its obligations under the Contract, as follows:

- In coordination and by agreement with the Employer/Engineer, inspection and test plans, which shall indicate effective quality control checks and inspections as well as routine and random inspections; and

- By agreement with the Engineer, (i) a schedule for submission of quality control data and (ii) the content and format of all quality control certification systems and submittals.

(j) The Contractor shall submit a detailed organisation chart, in accordance with Contract.

(k) This detailed organisation chart shall identify the responsibilities, authority and interrelation of all personnel who manage, perform and verify work affecting quality. The detailed organisation chart shall be specific only to this Contract. The detailed organisation chart shall identify the quality management representative who shall act as the quality co-ordinator for the Contractor in all dealings with the Employer/Engineer.

(l) The Quality Management Plan shall be reviewed, updated and resubmitted as necessary throughout the period of the Contract, or as instructed by the Engineer.

3.1.1 *INSPECTION AND TEST PLANTS*

(a) The Contractor shall prepare, and submit for approval, the relevant inspection and test plan ("ITP") for all supplies, materials and prefabricated items and for all works on or off Site to the Employer/Engineer prior to commencing work on each activity. The format of the ITPs shall be approved by the Employer and shall indicate, where applicable, the method of testing, the type of test, inspection and hold points for the inspections, testing, audits and approvals to be carried out by the manufacturer, third party inspection body, Contractor's or the Employer. They shall also include details of the testing establishments the Contractor proposes to use.

(b) The plans shall cover manufacture, transportation, acceptance, storage, installation, commissioning and tests, as appropriate. All references in the Contract of the need for the Contractor to obtain the Employer's/Engineer's Approval or Consent shall be deemed a Hold Point unless otherwise agreed by the Employer to designate any as witness points.

(c) The Contractor shall be responsible for testing and inspecting all materials and workmanship. No work shall be covered up without the written approval of the Employer/Engineer. All items of work concealed in the finished work shall be inspected immediately before they are covered up. Inspection and testing shall be recorded according to the procedure specified in the Employer's Requirements.

(d) The records shall identify the inspector, the place, the date and time when the inspection was completed, the section of the Works and the materials tested or inspected, and its state of completion. Reference shall be made to the relevant detailed drawings and the specific aspects or properties which were checked or measured shall be recorded. Six (6) hard copies and Two (2) electronic copies of each record of inspection by the Contractor shall be submitted to the Employer/Engineer.

(e) The records of inspections and tests shall be stored in an orderly fashion on the Site by the Contractor until the issue of the Taking - Over Certificate for the whole of the Works, or such earlier time as the Engineer may instruct, and the Employer/Engineer shall have the right of access to them at all times.

(f) In addition to the Contractor's testing and inspection, the Contractor shall afford and facilitate access at all

times for the Employer/Engineer's inspection and testing of materials and workmanship on Site and, when so ever required by the Employer/Engineer, off-site and at manufacturers' workshops. The Contractor shall provide means of safe access and assistance as may reasonably be required by the Employer/Engineer. For all items of work the Contractor shall give adequate notice in writing to the Employer/Engineer that the item in question is complete and is ready for inspection, and shall not cover it by subsequent work until the Employer/Engineer has confirmed in writing that it has been inspected and is approved. No inspection or approval by the Employer/Engineer shall relieve the Contractor of his duties, obligations and responsibilities under the Contract. The Contractor shall ensure that such access and records are also provided for all off-site fabricated items and proprietary products.

3.1.2 *QUALITY TESTS*

(a) The Contractor shall be responsible for the quality of all products, processes and services supplied under the Contract, and shall provide all test facilities and perform demonstrative conformance of all products, processes and services to the requirements of the Contract.

3.1.3 *EXTERNAL QUALITY AUDITS*

(a) External quality audits shall be carried out in accordance with the Contractor's Quality Plan but shall be conducted no later than Twelve (12) months apart. Upon request, the Employer/Engineer shall be given access in conjunction with or through the Contractor to carry out quality audits, reviews or surveillance or ascertain the effectiveness of the quality system put in place by the Contractor.

(b) The Employer/Engineer shall be entitled to carry out audits of the Contractor's quality system by:

- Review of the Contractor's conformance with the Quality Plan; and
- Review and verification of the Contractor's quality procedures and work instructions and documentary evidence of compliance with the technical requirements of the Contract.

(c) The Employer/Engineer may require compliance audits of the Contractor's quality system. Not less than three (3) weeks' notice will be given by the Employer/Engineer. During audit by the Employer/Engineer, the Contractor shall provide staff trained and registered as ISO auditors to accompany the Employer/Engineer. The Contractor shall make available on request any document which relates to internal audits.

(d) Internal and external audits shall be carried out at Six (6) monthly and yearly intervals respectively. A copy of all quality audit results, reports and corrective actions shall be submitted to the Employer/Engineer.

3.1.4 *TRACEABILITY*

(a) The Contractor shall maintain records clearly identifying the source and condition of all Plant, Materials and equipment used for construction of the Works, along with any relevant test results, design drawings, and the place and time of delivery to store or to Site. The Contractor shall be able to demonstrate ease of traceability of non-conforming items for rectification.

3.1.5 *QUALITY RECORDS AND REPORTS*

(a) Quality records shall be stored and maintained such that they are readily accessible in facilities that provide a suitable environment to minimize deterioration or damage, and to prevent loss.

(b) Quality records shall be available for the evaluation of the Employer/Engineer during the term of the Contract and shall include all pertinent SubContractor or secondary consultant records.

(c) The Contractor shall maintain quality records for a period of Five (5) years from the Completion Date.

(d) The Contractor shall maintain records in Two (2) categories:

- Test records - which shall comprise all working sheets including manufacturers' certificates (i.e. mill certificates), associated with testing in accordance with the inspection and test plans.
- Project quality records - which shall include, but not be limited to, site meeting minutes, technical reviews, minutes of meetings with the Employer/Engineer, SubContractors and consultants, non-compliance reports, corrective action reports, registrations, all calculations, as-built drawings and other relevant documentation.

(e) The Contractor shall submit for the Employer/Engineer's Review and Approval, quality reports as evidence that the work has complied with the specified quality requirements. These reports shall include summaries of inspection and test results. The reports shall be submitted to the Employer/Engineer within seventy-two (72) hours of the relevant inspection or testing, or, if that falls on a non-working day, on the start of business of the next working day.

(f) The Contractor shall supply together with each monthly progress report, an updated register of all the quality records held and a list of non-compliances. The Contractor shall also supply a list of all items of non-compliance, which have been rectified since the previous monthly progress report. The Contractor shall supply a copy of all quality records requested by the Employer/Engineer.

3.1.6 *INSPECTIONS*

(a) The Employer/Engineer shall be given access in conjunction with or through the Contractor to all laboratories and other facilities used for quality control tests to verify that the specified requirements are being met.

3.1.7 *COMPLIANCE*

(a) To ensure the Contractor, the Contractor's personnel, the Contractor's Sub-Contractors and Suppliers will comply with the Contractor's quality assurance obligations under the Contract. The Contractor shall translate into Nepalese and national language of the Contractor, all documents to ensure the Contractor, the Contractor's personnel, the Contractor's Sub-Contractors and Suppliers understand the requirements for executing the Works in accordance with the Contract. The Contractor shall also submit copies of the translated documents to the Employer/Engineer.

3.1.8 *PROJECT PROCEDURES*

(a) Consistent with the approved Quality Management Plan, the Contractor shall prepare a Project Procedures Manual, for review and approval of the Employer/Engineer, and implement the approved procedures together with suitable communication systems for the efficient management of the Contract covering responsibilities, communications, document control, meetings, reporting and administration. The Contractor shall provide to the Employer/Engineer, for the duration of the Contract all software (if any) needed to implement these systems free of charge or liability.

(b) The Project Procedures Manual shall be reviewed, updated and resubmitted as necessary throughout the period of the Contract, or as instructed by the Employer/Engineer.

3.1.9 *QUALITY CONTROL MANAGER*

The Contractor shall appoint a Quality Control Manager with authority to develop and enforce the Contractor Quality Assurance Plan and Quality Control activities, as well as coordination with the Employer/Engineer.

4 CHAPTER 4: ENVIRONMENT

4.1 GENERAL REQUIREMENTS

(a) This section comprises the Employer's minimum general environmental requirements that shall be observed by the Contractor at all times.

(b) In accordance with the Conditions of Contract, the Contractor shall comply with all the environmental regulations that apply to the Project and all other Laws, including legal requirements issued by related authorities.

(c) Applicable laws, regulations, codes and rules include, but not limited to:

- The Constitution of Nepal, 2072 (2015)
- Environment Protection Act, 2053 (1997)
- Environmental Protection Rules, 2054 (1997)
- National Environmental Impact Assessment Guidelines, 2050 (1993)
- EIA Guidelines for Forestry Sector, 2052 (1995)
- Draft EIA Guidelines for Water Resources Sector, 2052 (1995)
- Forest Act, 2049 (1993) and Forest Regulations, 2052 (1995)
- Forest Rules, 2051 (1995)
- Forestry Sector Policy, 2054 (1997)
- Soil & Watershed Conservation Act, 2039 (1982)
- Aquatic Animals Protection Act, 2017 (1960) & Amendment, 2055(1997)
- Electricity Act, 2049 (1992)
- Electricity Rules & Regulations, 2050 (1993)
- Land Acquisition Act, 2034 (1977)
- Water Resources Act, 2049 (1992)
- Water Resources Rules, 2050 (1993)
- Local Self Governance Act, 2055 (1999) & Regulations, 2056 (1999)
- Explosives Act, 2018 (1961)
- Motor Vehicles and Transportation Management Act, 2049(1992)
- Labour Act, 2048(1992)
- Hydropower Development Policy, 2058(2001)
- Electricity Development and Management Act, 2062 (2005)
- National Parks and Wildlife Conservation Act, 2029(1973) and Wildlife Reserve Rules, 2034(1977)
- Guideline for the Physical Infrastructure Development and Operation in the Protected Areas 2065 (2008)
- Guidelines to permit forest land for other purpose, 2006 (Forest Guideline 2006)
- The Environmental, Health and Safety Guidelines (Waste Management), the Environmental, Health and Safety Guidelines (Water and Sanitation), the Environmental, Health and Safety Guidelines for Construction Materials Extraction; and, the Performance Standards and Environmental Sustainability (2006) published by the International Finance Corporation and

- ISO 14001 Environmental Management Systems Standard (2004)

(d) The Contractor shall be responsible for complying with the Environmental Impact Assessment (EIA)/Initial Environment Examination (IEE) or any other requirements due to changes in the Project design in addition to the Employer's Environmental Management Plan (EMP). In order to demonstrate the compliance the Contractor shall be responsible for the preparation and implementation of an Environmental Management Plan during all the construction phases.

(e) The Contractor shall manage the Environmental Management Plan and shall review it on a regular basis and shall update or revise the Environmental Management Plan as necessary, with the Engineer's acceptance. This process is in order to ensure that the Environmental Management Plan continues to give guidance during the life of the Contract and incorporate new elements to address subjects in greater depth where new environmental issues have been identified during construction.

(f) The Employer will monitor and review the Contractor's environmental performance and will undertake formal environmental audits of the Contractor's performance.

4.2 ENVIRONMENTAL MITIGATION

(a) An Environmental and Social Unit shall be established under the Employer to monitor the Contractor's environmental performance. In accordance with the Condition of Contract, the Contractor is required to develop an Environmental Management and Monitoring Plan which shall detail the work program/s, schedule of program/s, the responsibilities for implementing the mitigation measures and monitoring programs.

(b) Land acquisition and compensation for Permanent works area will be carried by the Employer. The Contractor shall carry out the environmental impact mitigation works as mentioned in this section as per the findings of the EIA/IEE report and the Employer's Environmental Management Plan.

(c) The Contractor shall follow good management and environmental practices during the construction activities, which include, but is not limited to, the following:

4.2.1 *Physical Environment*

(a) The Contractor shall take all necessary care and appropriate action to conserve and protect the environment at the construction sites and in the immediate vicinity of the construction sites.

(b) The Contractor shall take due care to minimize land requirements for temporary structures and facilities.

(c) Only quarries and borrow sites approved by the Employer shall be exploited.

(d) The Contractor shall implement an integrated Health and Safety and Environmental Management System.

(e) The Contractor shall dispose the muck in the areas as specified in areas as directed by Employer;

(f) The Contractor shall spray water along the road and in and around the construction areas at least three times a day depending upon the construction schedule, season and intensity of the dust pollution or directed by the Engineer.

(g) The Contractor shall prepare a Waste Management Plan which details the controlled usage of treatment of all toxic materials and wastes, sanitary wastes and solid waste used or produced on-site and in relation to

the works;

(h) The Contractor shall meet all existing environmental standards and those environmental standards which come into effect during the construction period;

(i) The Contractor shall restore the temporary areas like construction camps, garage and construction yards once it is not required, to its original state; and

(j) The Contractor shall rehabilitate Borrow areas and quarry sites.

4.2.2 *Biological Environment*

(a) The Contractor shall see that the clearance of vegetation will be restricted only in the required area;

(b) The Contractor shall prepare re-vegetation plan in consistent with mitigation measures proposed in EIA/IEE report;

(c) The Contractor shall inform the officer of the forest department before proceeding with any activities like vegetation clearance and any type of construction work inside the government area;

(d) The cleared area for construction shall be replanted as per the relevant agencies rules and regulations;

(e) The Contractor shall handover all the felled timber and timber products from the construction area over to landowners/Forest User's Group/District Forest Office depending from where the timber is felled;

(f) The Contractor shall take all reasonable steps to ensure that the staff and labour force does not engage in hunting or trapping of wildlife;

(g) The Contractor shall be liable for any illegal use of explosives for the purpose of fishing; and

(h) The Contractor shall not release toxic materials, or other pollutants that would damage aquatic life in any of the water bodies.

4.2.3 *Socio-economic and Cultural Environment*

(a) The Contractor shall minimize disturbance to religious sites, archaeological sites, public infrastructure and cremation areas through careful siting and scheduling;

(b) Any conflicts and problems arising during construction which cannot be resolved by the Contractor shall be referred to the Employer;

(c) The Contractor shall be responsible for any compensation due or reinstatement in respect of any damage caused by the construction activities to areas outside the site and no separate payment will be made in this regard;

(d) The Contractor shall erect necessary warning signs and barriers at construction areas and road bends for safety and to prevent accidents; and

(e) In events like blasting, the Contractor shall give notice to the public through various media prior to undertaking the blasting operations to prevent accidents.

4.3 CONTRACTOR ENVIRONMENT POLICY

(a) The Contractor shall, in the form of an Environmental Policy Statement, state his target, management

commitment, and strategy with regard to environmental issues of the Project. The Environmental Policy Statement shall be fully supported by senior management and is expected to be signed by the chairman or board of directors, or all chairmen or board of directors in the case of a joint venture.

(b) The Environmental Policy Statement shall be displayed in a prominent position within the Contractor's offices on each worksite and communicated to all employees.

(c) The Environmental Policy Statement shall include all those requirements set on the ISO 14001 Standard, this means that the Contractor's management shall define the environmental policy and ensure that it complies with the following:

- is appropriate to the nature, scale and environmental impacts of its activities, products or services;
- includes a commitment to continual improvement and prevention of pollution;
- includes a commitment to comply with relevant environmental legislation and regulations, and with other requirements to which the organization subscribes;
- provides the framework for setting and reviewing environmental objectives and targets;
- is documented, implemented and maintained and communicated to all employees; and
- is available to the public.

4.4 ENVIRONMENTAL PROCEDURES MANUAL

(a) The Contractor shall produce an Environmental Procedures Manual for the Employer's/Engineer's Review and Approval that shall include all the necessary environmental procedures to ensure compliance with all environmental legal requirements, the Employer's Environmental Management Plan and other needs as required by the Employer or legislation during the contract period. The Contractor shall prepare at a minimum the following procedures:

- Environmental communication and reporting
- Environmental training
- Work instructions
- Documents and records control
- Legal and Permits compliance
- Environmental internal audits and inspections
- Environmental work areas clearance
- Non-conformance and incident reporting
- Emergency preparedness and response
- Spill prevention and control
- Handling of domestic, industrial and hazardous wastes
- Air pollution control
- Fire prevention and control

(b) Each procedure shall be prepared in a format acceptable to the Employer/Engineer that shall include the

following aspects: (i) purpose and scope; (ii) timing; (iii) responsibilities; (iv) procedure; (v) register of environmental aspects. The format shall detail the necessary information to keep control of it, dates, approvals and reviews and descriptions of the revisions made.

(c) The Contractor shall identify environmental issues by area or subject and identify the responsible persons who shall supervise the implementation of the procedures and communicate the needs of new procedures or modifications to those in use.

4.5 ENVIRONMENTAL RECORDS

(a)The Contractor shall produce and maintain formal records of environmental matter that shall include all the necessary environmental records that demonstrate compliance with legal requirements, implementation of the Environmental Management Plan, and other environmental aspects. Each record shall be in a format according to the information being kept. Records shall include, but not limited to the following:

- Monitoring results
- Non-conformance and incidents reports
- Training performed
- Corrective actions
- Permits
- Internal audits performed

(b) The Contractor shall develop and incorporate any new records as required by the Environmental Management Plan or the Employer/Engineer during the course of the Works.

4.6 ENVIRONMENTAL DOCUMENTATION

(a) The Contractor shall keep and maintain a copy of the following documentation on Site for reference by the Employer/ Engineer.

- Social and Environmental Impact Assessment;
- Independent audits report;
- Environmental resolutions;
- Applicable environmental legislation;
- Agencies inspection acts; and
- Internal environmental reports.

(b) The Contractor shall incorporate any new documentation required by the Employer/ Engineer in order to address all environmental issues that have been identified during construction.

4.7 ENVIRONMENTAL SCHEDULE

(a) The Contractor shall produce a schedule of environmental activities, as part of the implementation of the Environmental Management and Monitoring Plan. The schedule shall address all environmental related

activities that will be required for the works and shall include but not be limited to:

- Internal audit,
- Regular inspections,
- Monitoring,
- Reporting.

(b) The schedule shall include activities, dates, personnel involved and manager responsible together with a narrative describing the activities.

(c) The schedule shall be adjusted as required to suit the findings of audits, inspections, etc, to ensure environmental regulatory compliance and good environmental practices.

4.8 CONTRACTOR'S ENVIRONMENTAL OFFICER

(a) The Contractor shall designate qualified environmental personnel, with appropriate certification from the relevant authorities, to act as Environmental Officer, who shall have the authority to administer and be responsible for the implementation of and ensure compliance with the Contractor's Environmental Plans and Manuals. In conjunction with the safety officer, he/she shall carry out frequent inspections at random intervals and monitor activities at the working areas of personnel, materials, and equipment, and shall submit records to the Employer/Engineer.

4.9 ESHS REPORTING

a. The Contractor shall prepare monthly reports for UAHEL on the status of mitigation measure implementation, any ESHS-related incidents (e.g., spills, grievances, injuries), and the Project's overall ESHS performance.

b. In the event of any project-related incidents resulting in an injury to the public or a worker hospitalization or fatality, the Construction Contractor and Facility Operator shall notify UAHEL and the Project Engineer immediately (within 24 hours),

4.10 PRESERVATION OF FLORA AND FAUNA

(a) The Contractor shall not be permitted to destroy, remove or clear trees, timber, scrub and other flora to an extent greater than that approved by the Employer, as being necessary for the execution of the Contract, nor use such material in the construction works.

(b) The Contractor shall ensure that all works are undertaken in a manner that minimises the impact on the local flora and fauna and shall take such measures as may be necessary to prevent his employees and those of his Sub - Contractors from hunting and fishing, disturbing, capturing or destroying, and trading in wildlife or parts of these and any such flora and fauna as may be protected by relevant statutes.

(c) The Contractor shall ensure that the work site is kept clean and tidy and free from rubbish which would attract animal pest species.

(d) There shall be no feeding of native animals.

(e) If, in the opinion of the Contractor, a particular animal species becomes a pest by virtue of its nature, population numbers or other factors, the Contractor may apply to the Employer for a control programme to

be initiated. Such application shall be in writing and shall contain justifications as to why a control programme is needed. The Contractor shall be responsible for obtaining necessary approvals from the relevant government or local authorities and for undertaking the control programme.

(f) The Contractor will be held liable, and shall indemnify the Employer against any consequences for any act or omission which causes or allows to be caused a breach of this sub - clause by its personnel or those of its Sub - Contractors.

4.11 SOIL EROSION AND SEDIMENT CONTROL

4.11.1 *General*

(a) The Contractor shall take all necessary measures to minimise the increase of the soil erosion induced by his activities and the subsequent increased siltation and sediments load on Arun River and other streams of the area.

(b) To this end, the Contractor shall take any or all of the following measures:

- Control the surface run-off by:

- Construction of stabilised diversion or perimeter cut-off drains to intercept run-off from undisturbed areas and to divert run-off around the work areas.
- Installation of stabilised interceptor and collector drains.
- Construction of sedimentation retention ponds.
- Construction of gabion weir structures.

- Limit movement of vehicles and Contractor's equipment.
- Minimise the disturbed area exposed by:

- Staging operations.
- Progressive stabilisation of works as soon as they have been completed.
- Provision of top soils, re-vegetation, sodding, grassing or other treatments to disturbed areas.

(c) All diverted and pumped water shall be discharged at locations from which it cannot re - enter the Works and in a manner which does not cause erosion, pollution or nuisance to landholders, Other Contractors employed by the Employer or other persons within or adjacent to the Site.

4.11.2 *Sedimentation Ponds*

(a) The Contractor shall design and construct sedimentation ponds for the treatment of construction waste water, particularly possible turbid water from quarries, dump sites, batching and aggregate crushing and screening plants. Turbid water from dumpsites may also be avoided by appropriate compaction, and subsequent re-vegetation using topsoil.

(b) If embankments are built to create sedimentation ponds, they shall be constructed on a foundation cleared of topsoil and other unsuitable material. Suitable material from required excavation or borrow areas shall

be used to form the embankments. All excavated surplus or unsuitable material shall be disposed off in approved disposal areas.

(c) The sedimentation ponds shall be emptied only by discharge from outlet pipes following treatment of the stored water. Before discharge, the stored water in the sedimentation ponds shall be dosed with an approved flocculation agent, and/or a sufficient retention time for sedimentation should be allowed. Such water shall not be discharged if the non-filterable residue (suspended solids) in the discharge exceeds 50 mg/litre and total filterable residue in the discharge exceeds 600 mg/litre. The Contractor may be required to monitor turbidity, concentration of suspended solids, and/or TDS before the water will be discharged from the sedimentation ponds.

(d) An approved oil skimming device shall be provided for the removal of oil from the surfaces of the ponds.

(e) The sedimentation ponds shall be kept empty for the longest practicable periods. In coming drainage during wet weather shall be promptly corrected. Water in the ponds shall be treated within 24 hours before water level of the sedimentation ponds reach discharge levels.

4.11.3 *Water Quality Standards*

(a) The Contractor shall implement Water Quality Monitoring Plan, in site which shall fulfil following requirement.

(b) The Contractor shall monitor and meet the water quality standards, in accordance with the Nepali National Standards together with measures which are necessary or appropriate to prevent or mitigate potential or actual impact on the quality of water, which are not foreseen or which are greater than those anticipated, and which can be attributed to activities of the Contractor, in order to minimise the impact of the project construction on the local environment and water supply.

(c) The Water Quality Monitoring shall include at least the following minimum requirements.

Domestic Wastewater

- Prohibit any open defecation and any washing, bathing, or urinating in any water courses or springs.
- Provide a sufficient number of toilets facilities (separate toilets for men and women, typical standard is 1 toilet per 15 workers) at each work site. Regularly clean out these toilets and dispose of waste at the wastewater treatment facility described below.
- Prohibit the discharge of any untreated wastewater to any receiving waterbody.
- Provide a wastewater treatment facility (e.g., a package wastewater treatment plant) at each workers' camps to treat domestic wastewater prior to discharge to a receiving water. The wastewater treatment facility will provide secondary treatment and ensure, through regular/frequent monitoring that the effluent meets Nepal's water quality standards.

Industrial Stormwater Runoff

- Batch plants

- Concrete mixing shall take place on impermeable surfaces or compacted soil.

- In case of spillage of the concrete mix, the area shall be cleaned immediately. The waste shall be collected and deposited in approved sites. Placing these mixtures in water courses is prohibited.
- All stormwater runoff from the batching plant shall be directed to a stormwater pond to allow the settling of any suspended material and the pH tested to ensure it is between 6.5–8.5 pH units before discharge to a watercourse.
- Unused cement bags shall be stored in a weather-proof area where they will not be impacted by rain. Used (empty) cement bags shall be collected and stored in weatherproof containers to prevent windblown cement dust and water contamination. The bags shall not be used for any other pur
- pose and shall be disposed of on a regular basis in accordance with the Waste Management Plan.
- All excess concrete shall be removed from site on completion of concrete works and disposed of in accordance with the Waste Management Plan. Washing of the excess concrete onto the ground or into water courses is prohibited.

Other industrial stormwater runoff

- All stormwater from the quarry, crusher site, spoil disposal areas, and workers' camps shall be directed to a stormwater pond to allow for the settling of any suspended material before discharge to a watercourse.
- All stormwater runoff from fabrication shops, maintenance yards, parking areas, and the fuel depot shall pass through an oil-water separator before discharge into a watercourse.

Groundwater Seepage from Tunnels and Spoil Disposal Areas

- All groundwater seepage from the tunnel portals and from spoil disposal areas shall be directed to a stormwater pond to allow the settling of any suspended material before discharge to a watercourse.

Stormwater Pond Maintenance

- All stormwater ponds shall be routinely maintained and cleaned out, with any deposited sediments disposed of in an approved upland location.

4.12 SPOIL AREAS

(a) The Contractor shall develop the management of all spoil areas taking into account the following requirements:

- Incorporation of the most appropriate stabilisation techniques at the sites.
- Where specifically approved by the Engineer, before using the area, topsoil shall be stripped and stockpiled for future landscaping use after closure of the site.
- Where specifically approved by the Engineer when a spoil disposal area is closed, the Contractor shall stabilise the spoil disposal area with grass, vegetation and permanent drainage.
- Balance earthwork to the extent possible to minimize spoil disposal requirements.
- Spoil shall be used, rather than treated as a waste, to the extent possible (e.g., use as aggregate for concrete, as base material for road construction, and backfilling of quarries and borrow pits).
- Test the pH of the water in the settling basins and add neutralizing material (e.g., lime) if there is any

evidence of acidic conditions, which can promote the mobilization of metals.

- Spoil and muck shall be placed only in designated and approved spoil disposal areas.
- Ensure Spoil Disposal Areas #3 and #4 are designed with measures to protect the integrity of the facilities from Arun River monsoon flows.
- Properly manage uphill drainage in the design of the spoil disposal facilities.
- Provide properly designed gabions/retaining walls for all spoil disposal sites.
- Provide stormwater ponds/settling ponds below all spoil disposal areas to allow for the settling of sediments before discharge to a waterbody.
- Provide immediate maintenance and corrective action as needed.
- The disposal sites shall be fully rehabilitated as soon as the disposal operation is completed. The rehabilitation shall include a complete cover of the site with native soil and fully landscaped/vegetated. The stability of the disposal areas shall be inspected on a regular basis.
- Provide enhanced vegetative cover over Spoil Disposal Areas #3 and #4 to reduce their visual impact on Barun Bazar/Mela site.

(b) A report on environmental management and monitoring shall be prepared for each spoil disposal site.

4.13 QUALITY MANAGEMENT

(a) The Environmental Management Plans for quarry and borrow areas shall include:

- Description of the measures taken to minimise the quarry and borrow areas and the efforts planned to reduce the visual impacts.
- Measures to be taken at the closure of the quarries to re-establish vegetation, natural water courses and drainage pattern.

4.14 CONTROL OF SOIL, WATER AND AIR POLLUTION

4.14.1 *General*

(a) The Contractor shall design, construct, maintain and operate suitable pollution control facilities to prevent air pollution, dust, and discharge of water containing polluting matters or visible suspended materials into rivers, streams or existing drainage systems. Such polluting matters includes but are not restricted to dust, refuse, garbage, cement, concrete, sewage effluent, industrial waste, oil and other petroleum products.

4.15 HAZARDOUS MATERIAL AND CHEMICAL STORE, HANDLING WASTE AND SPILLAGE MANAGEMENT

(a) Hazardous materials and chemicals that will be used during the construction include explosives, fuel and oils, paints, solvents, acids, concrete additives and other materials. The Contractor shall develop and submit to the Engineer for approval, detailed plans for transport and handling/storage of all such materials

and for the collection and handling of the corresponding wastes. The plan shall foresee:

- Conditions for handling and storage of fuel, explosives and other chemicals to prevent accidental pollution and injury.
- Facilities for collection of waste oil products. The locations for machinery and vehicle repair, maintenance and washing should be equipped with concrete floors and provided with oil skimmers / separators and collection facilities. Drainage from fuel storage and machinery maintenance areas shall be treated to remove oil and/or fuel. The oil collected in this manner should be disposed off or reused safely.
- Diesel fuel shall be stored in standard skid tanks with concrete bunker / building, which can provide 110% volume of the total capacity of the skid. The skid tank shall be located at least 100 metres away from any watercourse.
- The Contractor shall establish a standard procedure for loading the diesel into the skid tank to prevent any oil spillage and soil contamination from occurring.
- Spent oil or used oil generated from the workshop maintenance yard is categorised as a scheduled waste. This scheduled waste is to be stored in containers, with proper bunds, which are able to prevent spillage or leakage of the scheduled wastes into the environment. The containers of the scheduled wastes shall be clearly labelled for identification and warning purposes.
- The Contractor shall engage a licensed SubContractor to collect, transport and dispose all the scheduled waste (spent oil) generated at the project site.
- The oil waste should not be allowed to be used for uncontrolled burning or heating in the villages or the labour camps. Oil should not be allowed to be spread on roads or dumpsites as a mean of dust control.
- Soil contaminated by fuel or oil leakage shall be removed and placed in approved disposal areas.

4.16 WASTE MANAGEMENT

(a) The Contractor shall be responsible for collecting and disposal of garbage, rubbish and waste from its construction activities, housing, camp accommodations, camp amenities, workshops, stores, offices, public areas, etc.

(b) The Contractor shall develop a detailed Waste Management Plan and submit to the Engineer for approval within Twenty Eight (28) days of the Commencement Date, for collection, transport and handling/storage of waste. Particular care has to be taken to avoid spreading of waste, plastic etc. in the project site or labour camp surroundings. The waste handling shall be designed with an ecological, aesthetic and a hygienic perspective. The plan shall include the following requirements:

- Waste from construction activities shall be cleared/ collected, at a minimum, daily and shall be disposed off at designated waste sites.
- Waste collection containers shall be placed at regular intervals at the project site and in labour camps. These containers should be marked with clear labels for ‘organic’, ‘paper’ and ‘other waste’ for sorting waste collection.
- Garbage shall regularly be collected and disposed at designated sites, located above the 20 year flood

levels of adjacent water courses and at least 2 km from the nearest village.

- The disposal sites shall be protected from contaminating groundwater by an impermeable membrane or clay. Leachate shall be collected and properly treated before released into water courses.
- Garbage collections shall be made on a daily basis and the services shall be continued until completion of the construction work.
- Once a week the disposal sites shall be compacted and covered with soil. At closure the site shall be covered with at least 1.5 m of topsoil.

4.17 WASTEWATER MANAGEMENT

(a)The Contractor shall supply and install wastewater treatment facilities for processing and disposal of sewage from the Contractor's housing, camp accommodation, camp amenities, workshops, stores, offices and other buildings and facilities. The Contractor shall also install, operate and maintain temporary toilet facilities at all work sites. The facilities shall be complete with adequate closets, urinals and hand basins, septic tanks, absorption trenches or other sewerage disposal installations. The facilities shall be for use of its own personnel, SubContractors' personnel and those of the Employer and the Engineer.

(b) Wastewater from the camps and offices shall be collected and properly disposed off. The sanitary water and the grey water (used household water) should be kept separate. The grey water should be infiltrated in the ground at sites with soils of suitable filtering capacity and minimum 500 m away from watercourses and water supply springs in the area.

(c) The sanitary water should be treated by compact treatment units or by septic tanks before infiltration in the ground. At least one chemical portable toilet shall be installed for each 20 workers.

4.18 EMISSION, DUST AND NOISE CONTROL

4.18.1 *Emission, Dust and Noise Control*

(a) The emission and dust control shall be based on Nepali or international standards (which ever is the higher) for ambient concentrations of particulate matter. The emission and dust control plan shall identify all relevant places for emissions and dust control and monitoring. This includes roads, quarry sites, crushing and concrete batching sites, earthworks, waste burning sites, etc.

(b) Ambient air quality measurements shall be carried by monitoring the particulate matter (PM10) level at sites where construction related transport on dirt roads passes populated areas and if stone crushing takes place close to populated areas.

(c) The Contractor shall have available at site an approved particulate matter measuring equipment and shall take regular measurements as directed by the Engineer. In case of contradiction in values mentioned in this section: Environment and in EMP (attachment1) the stricter of the two will be followed.

(d) The guidelines for particulate matter are as follows:

	Averaging Period	Guideline value (µg/m3)
Particulate Matter (PM10)	24 hours	120
Particulate Matter (PM2.5)	24 hours	60

(e) Water spraying on all roads used by the Contractor and at construction sites using mobile water tankers shall be implemented to control dust pollution. The frequency of water spraying shall be 2 to 3 times per day for normal weather conditions. The water spraying frequency shall be increased to 4 to 6 times a day during dry and windy seasons.

4.19 NOISE CONTROL

(a) The Contractor shall implement a noise emission and control plan.

(b) In addition to complying with the requirements, the Contractor shall comply with the requirements of Nepali National Environmental Standards and/or ISO 1996 - 1:2003 Acoustics part 1, ISO 1996 - 2:2007 Acoustics part 2, IEC 61672 part 1 & 2 Electro acoustics,IEC 60942 Electroacoustics (whichever is the stricter).

(c) The Contractor shall have available at site an approved sound level meter and shall take regular measurements of noise levels at critical spots, as directed by the Engineer , including the rock quarrying site, other areas of outdoor rock drilling operation, and at villages with heavy construction traffic.

(d) The Contractor shall take the provisions required to assure that noise from his construction activities and from the operations of his industrial plants are within the World Bank Environmental, Health, and Safety Guidelines (IFC, 2007) as shown in the table herein below.

Receptor	One Hour Leq (dBA)	
	Day time (07:00 – 22:00)	Night time (22:00 - 07:00)
Residential; institutional; educational	55	45
Industrial; commercial	70	70

(e)The Contractor shall provide ear protectors to all personnel subject to noise levels above 85 dB on a continuous basis during work shifts.

4.20 OFF - SITE WASTE

(a) The Contractor shall prepare a Plan dealing with off - site waste caused by the Contractor's activities, for the approval of the Engineer, within Twenty Eight (28) days of the Commencement Date and which shall cover all aspects of the Contractor's operations and shall include at least the following minimum requirements:

- Establish a management system to ensure proper collection, segregation, and disposal of solid, construction, medical, and hazardous wastes so that there is no contaminated surface runoff or public health issues associated with the waste and the waste is appropriately disposed of.
- Develop and implement a worker and community awareness training program to ensure that these groups are aware of potential risks associated with different types of waste materials, safety precautions that should be applied, and notification procedures in the case of any leaks, spillage, or other emergencies.

Solid Waste Management

- The Contractor shall ensure that all facilities are maintained in a neat and tidy condition and no litter or dumping shall be allowed within the project area or by project employees.
- Measures shall be taken to reduce the potential for litter and negligent behavior with regard to the disposal of all refuse. At all places of work, the Contractor shall provide litter bins, containers, and refuse collection facilities for later disposal.
- The Contractor shall separate construction waste from domestic waste.
- Solid waste may be temporarily stored on site in a designated area. The storage area shall have a cover to avoid direct contact with precipitation, a berm to avoid direct contact with surface runoff, and a fence to prevent wind-blown litter. Waste storage containers shall be covered, tip-proof, weatherproof, and scavenger proof, and shall not attract wildlife.
- The Contractor shall identify and demarcate disposal areas clearly indicating the specific materials that can be deposited in each waste container. W
- aste containers shall be strategically placed in visible locations easily identified and marked. For example, recycle, organic waste, unusable waste, hazardous waste, paper, glass, etc.
- Recyclable materials (e.g., wooden plates for trench works, steel, scaffolding material, site holding, packaging material, paper, empty cement bags and containers, glass, wood, junk), shall be collected and separated on-site from other waste. Collected recyclable material shall be re-used or sold to a waste collector for recycling.
- Employees shall be educated on the segregation of waste with bins demarcated for recyclables and perishables placed in common and work areas.
- Burning solid waste in open air conditions shall be strictly prohibited.
- Solid waste shall not be buried within fill or backfill areas.

Disposal of Construction Waste

The Contractor shall carry out the following activities:

- The disposal of construction debris shall be carried out only at sites previously identified and approved by UAHEL.
- Debris generated due to the dismantling of existing structures shall be suitably reused by the Project or provided for reuse to local residents.

- The Contractor is responsible for arranging transportation and disposal of all construction waste, including dismantling and clearing debris.
- Once the work is completed, all construction-generated debris shall be removed from the site.

Management and Disposal of Hazardous/Medical Waste

The Contractor shall carry out the following activities:

- All hazardous/medical waste (e.g., bitumen, and waste oils, grease, solvents, acids and alkalis, paint, used needles, blood stained materials) shall be properly stored, handled, and disposed of or recycled in accordance with the environmental standards, regulations and management policies of Nepal and the producers of the material. Spent lead acid batteries shall be stored as hazardous waste until they can be shipped to a battery recycling facility.
- Only appropriately trained and authorized personnel shall
- handle hazardous/medical waste.
- Hazardous/medical waste shall be stored separately from other waste in a secure facility removed from active work areas with posted warning signs. Storage facilities shall meet the same siting and design requirements for hazardous materials, as described in Section 2.5.3, including a cover facility, impervious floor, secondary containment, and a berm to prevent contact with surface runoff, and appropriate placards.
- Under no circumstances shall the spoiling of tar, bituminous products, or any other hazardous
- waste be allowed on the site, over embankments, in borrow pits or any burying, in water bodies, on agricultural land, or in sensitive areas.
- Unused or rejected tar or bituminous products shall be returned to the supplier's production plant.
- Used oil, lubricants, cleaning materials, and other similar wastes from the maintenance of vehicles and machinery shall be collected in holding tanks and sent back to the supplier or removed from site by a specialist oil recycling company for disposal at an approved hazardous waste site.
- The transportation of hazardous/medical waste off the site shall be done in cooperation with an approved and authorized waste transport company.

4.21 LANDSCAPING AND RE - VEGETATION

(a) A joint survey of all the areas identified for the temporary use for construction purposes, and assets present on those areas, shall be undertaken by the Employer and the Contractor prior to hand-over of the areas.

(b) The Contractor shall prepare and submit to the Engineer for approval a Landscaping, Re-vegetation and Replacement of Assets Plan encompassing all areas temporarily used for construction purposes, such as camps, areas for industrial plants, spoil areas, quarry, construction roads, etc., within fifty-six (56) days before implementation.

(c) Requirements to be met by the Contractor are the following:

- All land where the natural vegetation has been destroyed or damaged shall be restored as far as possible to its initial status. Original drainage patterns shall be restored;

- Spoil heaps shall be profiled to allow for future use and erosion protection;
- Excavated topsoil shall be used for landscaping and if possible for agriculture;
- All damaged assets (structures, fencing, etc.) shall be restored to their former condition;
- Land shall be cleared of any waste or contamination;
- Any modifications to drainage channels, irrigation channels, water retaining walls or bunds, shall be reversed;
- Drainage shall be restored should it have been impacted by construction activities;
- Only indigenous and preferably local plant species shall be used for replanting and erosion control. The most relevant methods for creating a vegetation cover would be; close turfing, spot turfing, hydroseeding or vetiver. Which method to be used will depend on the soil conditions and slope; and
- The Contractor shall be held liable, and shall indemnify the Employer, for any costs caused by the Contractor, its personnel or its Sub-Contractor's actions during the construction of the Works.

(d) Landscaping and re-vegetation shall be implemented as soon as possible after the different construction activities have ended so to minimise the periods when bare soil will remain exposed.

4.22 MEASUREMENT AND PAYMENT:

No separate payment shall be made for ES works unless specifically provided in the BOQ. The cost of all Mitigation, Management and Monitoring activities, ES Staffing including preparation of reports shall be deemed included in the Contract /Bid Price.

SECTION 2
TECHNICAL REQUIREMENT
5 CHAPTER 5: SURVEYING WORK

5.1 SCOPE

This chapter specifies requirements for all surveying works, above ground and underground. General surveys will not be paid separately. Costs for all the survey works shall be included in the unit rates of the Priced Bill of Quantities.

5.2 SURVEY BY THE EMPLOYER

The Contractor shall identify and check the control points at the start of the Works based on benchmark provided in table 2-2.

The maps that have been produced during previous studies will be made available to the Contractor upon request. The use of these maps does not relieve the Contractor of his sole and exclusive responsibility for the accuracy of the survey and measurements of the Works.

The Contractor shall, at his own cost and under his own responsibility give special attention to verifying, confirming or otherwise amend the information given in the available documents, whenever he is responsible for application of the information.

5.3 SERVICES BY THE CONTRACTOR

5.3.1 *General*

The Contractor shall provide all services for geodetic survey and measurements as required for the execution of the works and performance of all obligations under the Contract. The Contractor shall clear and maintain sight lines to establish direct view between neighbouring control points as necessary in the basic network. He shall secure and maintain all control points until his works are completed and he shall re-establish to the same standard any point damaged or destroyed during the construction period.

The survey plan shall be prepared to submit to the Engineer subject to the Construction Plans. The Contractor shall submit the following for approval:

1. Detailed Survey Plan, including:

a. Methodology

b. Control network design.

c. Accuracy standards

d. Instrumentation

2. Survey Reports:

a. Control point establishment records.

b. Alignment verification reports

c. Monthly survey reports

5.3.2 *Setting out for the Works*

The Contractor shall check all GPS monuments, benchmarks and other relevant data in the basic networks established previously, to confirm co-ordinates, elevations, distances and directions, submit a report showing the results of control measurements and in writing approve their sufficiency for his works or propose corrections.

Based on these data, the Contractor shall establish all additional control points and benchmarks necessary to determine the exact alignment of the access tunnel. It is the Contractor's responsibility to maintain all control points. Control points shall be the centre of a 12 mm diameter pin set to protrude 3 mm above the top of a 0.25 x 0.25 x 0.30 m deep concrete block, embedded 0.25 m into the ground. The level and/or other markings shall be painted on the surface of the concrete block as directed by the Engineer.

The Contractor shall set out the lines and levels of surface excavation and earth works at intervals of not more than 25 m or as required for constructing the works. For the tunnel excavation the Contractor shall establish, and continuously extend, an at all time available alignment and benchmark control system for checking the location of the working face and setting out the next round. A properly maintained laser based system is required.

Tunnel control surveys, based on the GPS basic control network, shall be carried out when the tunnel has been excavated through the curve and further 200 m of the straight alignment. A comprehensive report from such basic controls shall be presented to the Engineer.

During excavation the Contractor shall use a continually operating laser-based guidance system. Geometric control shall take place as soon as possible after excavation, and before any application of sprayed concrete.

The Contractor shall put chainage marks on the tunnel wall at 10m intervals. The chainage marking shall be carried out with clearly visible spray paint, and the accuracy shall be within 250 mm.

The Contractor shall take full responsibility for the correctness and accuracy of his survey work and for the actions of the personnel engaged in it. He shall supply all such stakes, templates, ranges, gauges, precision survey instruments and other tools and materials required, and all labour necessary in setting out and checking any part of the work.

The Contractor shall submit comprehensive reports on all his survey and setting-out work, for control and approval by the Engineer. Any control by the Engineer shall not relieve the Contractor of his full responsibility for the accuracy of measurements and for structures, and parts thereof, having positions and dimensions within the tolerances specified.

The benchmark data shall be reviewed and verified by the Contractor, as necessary. The Contractor shall also carry out a detailed topographical survey of the site to establish and confirm the existing ground conditions and relevant survey data.

5.3.3 *Survey Points and Benchmarks*

Table 5-1: Benchmark table

S.N.	Point ID	Easting (m.)	Northing (m.)	AMSLs (m.)
1	Trig. 101	538206	3055671	2845.534
2	Trig. 169	533456.4	3048374	2008.88
3	Trig. 170	536416.4	3048703	3228.128
4	DS-3	535446.9	3060667	1108.79
5	DS-4	535532.3	3060385	1117.589
6	W-10	535806.2	3061364	1087.283
7	A-01	535910.6	3061447	1084.447
8	A-02	535783.9	3061290	1084.124
9	A-03	535669.1	3061207	1083.559

5.3.3.1 Temporary Survey points and Benchmarks

a) All such points and marks shall be maintained for the Engineer's control survey.

b) The Contractor shall, without additional payment, at any time on the request of the Engineer shall:

- expose covered survey points
- shift machinery and equipment out of the required sight lines
- halt construction work, drilling, mucking and machine operations
- restrict or stop traffic of persons or vehicles near instruments or in sight lines
- provide materials, tools, stakes, marks and an adequate number of assistants as directed by the Engineer
- clear bushes, remove obstacles and level off ground to a required extent for the Engineer's auxiliary surveys
- properly re-install lost survey points which are still required.

5.3.3.2 Permanent Survey Points and Benchmarks

The Contractor shall supply and install additional survey points and benchmarks to be left as future reference points. The Contractor may install such points as the work progresses, and use them for his setting-out work during the construction period.

Permanent survey points and benchmarks shall be firmly anchored to solid rock or to concrete structures by grouted bolts. A clearly visible template in stainless steel shall, similarly, be anchored next to the point where the number, designation and geodetic data of the point are clearly and durably engraved. Exact location and installation details shall be presented for and approved by the Engineer.

5.3.3.3 Survey for Measurement of Quantities

The Engineer shall be given due notice of the Contractor's intention to carry out quantity surveys to enable him to attend and witness such surveys.

The Contractor shall carry out and provide all personnel, equipment and materials required to effectuate surveys and to determine the quantities of work performed. Measurement of existing surface profiles, intermediate and final excavation and fill lines and related fieldwork shall be carried out as specified in the Contract or as required for proper documentation of records or and as approved by the Engineer.

At all sites where quantities of earthworks and rock excavations shall be measured in-place, the Contractor shall take ground cross-sections (after site clearance and topsoil removal, and after soil excavation, when applicable) or at such intervals as necessary for proper calculation of quantities and as approved by the Engineer. These shall be plotted and submitted to the Engineer for approval. If the Contractor fails to take the requisite levels, levels determined by the Engineer shall be taken as correct.

5.4 QUALITY CONTROL AND VERIFICATION

i. All surveys shall be subject to Engineer’s approval.

ii. Any deviation beyond tolerance shall be corrected at the Contractor’s expense.

iii. Survey data shall be digitally recorded and submitted.

5.5 MEASUREMENT AND PAYMENT

The work of establishing Benchmark shall be measured by number (No.) of control points established and accepted by the Engineer. Measurement shall be made for each completed control point, including verification of existing BM points, transfer of coordinates/elevations, establishment of control points, and traverse closing.

Payment shall be made at the contract unit rate per No. for each accepted control point. The rate shall include all surveying work, verification of existing BM points, coordinate and elevation transfer, establishment, maintenance and marking of control points, internal and external surveying, over-break measurement, preparation of reports, survey instruments/equipment, manpower, calculations, field books, documentation, and all other labour, materials and incidental costs necessary all complete.

No separate payment shall be made for surveying works unless specifically provided in the BOQ. The cost of all survey activities, including establishment and maintenance of control points, internal and external surveying, over-break measurement, preparation of reports, and as-built drawings shall be deemed included in the Contract /Bid Price.

6 CHAPTER 6: EARTHWORKS

6.1 GENERAL

This Specification shall be applicable to site clearance and excavation of the surface structures. The site clearance shall be referred to the activities related to clearing, grubbing, stripping and excavating the area of the work within the limits of the site as defined in the drawings and ordered by the Engineer for all trees, stumps, bushes, roots, down-timber, rotten wood, rubbish, debris, humus, swamp material and vegetation or unacceptable materials. Excavations shall be executed in accordance with the lines and slopes shown on the Drawings, or as indicated by the Engineer. During the progress of the work, it will at times be necessary or advisable to alter the slopes or the dimensions of the excavations shown on the Drawings which shall be done as per advised by Engineer or with prior approval of Engineer. Any increase or decrease of the excavated quantities resulting from the above-mentioned alterations will not affect the unit prices of the excavation which shall be executed by the Contractor at the unit prices agreed on the contract for each one of the excavation items.

The Contractor shall be responsible for the management and sorting of all excavated and borrowed materials to enable the placement and disposal of materials in accordance with the Contract. Excavated materials shall, according to their nature and to the Contractor's materials management plan, be placed as fills in their final locations in the Works, stockpiled for later placement, or removed to a nominated or approved spoil disposal area. All excavated materials belong to the Employer and no material shall be removed from the Site without the written approval of the Engineer.

The design lines and levels of excavations shall be defined as those shown on the Drawings or specified in the Contract, or as adjusted or otherwise determined by the Engineer.

Excavations shall be taken to the design lines and levels or to such other limits as the Contractor may require enabling him to construct the Works in accordance with the Contract. Excavation beyond the design lines and levels made without the Engineer's direction or approval, including but not limited to, excavation to provide working space and excavation below approved stripping levels, shall be backfilled with approved material unless otherwise specified or approved, and at the Contractor's expense.

Save and except as specified below, the Contractor, having due regard for safety and stability considerations, shall bear sole responsibility for determining the method and extent of all excavations, and no warranty is given or implied by the Employer that excavations will be stable under all conditions if excavated to the design lines and levels.

Excavations, whether permanent or temporary, shall be braced, battered, benched or otherwise shaped and/or supported in accordance with the requirements and recommendations of BS 6031 and in a manner consistent with the Contractor's obligations to provide a safe working environment for all personnel.

Excavations shall be adequately protected by barriers and/or signed by warnings such that people and equipment are not endangered.

Unless otherwise specified or approved by the Engineer, earthworks shall be maintained in a dry, dewatered state at all times. The Contractor shall to the extent practicable divert surface water away from earthworks and shall minimise interference with natural drainage lines. Water diverted away or removed from earthworks shall be controlled and disposed of in accordance with the plans and provisions submitted by Contractor and approved by the Engineer.

6.1.1 *Definitions*

The following definitions shall apply to earthworks:

1) Topsoil is defined as the top layer of soil containing fine roots and decomposed organic matter.
2) Soil is defined as all materials other than topsoil or rock. Weathered rock that can be excavated by thirty tons excavator with backhoe with teeth, or equivalent equipment, and blocks less than 1 m^3 shall be classified as soil.
3) Rock is defined as all materials which require blasting, or the use of compressed air drilling, or the use of pneumatic tools for their removal, and which cannot be excavated by thirty tons excavator with backhoe with teeth, or equivalent equipment. Boulders larger than 1 m3 shall be considered as rock.
4) Fill includes the supply, hauling, placing and compaction of suitable soil or rock materials as backfill, embankments etc.

   Fill shall include the supply, hauling, placing, compaction and placing suitable soil or rock materials in backfill or embankment fill, in accordance with these Specifications and to the lines, levels, grades, dimensions and cross sections shown on the drawings or as required by the Engineer.

a) Suitable material shall comprise all material that is acceptable for use in the works and which is capable of being compacted to form a stable fill in accordance with the Specifications having side slopes as indicated on the Drawings.
b) Unsuitable material means other than suitable material and includes:
   - All material containing more than 5 percent by weight of organic matter (such as topsoil, material from swamps and marshes, peat, logs stumps and perishable material).
   - Materials that cannot be adequately compacted due to excessive moisture content.
   - All material with a 4 day soaked CBR -value (AASHTO T193) of less than 5 percent at 96 percent MDD (AASHTO T99).

c) Structural backfill shall comprise blasted rock or sandy gravel. The material shall be well graded. Contents of fines (passing sieve size 0.075 mm) shall be maximum 5%. Maximum stone size shall be 2/3 of the thickness of each compaction layer and maximum 300 mm.
d) Rockfill shall comprise blasted rock of high permeability. Contents of fines (passing sieve size 0.075 mm) shall be maximum 5 % and maximum stone size 2/3 of the given layer thickness. High Quality Rockfill shall be defined as rockfill produced from rock with a uniaxial compressive strength of minimum 40 MPa and weathered to a degree not more than “slightly weathered”.
e) Drainage zones shall consist of processed blasted rock or gravel/stones of size 50 - 100 mm.

f) Filter zones shall consist of 0 - 60 mm blasted rock or sandy gravel with maximum 2 % fines passing sieve size 0.075 mm (non-cohesive). Filters next to core materials in earth or rockfill dams shall be in accordance to the filter criteria of ICOLD, Bulletin 95, 1994.

g) Low permeability materials shall comprise clayey or silty materials with 20 - 75% passing sieve size 0.075 mm and maximum particle size 100 mm and placed at a moisture content at approximately 2 % above the optimum water content (AASHTO T99).

6.1.2 *Reference Standards*

All materials, equipment and workmanship incorporated in the Earthworks shall, except where specified otherwise or where specific standards are referred to, comply with any of the latest issues of the Standards and Codes of Practice, as relevant and appropriate, published by the following Organizations:

- The Nepalese Building Control Act
- Nepalese Standard Specification of Materials and Workmanship for Building Contracts.
- ASTM: American Society for Testing and Materials
- AASHTO: American Association of State Highway and Transportation Officials
- BS: British Standards Institution
- CEN: European Committee for Standardization
- COPANT: La Comisión Panamericana de Normas Técnicas
- ICOLD: International Commission on Large Dams
- IS : Indian Standard

6.1.3 *Documents*

The Contractor shall prepare and submit documents to the Engineer in accordance with requirements in Chapter **Error! Reference source not found. Error! Reference source not found.**, and the following Table 6-1:

Table 6-1: Documents to be prepared and submitted by the Contractor

Documentation	Issue for approval	Issue for info	Issue time
Record profiles/drawings of ground level surveys of all areas to be excavated or filled.		*	2F
Record profiles/drawings of level surveys taken for the purposes of measurement of quantities of excavation or fill.		*	2T
Proposed excavation plan showing solutions and possible actions to ensure satisfactory stability of	*		4F

	open cuts			
	Proposed plan for deposits of different materials, soils or rock, spoils or temporarily stockpiles for later use. The plan shall include proper actions for ensuring satisfactory stability during rain and floods.	*		4F

XF = X number of weeks prior to start of manufacture/work as applicable.

XT = X number of weeks after completion of test/inspection/work as applicable

6.2 CLEARING AND GRUBBING

6.2.1 *General*

The Contractor is responsible for all clearing and grubbing of all temporary areas, areas for spoil deposit, access road leading up to the spoil deposit and of areas for permanent roads and facilities as indicated on drawings. The works shall include clearing of designated areas of all trees, down timber, snags, rubbish, bushes and other vegetation, and shall include grubbing up roots and stumps and disposing of all material resulting from the clearing and grubbing. It shall also include the demolition, removal and disposal of structures that obstruct the work.

Attention is directed to the Contractor's obligations under Nepalese law and under this Contract with regard to damage, particularly with regard to protection of property and landscape and to responsibility for damage claims.

Existing roads, property, utilities, services and areas designated for preservation shall be protected from damage that could result from the Contractor's operations.

6.2.2 *Clearing*

Clearing shall consist of the removal and disposal of everything above ground level including overhanging branches except those items the Engineer directs to be left undisturbed. The material to be cleared shall include, but not be limited to trees, stumps, logs, bushes, undergrowth, grass, crops, loose vegetable matter and structures unless provided for elsewhere.

Felling, trimming or removal of trees shall be restricted to the minimum practicable for the execution of the Works. The Contractor shall protect from damage all trees designated by the Engineer. Except for large trees, clearing shall not extend more than 3 m beyond the limits of excavation or fill without the Engineer's written permission.

The Contractor shall demolish, break up and remove any structure and superficial obstructions on the Site that could be in the way for or otherwise affect the Works, unless such structures or obstructions are designated for preservation. He shall clear each part of the Site at such times and to the extent required and approved by the Engineer.

Materials removed in clearing operations shall be burned to their minimum practical volume and buried in spoil disposal areas with a minimum cover of 500 mm of earth and/or rock spoil, or shall be otherwise disposed of or stored according to the Environmental Management and Action Plan or as approved by the Engineer. Burning of cleared materials shall be done in such a manner and in such locations as to cause the least fire risk. The Contractor shall take special precautions to prevent fire from spreading and shall have available at all times suitable equipment and supplies to prevent and suppress any fire.

6.2.3 *Grubbing*

Grubbing shall consist of the removal and disposal of stumps and roots to a depth of at least 200 mm below cleared level. Any holes left below permanent level after grubbing of stumps, roots etc. shall be backfilled with suitable material and compacted in accordance with these specifications. Grubbing of channels and ditches will be required only to the depth necessitated by the excavation within these areas.

6.3 TOPSOIL EXCAVATION

Topsoil excavation shall consist of removal and stockpiling of all organic topsoil in an operation separated from soil excavation in all areas for excavation, below embankments, foundations, permanent roads and where the topsoil is not of adequate quality for temporary or permanent areas, as directed by the Engineer.

The stockpiled topsoil shall be used for reinstatement of excavated areas and for landscaping as directed by the Engineer.

6.4 SOIL EXCAVATION

6.4.1 *General*

The Contractor shall carry out the excavation of cuts in accordance with the Contract and shall adhere to the lines, grades, depths and levels shown on the Drawings, unless directed otherwise by the Engineer.

The Contractor shall notify the Engineer sufficiently in advance of the beginning of any excavation so that profiles and measurements may be taken of the undisturbed ground. These measurements shall be performed by the Contractor. The natural ground adjacent to the planned excavations shall not be disturbed without permission of the Engineer.

Excavated materials shall, according to their nature and to the Contractor's materials management plan, be placed as fills in their final locations in the Works or stockpiled for later placement, or removed to a nominated or approved spoil disposal area. Boulders and rock suitable for erosion protection shall be sorted out and stored separately for later use as instructed by the Engineer. All excavated materials belong to the Employer and no material shall be removed from the Site without the written approval of the Engineer.

Any excess excavation outside the design limits shall be made good by backfilling with suitable material compacted in accordance with the Specifications, and at the Contractor's expense.

Boulders, logs and other unsuitable and non-approved material encountered in excavation shall be removed.

The cut slopes shall be cleared of all loose and unstable stones and boulders.

Excavations shall be cleaned of all loose and disturbed material and cut to a firm surface, either levelled or terraced, as specified or shown on the Drawings or directed by the Engineer.

Stones and boulders that jut out of the excavated surface with more than 100 mm are not acceptable in permanent cut slopes. The Contractor shall remove such stones and boulders to a depth of min. 500 mm normal to the slope line and build up the resulting hollows with materials approved by the Engineer so as to ensure an even and solid surface. Demolition by drilling and blasting or by hydraulic chisel hammer may be necessary before excavation and shall be included in the prices for the excavation work.

Necessary ditches shall be excavated together with the main excavation. The Contractor shall make all necessary precautions to take care of surface water during the construction period without causing erosion damage. All ditches shall have proper gradient towards natural run-off, ditches or pump sumps. Reference is made to Chapter 12 Care of water .

Shaping of the excavated surfaces, including removal of stones and boulders as specified above, and compaction of the bottom when required shall be included in the prices for the excavation work.

6.4.2 *Stability and Safety of Excavations*

The Contractor, having due regard for safety and stability considerations, shall bear sole responsibility for determining the method and extent of all excavations.

No warranty is given or implied by the Employer that temporary excavations will be stable under all conditions if excavated to the design lines and levels.

All the necessary measures, efforts and actions to ensure sufficient stability and safety of temporary excavations/slopes for which the Contractor is responsible shall be included in the prices for the excavation work.

6.4.3 *Open Cut for Tunnel Adits*

The Contractor shall be responsible for the stability and safety of the temporary cuts in the open cut area. Approval by the Engineer of the documentation required in this respect will not relieve the Contractor of his responsibility. Start of work shall be subject to the Engineer's approval.

Proposed excavation plan, stability calculations and possible measures to ensure satisfactory stability of the temporary cuts and satisfactory safety conditions shall be submitted to the Engineer for approval minimum 28 days prior to the start of excavation.

6.4.4 *Structural Excavation*

After excavation is completed, the Contractor shall notify the Engineer. No footing/bedding material or structure shall be placed until the Engineer has approved the depth of excavation and the characteristics of the foundation material.

Special care shall be taken not to disturb the bottom of the excavation. When, in the opinion of the Engineer, the foundation material is soft, dirty or otherwise unsuitable, such material shall be replaced by suitable compacted structural backfill material or concrete as specified or shown on the Drawings or directed by the Engineer. If foundation fill material is required, such material shall be placed and compacted in layers not more than 150 mm thick to minimum 100 percent MDD (AASHTO T 99).

6.4.5 *Use of Materials*

Excavated materials shall be used for forming of fills of access road or spoiled as approved by the Engineer. Spoiled materials shall be kept separate as for topsoil, suitable soil, unsuitable soil, and rock. Unless designated by the Employer or Engineer, and approved by the Engineer.

No excavated suitable material other than surplus to requirements shall be spoiled or removed from the Site except on the direction of the Engineer. Should the Contractor be permitted to remove suitable material from the Site to suit his operational procedure then he shall make good at his own expense any deficit of filling that might arise there from.

Where excavation reveals a combination of suitable and unsuitable materials and the Engineer considers it practicable, the Contractor shall carry out the excavation in such a manner that the suitable materials are excavated separately for use in the works without being contaminated by the unsuitable materials.

6.5 FILLS

6.5.1 *Embankments*

The Contractor shall carry out the forming of embankments and other fills in accordance with the Drawings and shall adhere to the slopes, levels, depths and heights shown thereof, unless directed otherwise by the Engineer.

Embankments shall be formed of suitable materials conforming to AASHTO M57 and approved by the Engineer.

No material shall be placed until the embankment foundation has been cleared, grubbed and dewatered as necessary, treated as specified below, and inspected and approved by the Engineer. Inspection shall include recording detailed information on soil and rock characteristics, any defects and groundwater.

Before any fill materials are placed on the foundation, all organic matter, topsoil and compressible soils and any other deleterious materials, which in the opinion of the Engineer are unsuitable as foundation materials, shall be removed from the foundation to the satisfaction of the Engineer.

Road embankments shall be built up evenly over the full width. During the construction of embankments, the Contractor shall control and direct construction traffic uniformly over their full width.

Where the slope of the existing ground is steeper than 1:3, or where directed by the Engineer, level terraces in steps not less than 2 m wide shall be cut in the existing ground before laying suitable fill material, if not otherwise directed by the Engineer.

Excavated soil material placed in fills shall be deposited and compacted as soon as practicable after excavation in layers of thickness appropriate to the compaction plant used or as directed by the Engineer.

Stockpiled material intended for later use in fill, shall be properly deposited and protected.

Rockfill used in embankments shall, except for any specified external cover to slopes, be of such size that it can be deposited in horizontal layers each not exceeding 1.0 m thickness, and compacted by vibrating roller with weight minimum 80 kN.

The side slopes of embankments shall be thoroughly blinded with approved fine graded material to seal the surface. Topsoil may be used for this purpose on side slopes and verges on road embankments.

Embankments shall be constructed in horizontal layers and compacted as given in Table 6-2.

Rockfill, drainage materials, filters and low permeability materials shall all be constructed in horizontal layers.

Rockfill shall be spread and levelled by a dozer weighing not less than 15 tons.

Other materials may be spread by dozers or backhoes, as appropriate.

Table 6-2: Specifications for layer thickness and compaction

Material	Compaction equipment	Maximum layer thickness (m)	No. of passes	Comment
Rockfill	Minimum 80 kN vibr. roller	1.5	6	
High Quality rockfill		1.0	8	
Filter material Drainage material	Minimum 80 kN vibr. roller	0.5	4	
Low permeability fill	Minimum 40 kN vibr. roller1)	0.5	6	98 % MDD (AASHTO T99)
Erosion protection	Placed by backhoe	-	-	Each block individually placed
Top of road subgrade	Minimum 60 kN vibr. roller1	2 layers of 0.2 m	6	98 % MDD (AASHTO T99)
Structural backfill	minimum 5 kN vibrating plate	0.2	4	Layer thickness may be increased if heavier equipment is used

1) A sheep's-foot roller may be used (based on trial compaction test)

Low Permeability Materials shall be compacted in layers to a density not less than 98 percent of maximum dry density, MDD (AASHTO T99). The suitable combination of compaction plant and layer thickness shall be decided based on compaction trials at the Site. Until such trials have been carried out the following may be considered as a guideline.

The surfaces of embankment fills shall have a cross fall of 4-5 percent during construction unless otherwise directed.

If the Contractor wishes to use other types of compaction equipment, this shall be specified together with the layer thickness which he proposes to use in order to obtain minimum the same degree of compaction as for the cases specified above. The Engineer shall approve the use of such other plant.

6.5.2 *Spoil* ***Deposits***

Tunnel spoil and excavated soil not used as structural backfill or in embankments shall be deposited as indicated on drawings or as otherwise directed by the Engineer.

No material shall be placed before the actual spoil deposit area has been cleared and grubbed, dewatered, when necessary, treated as specified and inspected and approved by the Engineer.

Topsoil shall be stockpiled in the Spoil Deposit area in a manner approved by the Engineer. Stockpiled topsoil material shall be properly deposited and protected against erosion.

Where the spoil tips are placed along riverbanks and on riverbed the slope and slope base of the spoil tip shall be erosion protected as describes in chapter 4.

The Contractor shall carry out the forming of the spoil deposits in accordance with information given on the Drawings or as directed by the Engineer. Permanent drainage and erosion protection shall be provided as specified in Chapter 4.

Tunnel spoil shall be placed in layers not exceeding 2.0 m thickness and spread by dozers weighing at least 80 kN.

6.6 MEASUREMENT AND PAYMENT

Earthworks for mobilisation areas, camps, offices etc. and other temporary works will not be measured for payment. Also cost of dewatering if required shall be included in the pay items stated in the Bill of Quantities.

a) Clearing and Grubbing shall not be measured for payment. Costs for cleaning and grubbing shall be deemed to be included in the pay items stated in the Bill of Quantities.

b) Soil excavation shall be measured by volume in its natural state. Measurement of soil excavation shall be made based on cross sections of the terrain after topsoil excavation and to the exposed and cleaned rock surface where relevant, and to the lines, grades, dimensions, and cross section shown on the Drawings or directed by the Engineer.

c) Fill or backfill shall be measured by the net volume in place of the compacted specified material in the completed fill to the width and slopes shown on the Drawings or as directed by the Engineer. The quantities shall be calculated from cross-sectional profiles of the fill/backfill. Such profiles shall be measured by the Contractor according to instructions given by the Engineer. The profiles shall show the ground levels after Site clearance and any topsoil excavation or other excavation as agreed by the Engineer, and the design cross section of the fill or backfill. No additional measurement or payment will be made in respect of variations to the specified net cross-section.

The quantities measured as specified in b) to c) above shall be paid at the contract prices included in the Bill of Quantities, which prices and payment shall constitute full compensation for furnishing all manpower, materials, machine and all works required to complete the specified work items according to the requirements of the contract.

For all earthworks shaping, cleaning and other finishing of surfaces in cut and fill shall be deemed to be included in the excavation or fill except where a separate item is included in the Bill of Quantities for such work. Furthermore, all loading and transport to fill or spoil, and all works required at the place of disposal, shall be inclusive. Any extra handling of materials if required will not be measured and paid.

d) Tree cutting shall be measured on a number (No.) basis, irrespective of tree size, exceeding 300 mm diameter. Payment shall be made based on the actual number of trees cut, with no separate payment for trees of size smaller than 300 mm diameter. The size of the tree shall be measured at 4ft from the ground level. The payment for tree cutting shall be considered full and final payment for all associated works, including cutting, removal, handling, and disposal of the trees and related materials.

7 CHAPTER 7: MAIN ACCESS TUNNEL PORTAL

7.1 GENERAL

7.1.1 *Scope*

This Specification shall be applicable to construction of start point of the tunnel or tunnel portal.

7.1.2 *Reference Standards*

Concrete slump test- ASTM C143

Concrete compressive strength - ASTM C39

Reinforcement bars - ASTM A615M or equivalent

7.1.3 *Submittals*

The construction plan shall be made to submit to the Engineer subject to the Construction Plans.

7.2 MATERIALS

Concrete, Reinforcing Bars, Light duty steel gate at Access, RRM, Gabion

7.3 CONSTRUCTION

7.3.1 *Location and Types of Tunnel Portals*

1. The location of the tunnel portal has already been located. The location information will be provided in drawing.
2. Construction shall follow approved plans and include methodologies, equipment, formwork layout, and sequencing.
3. The super elevation, steep alignment, and large-scale cutting shall not be formed in the vicinity of tunnel portals, minimizing impacts on landscape.
4. The type of the tunnel portal is inverted D Shape with finished diameter as per drawings.
5. Drainage of Tunnel Portals
6. The drainage with excavation near the Tunnel Portal shall be well maintained.
7. The efficient drainage systems, pipe or blind drain, shall be planned to drain through gully pits.

7.3.2 *Excavation in Boulder-Mixed Soil*

The work shall comprise excavation in boulder-mixed soil at the tunnel portal and associated areas using approved mechanical equipment. The work shall include loosening, excavation, segregation where required, loading, hauling, transportation and disposal of excavated material at approved disposal areas. The work shall also include setting out, preparation and maintenance of access, trimming and dressing of excavation surfaces, removal of unsuitable materials, protection of adjacent structures and slopes, dewatering where required, and all necessary safety and environmental protection measures.

Excavation shall be carried out to the lines, levels, slopes and dimensions shown on the Drawings or directed by the Engineer. The Contractor shall ensure that excavation does not cause instability, excessive loosening or damage to the surrounding ground. Excavated material suitable for reuse shall be separately handled and stockpiled at locations approved by the Engineer.

7.3.3 *Open-Cut Excavation in Rock*

The open-cut excavation in rock for the tunnel portal, includes drilling, controlled blasting where permitted, excavation, breaking, loading, transportation and disposal of excavated rock at approved locations. The work shall also include scaling, trimming and dressing of rock surfaces, stabilization of excavation faces, protection of adjacent works, removal of loose rock, dewatering and all necessary safety and environmental protection measures.

Rock excavation shall be carried out to the required lines, levels and profiles shown on the Drawings. Loose and unstable rock shall be removed by scaling. The Contractor shall take all necessary measures to maintain stable excavation faces. Any rock fall or instability caused by inadequate excavation methods or failure to provide required protection shall be rectified at the Contractor's cost.

7.3.4 *Plum Concrete – (60% M15 Concrete + 40% Boulders)*

The work shall comprise construction of plum concrete for tunnel portal retaining walls, breast walls, foundations, drainage structures and other portal protection works as shown on the Drawings or directed by the Engineer.

The plum concrete shall consist of approximately 60% M15 concrete and 40% approved boulders/stones by volume, unless otherwise specified in the Drawings or Technical Specifications.

The work shall include foundation preparation, setting out, supply and preparation of materials, mixing, transportation, placing and embedding of boulders in concrete, compaction, finishing, curing, formwork where required, and

7.3.5 *Weephole and installing HDPE Pipe*

The work shall comprise of drilling 75 mm weep holes and installation of HDPE perforated pipe wrapped with geotextile drainage arrangements wherever applicable. The size of weephole shall be 75 mm dia, 4.0 m long and the drainage size is 75mm dia, 4.0 m long 56 mm dia. HDPE perforated pipe wrapped with geotextile.

7.3.6 *REINFORCEMENTS FOR CONCRETING WORK*

The mass of steel reinforcement measured shall be calculated from the nominal diameter of the reinforcement and the net length of the reinforcing bars as detailed in the bending schedules.

No allowances shall be made for laps, splices, connectors, tying wire, templates, stools, blocks, ordinary spacers and other supports. No measurements of any cutting, bending or forming of shapes will be made.

7.3.7 *Steel gate at Main Access Tunnel Portal*

It comprises of Design (if required), Supply, Fabrication, Transportation, Erection and Commissioning of Mild Steel Security Gate with GI Wire Mesh Infill, Concrete Foundations, Painting, Hinges, Drop Bolts, Locking Arrangement and All Ancillary Works Complete in Place as shown in the drawings or as directed by the Engineer.

7.4 BOULDER RIP RAP

7.4.1 *General*

Rip rap shall be done in the upstream and downstream of the temporary river crossing works to mainstream the flow through the hume pipe for the purpose of preveting excessive errosion upstream and downstream of the river constriction.

7.4.2 *Material for Rip-Rap*

Riprap shall be taken from hard rock layers of quarries or rock excavation or underground rock excavation, as approved by the Engineer. The rock shall be compact, firmly-bound, of uniform grain texture and absolutely weather-resistant, shall not have cracks, holes and laminations of detrimental materials. The rock blocks shall be of natural irregular cubic shape and of the size as specified hereunder. Thin-sliced blocks shall not be accepted. Any blocks covered by impurities shall be cleaned thoroughly before being used. Moisture absorption of rock blocks shall be limited to such a quantity that any cracking, bursting, and chipping as a result of wave action or weather influence will not occur.

The use of rocks mixed with soil, sand, clay and decomposed or decomposable materials, or the use of small rock fragments shall not be permitted. The Contractor shall not use weathered, fractured, dirty, inadequate grain-size distributed material or any material that, in the Engineer's opinion, is not sufficiently durable, and because of this, the Contractor shall not demand a compensation different from the unit prices established for rip- rap.

Rock not meeting the specified requirements will be rejected and the Contractor shall without delay follow instructions to remove such rock material from the Site. In the event of it’s failing to do so, the material will be removed by the Employer at the Contractor's expense.

The Contractor shall in no circumstance be entitled to payment for rock material placed which has not been accepted or approved.

Composition of Riprap

Unless otherwise specified or directed by the Engineer the following grading shall be applied for riprap.

- The largest individual blocks shall be not exceeded 2 tons.
- At least 25 percent of the block for riprap shall be greater than 800 kg 45 percent to 75 percent shall be graded between 50 kg to 800 kgs.
- Not more than 25 percent of blocks shall be under 50 kgs.

7.4.3 *Execution of Works Rip-rap*

The rock blocks in rip-rap as specified need not to be compacted but shall be placed and graded in a manner to provide a uniform distribution of the Larger blocks the Smaller rock blocks shall fill the interstices between the larger rock in a manner that will result in compact uniform layers of rip-rap of the specified thicknesses.

Placement of rip-rap in layers parallel to the slope to obtain the required thickness shall not be allowed. Placement shall be done in such a way as to obtain the required thickness at each level in a single operation. Methods of placing shall be avoided which may result in segregation of the rock by sizes or cause damage to the layer serving as the foundation for the rip-rap. Hand placing will be required only to the extent necessary to secure the results specified above. However, upon the request of the Engineer the Contractor shall at any time during the construction period and the guarantee period place new material or correct the existing material to the satisfaction of the Engineer.

Unless otherwise specified, rip-rap shall be bedded in a continuous layer according to the Drawings. The lowest part of the protected area shall be made up of boulders, well placed in a ditch, forming a protective support for the rip-rap.

Except for the rock fragments and spalls to be used as wedges, the rocks shall be irregular cubic-shaped and the smallest dimension of a given piece shall not be less than one-third of the largest dimension. Furthermore, no element whose largest dimension is smaller than two third of the thickness of the rip-rap, shall be placed in it. Spalls and small rock fragments shall not be piled in certain places to make up for the volume of larger rocks. The finishing tolerances for the rip-rap outer layers shall be equivalent to more or less a fourth of the thickness of such rip-rap layer, provided the differences in either direction are not continuous over an area greater than twenty square meters.

The gradation and structure of rip-rap slopes shall meet the requirements for expected wave height and intensity of flowing water, as well as the underlying protective layers. Earth, sand or rock dust not in excess of 5 % will be permitted in rip-rap or coarse gravel protection.

7.4.4 *Rip-rap*

Raising the rip-rap layer on the slope of dam/diversion construction shall take follow the progress of the shell fill, the height of the shell always being one or two layers ahead of the rip-rap. The rip-rap shall be placed with an excavator operating from the shell level. The larger blocks shall be placed at the outside slope and be secured and wedged with smaller size rocks to form a stable body of rip-rap.

7.5 GABION RETAINING/PROTECTION WALLS:

It comprises of foundation preparation, assembly of gabions, installation of geomembrane, filling of Gabions, layering, Drainage Considerations as required.

Gabions shall be provided as shown on the drawings or as directed by the Engineer if high strength of stone protection is required or the stone protection is used to stabilize the slope.

Gabions are wire mesh boxes filled with selected gravel or rock of suitable size and shape to facilitate packing. The grain size of the gravel or rock shall be greater than about 1.5 times the diameter of the mesh openings, but at least 10 cm. The stone quality shall be as specified for riprap.

The standard type gabion shall be fabricated from flexible hot-dip galvanised wire and/or wire mesh plastic coated type and sizes specified below, with a selvedge as specified in the following.

The mesh shall be hexagonal woven mesh, the joints formed by twisting each pair of wires through three half turns. The size of the mesh shall conform to the standard specification issued by the manufacturer and shall be not greater than 1/3 of the smallest stone filled in the gabion. All wire used in the fabrication of the gabions and in the wiring operations during construction shall be "Mild Steel Wire", i.e. wire having an average tensile strength of 44 kg per square millimetre. The diameter of the wire used in the fabrication of the mesh shall be 3.0 mm according to the Engineering requirements. Test shall be made on the wire before fabrication of the gabions on a sample 30 cm long. Elongation shall not be less than 12 %. All wires used in the fabrication of the gabions and in the wiring operations during construction shall be galvanised. The minimum weight of the zinc coating shall be 275 gr/m2.

All edges of the standard gabions including end panels and the diaphragms, if any, shall be mechanically selvedged in such a way as to prevent unravelling of the mesh and to develop the full strength of the mesh. The wire used for the selvedge shall have a diameter greater than that of the wire used to form the mesh. For wire of a diameter of 3.0 mm, the selvedge wire shall have a diameter of not less than 3.9 mm.

The standard gabions shall have the following dimensions:

- Length = 2.0 or 3.0 or 4.0 m
- Width = 1.0 m
- Height = 0.3 or 0.5 or 1.0 m

Sufficient lacing and connecting wire shall be supplied with the gabions for all wiring operations to be carried out in the construction of the gabion work. The quantity of such wire is estimated to be 8 percent

of the gabions supplied. The diameter of lacing wire shall be 2.4 mm for the gabions made of wire gauge 3.0 mm

Gabions shall be packed carefully and tight by hand to ensure long term stability of gabion structure.

According to the Engineering requirements, the gabions might incorporate diaphragms to form cells having a length not greater than one time and half the width of the gabion.

A tolerance on the diameters of all wire in the above paragraphs of ±2.5 percent is permitted.

The length of the gabions is subject to a tolerance of ±3% and the height and the width to a tolerance of ±5%.

In case stabilization and anchoring of gabions are required, such stabilization and anchoring (including provision of "dead men") shall be performed as shown in the drawings or as instructed by the Engineer.

Contractors Alternative Proposal

If not otherwise specified in the Contract Documents, the Contractor shall submit a proposal of the type and dimension of gabions, the stone fill (type, strength, grain size), the method of placing and the time schedule for delivery and/or construction. He shall not commence with the order and/or construction of gabions prior to the approval of the Engineer.

Supply and placing of gabions shall include all works for a complete slope protection by these means, which shall include all the following operation but not being limited to:

- producing the required rock material
- manufacturing the gabions
- provision of an adequate location for manufacturing the gabions
- transportation and placing
- preparation of the foundations, levelling and compacting if required.
- tying and anchoring works where required

7.5.1 *Boulder for refilling gabion boxes*

The stone shall be hard, tough, sound, durable and free from detrimental materials and shall not have cracks, holes, and laminations enough and should be filled in such a manner that it will be well packed, have smooth face finishing by well-shaped stone or as directed by Engineer.

7.6 QUALITY CONTROL

Materials shall be tested and approved prior to use. Mesh coating, wire diameter, and strength shall be verified. Mortar mix and stone quality shall be regularly checked. Line, level, alignment, and structural stability shall be monitored.

7.7 MEASUREMENT AND PAYMENT

1. The quantities of tunnel concrete (Plum Concrete) in portal for the various classes of earthwork to be measured for payment under the contract shall be limited to the lines, grades, slopes and dimensions shown on the Drawing or as determined by the Engineer.

2. No payment shall be made for the disposal of the excavated materials irrespective of all leads and lifts, preparation of foundation base, cofferdams, cribs, sheeting, shoring and bracing, foundation sealing, dewatering including pumping, removal of logs and stumps, cleaning and grubbing, diversion of
3. Measurement of reinforcement shall be made in kg of material executed, calculated at the manufacturers kilogram rate per square metre, for the area covered by the material, but without allowances for laps, bends, cutting, notching around obstructions, tying wires, templates, stools, blocks, spacers or other supports and without deductions for voids less than one square metre.
   This price includes in particular:
   • All steel acceptance tests;
   • The supply of steels on site including transport;
   • Storage sheltered from bad weather;
   • Shaping, assembly of steel bars;
   • The installation of the reinforcement cages and the wedging inside the formwork, including the tying, supply and installation of spacers;
   • The supply and installation of temporary plastic covers for protection of pending steels that may present a risk of injury;
4. • The mounting steels, fixings as well as the chairs necessary for the installation of the reinforcements.
5. The Steel Gate at Main Access Tunnel Portal shall be measured and paid in LS basis as specified in the Bill of Quantities. The rate shall include:
   - Supply, and transportation of all materials.
   - Installation, including gate posts, foundations, and embedment.
   - All fittings, fixtures, locking systems, and accessories.
   - Surface preparation, painting, and corrosion protection
   - Labor, equipment, tools, and incidentals necessary to complete the work.

6. Concrete work and Gabion wall including Geo-membrane shall be measured in cubic meters (m^3). The rate shall include
   - Supply of all materials (stone, cement, sand, mesh, geomembrane, wires)
   - Fabrication, assembly, placing, and filling of gabions
   - Mortar preparation and masonry works
   - Foundation preparation and surface treatment
   - Installation of geomembrane and sealing
   - Labor, equipment, scaffolding, and transportation
   - Drainage provisions and incidental works.

7. Measurement of gabion shall be volume of gabion box filled as per the placement of gabions according to the neat lines and dimensions in final positions as specified in the drawing, specification and rate shall include for supplying and laying of wire mesh boxes and stone fill and placing as according to the specification and close up.

8. The quantities of materials for riprap will be paid for providing, laying, dumping, selective placing and bedding of riprap. For payment measurement of the quantities in m3 of the neat-line in final position shown on the drawings or as directed by the Engineer shall be applicable. The unit price will include providing and laying including proper bedding, placing, grading, wedging, barring, dumping in lines and levels etc.
9. Weep holes and HDPE perforated pipes shall be measured in number and paid separately as mentioned in BoQ.

8 CHAPTER 8: DRILLING OF HOLES, EXPLORATORY DRILLING AND GROUTING

8.1 SCOPE

8.1.1 *Coverage*

This chapter specifies requirements for drilling of holes for ground water and seepage control and all exploratory drilling and grouting in order to explore and modify the properties of the rock through which the Works are to be constructed. The extent of such work depends on the properties of the rock encountered during the tunnel excavation and shall be carried out as directed by the Engineer.

8.1.2 *Classification and Definition*

Definition of grouting at the face and grouting behind the face, shall be similar as defined in Chapter 10.1.2 Classification and Definition, under definition of "Support work at the face" and "Support work behind the face".

8.2 REFERENCE STANDARDS

The work shall be performed according RMR or relevant standards, or if no standards exist, the work shall be performed according to recognised practice approved by the Engineer.

8.3 SUBMISSIONS BY THE CONTRACTOR

Submissions that the Contractor is required to make to the Engineer are described below.The issue time defines the date that the Engineer shall receive the first issue of the documents:

XF = X number of weeks prior to start of manufacture/work as applicable.

XT = X number of weeks after completion of test/inspection/work as applicable.

8.3.1 *Documents*

The Contractor shall prepare and submit documents in accordance with Table 8-1.

Table 8-1: Submittals of Documents

Documentation	Issue for approval	Issue for info	Issue time
Organisation plan for the Works showing procedures and materials for the work and the responsibilities and qualifications of the personnel	*		6F
Log of all drilled holes		*	1T
Specific grouting procedures, material, composition, properties and equipment	*		6F

The Engineer's approval does not relieve the Contractor of his sole responsibilities for efficient and successful execution of the work.

8.3.2 *Test Reports*

The Contractor shall make tests and prepare and submit test reports in accordance with Table 8-2.

Table 8-2: Submittals of Test Reports

Item	Issue for approval	Issue for info	Issue time
Characteristics of grout agents	*		6F
Characteristics of packers and flexible hoses	*		6F

The Engineer's approval does not exempt the Contractor of his sole responsibilities for efficient and successful execution of the work.

8.4 DRILLING GENERAL

Drilling of holes for exploratory drilling, ground water control and rock mass grouting encompasses:

- Drilling of holes for exploratory drilling and grouting from the tunnel front or from elsewhere in the tunnel at any angle as instructed by the Engineer. Or as per drawings.

  Grouting works will be performed in the tunnel for control of permeability and influx of water or for consolidation.

  Grouting may be done either as cement grouting or as chemical grouting.

  Grouting operations are not designed and specified in detail at the tender stage. The grouting works will be decided and designed by the Engineer in co-operation with the Contractor during excavation.

  The Contractor shall at any time during the progress of the Works provide and maintain adequate equipment and materials with stand-by reserves to be able to carry out any drilling and grouting operation ordered by the Engineer.

  The grouting shall be supervised by an Engineer with documented grouting and drilling experience from similar works. At least one additional crew member shall document appropriate experience.

  The Contractor shall keep daily updated records and logs of all drilled holes, flexible grouting tubes, water pressure tests and grout take. The results shall be presented in numerical and graphical format, comprising every borehole and every flexible tube with results of water pressure tests, grout takes at the various depth intervals, and data for performance and applied pressures. The boreholes and tubes shall be given a number, identifying location as well as direction.

8.5 EQUIPMENT AND EXECUTION

8.5.1 *Exploratory Drilling and Grouting*

Percussion drilling equipment shall be used for drilling of exploratory drill holes, grouting holes, control holes, sounding holes, and drainage holes etc. from the tunnel, if not otherwise requested by the Engineer.

Percussion drilling equipment shall be capable of drilling holes up to 50 m length in any direction. Percussion drilling equipment shall be available from start of excavation work.

Equipment units for excavation and rock support work may be used when satisfying the above requirements.

Water flushing shall be used during drilling of all grout holes. The use of grease or lubricants on drill rods or use of mud for drilling is not permitted.

After drilling, the hole shall be flushed with water and air. Pumps for supply of air and water for flushing shall be capable of delivering a pressure of minimum 10 bar.

The tolerance for collaring of drill holes is 0.10 m measured from theoretical pattern and for alignment deviation the tolerance is 4% of the depth of the hole.

All drill holes not designated for further use extending beyond planned excavation perimeter shall be grouted with shrink compensated mortar.

8.5.2 *Holes for other Purposes*

The purpose of drilling is indicated under the payment items in the Payment Schedules.

The method of drilling is the choice of the Contractor. The diameter of the hole is the choice of the Contractor, if not specified. The Contractor shall be able to drill long holes in all directions and within the drilling accuracy specified. Steering rods and special bits may be required in order to fulfil these requirements. Efficient equipment is required in order to secure an adequate advance according to the time schedule.

Packers for water pressure testing and grouting shall be available for all drill hole diameters.

All relevant field observations and measurements shall be logged.

Ground water monitoring shall be performed. Ground water levels shall be recorded twice a shift for each hole during drilling operation.

8.5.2.1 Drilling Accuracy:

- Collaring = 0.20m
- Maximum deviation = 4% of drilled length

8.6 LOGGING OF DRILL HOLES

All drill holes shall be logged. The log shall include the following as a minimum.

- Precise location, direction and length of each hole
- Location of weakness zones, including notes on variation in penetration rate and colour of returned flushing water. Location shall be recorded if loss of flushing water occurs.
- Location, nature and quantity of any occurrence seepage.

8.6.1 *Flushing between holes*

If flushing between holes is required, the Contractor shall have available a high capacity water pump (min. 200 l/min. at 50 bar), air compressor and other equipment (radial flushing head) needed for efficient flushing operation.

8.6.2 *Grouting*

Equipment both for cement grouting and chemical grouting shall be available and in working order at any time at the site.

Each unit of equipment for cement grouting shall include, but are not limited to:

- Grout mixer
- Grout agitator
- Grout pump
- Flow meter, pressure gauges for air, water and grout supply lines, grout supply, valves, packers and fittings to supply a continuous flow of grout and an accurate pressure control

The Grout Mixer shall be a high-speed colloidal grout mixer. The mixer shall be capable of mixing grouts with water/ cement ratios between 0.4 and 1.0. An accurate measurement of materials shall take place at the mixer so that mix proportions can be exactly controlled. Cement may be added to the mixer by weight or by volume. Each component added to the mixer shall be measured to an accuracy of +/- 5 %. Minimum mixer capacity shall be 250 liters.

The Grout Agitator shall be capable of keeping grout of specified water-cement ratios (between 0.4 and 10) in suspension. It shall be equipped with screen to remove particles not passing a 4.75 mm sieve. The sump shall be graduated to metric standards so that the volume of grout injected into a hole can be measured accurately. The capacity of the agitator shall not be less than twice that of the mixer.

The grout pumps shall be a progressive cavity, pulse free type, capable of handling thin and viscous grouts with no pulse. The capacity shall be at least 0.08 m3 grout per minute at a discharge pressure of 50 bar, and minimum 0.05 m3 per minute at 100 bar. The pump shall be equipped with a pressure regulating device securing a maximum grouting pressure within ± 10 % of the required pressure. Required working pressure shall be maximum 120 bar.

Pressure gauges shall be Bourdon type or similar of heavy-duty quality and shall measure pressures as appropriate to the range of grouting pressure employed. Two pressure gauges shall be supplied for the grouting plant, one at the header and one at the pump. In addition, a pressure recording unit shall be connected to the pressure line from the grout pump. The dial size of the pressure gauge shall not be less than 150 mm. The pressure recording unit shall record the pressure within ±1 bar. The records may be in analogue or digital form and with the possibility of pressure readings every minute. The Contractor shall supply a calibrated master gauge for each pressure range for checking the accuracy of all gauges used.

The pump and the connected agitator shall be located at a distance of maximum 30 metres from any hole being grouted.

Packer dimension and construction of the packer shall correspond to the diameter of the drill hole, to the drilling method used to produce the hole, and to the applied pressure. Double packers and single packers shall be available. Disposable packers may be used if approved by the Engineer.

For chemical grouting, suitable pumps as well as necessary accessories shall be available. Required working maximum pumping pressure is 250 bar. Equipment shall be compatible with grout data as given by manufacturer. Pumping capacity shall as a minimum be 4 litre/min.

All grouting units shall at all times be clean and in proper working condition. The Contractor shall supply sufficient operating personnel, supervision, labour, spare parts and tools to operate the units at

full capacity and top efficiency. A minimum of three grouting units of each type shall be available at site.

The grouting plant shall be provided with satisfactory storage for supplies of grouting material so that the operations may proceed without interruptions. The plant shall be provided with suitable housing for protection against rain and direct sunshine.

Flexible grouting tubes, both for chemical and for cement grouting, will be required for contact grouting. Acceptable brands are FUKO 2 for cement grouting and Multijet (ULTRA) or FUKO 1 for chemical grouting, or equivalents.

8.6.3 *Grouting Materials*

8.6.3.1 Water

Water for concrete, mortar, grout or curing shall be clean, fresh and free from matter in solution or suspension that may adversely affect the strength, durability or appearance of the Works or cause corrosion on reinforcement and embedded items.

8.6.3.2 Cement

The cements to be used shall be fresh Portland Cements. Transport, handling and storage shall conform to the requirements in the corresponding clauses of the specifications for cement to be used in concrete or as recommended by the manufacturer.

The cement grout shall be of the stable mix type.

The following cement grout types may be used with the approval of the Engineer.

8.6.3.3 Admixtures

The Engineer may require the addition of materials other than those specified above in order to improve the properties of cement grouts with respect to stability, pumpability, acceleration and retarding, and penetration ability. Such admixtures shall include, but are not limited to, micro-silica powder, as well as expanding, water reducing, accelerating and stabilising admixtures.

8.6.4 *Type of Grout*

The following grouts may be used:

8.6.4.1 Cement Grouting

Grouting shall be done according to procedures and criteria approved by the Engineer.

The procedure for cement grouting starts with drilling of grout holes. Before grouting, the hole shall be flushed for 3 minutes or until return water is clean. If the flushing reveals washing out of material into neighbouring holes, a more comprehensive flushing has to be done.

For rock mass grouting at the tunnel face all holes drilled shall be grouted.

Control holes shall be drilled between grouted holes when the grout agents have set, and the grouting will continue in a split spacing system until control holes demonstrate that the required permeability is reached unless otherwise ordered by the Engineer.

Normally, cement grouting is to be performed at high pressure with a cement suspension consisting of cement, water and admixtures as specified. The detailed procedure will be defined during excavation according to the local rock mass conditions.

If grout is pressed from one hole into neighbouring holes, all holes shall be grouted simultaneously according to the procedure described above. The Contractor shall be able to hook up to such holes for simultaneous grouting of up to 5 holes.

The grouting sequence shall start with the leanest grout mix at each packer setting. If the grout take exceeds a certain quantity of cement (will be specified during construction) without increasing grout pressure, a richer grout mix or other grout types shall follow. Grouting is terminated when a predefined pressure level or grout take level has been reached.

Grout type C shall be used for the termination of all holes if not otherwise ordered by the Engineer.

If grout is found to by-pass to rock surface behind the face during grouting, such leaks shall be plugged or caulked. Plugging materials and spill of grout shall be removed as required by the Engineer.

The grout material shall be adequately set (cured) prior to blasting into a grouted area.

The Contractor shall specify the manufacturer and type of grout he intends to use.

8.7 MEASUREMENT AND PAYMENT

The drilling for grouting prices shall be based on the evaluation of the rock conditions. Grouting procedures shall be adapted to local rock mass conditions. Price and/or time adjustments due to geological conditions or drilling- and grouting problems will not be approved and shall be included in the rates.

Payment for the measured quantities as specified below in a) to d) shall include all deliveries, and work described in the Specifications, directed by the Engineer or as required to complete the grouting work according to modern methods and recognised good practice.

For grouting works at the tunnel face shall be paid as a separate item in ToN.

The payment items are as follows:

a) In general, drilling for grouting and exploratory drilling hole will be measured by the metre of drilling as specified, independent of type of drilling and drill hole diameter, all costs inclusive.

b) Cement pressure grouting shall include flushing between drilled holes and will be measured as follows:
   - Packer setting by number of settings and depth interval.
   - Dry weight of consumed cement in the volume of grout of specified type as injected into the rock mass at each packer setting or tube connection in accordance with Specifications or as directed by the Engineer.

c) Time for grouting shall cover all other direct and indirect costs and shall be measured and paid for per shift hour. Grouting time shall be measured from start of grout pumping to end of normal setting time or extended as described under 4.7.2 Cement Grouting.

Price for packer installation shall not be calculated separately.

Time for general grouting underground is to be measured and recorded from the start of grout pumping to the end of the normal setting time for the last hole or pipe/tube grouted. Time lost due to any technical or mechanical break-down of equipment is the Contractor's own responsibility and expense. The price shall be based on three separate mixing and pumping lines.

Use of admixtures, micro-silica powder, expander, accelerator and water reducing, stabilising or other chemical admixtures shall be included in the unit prices of the grouting.

All reporting is to be included in the unit rates and prices.

The quantities measured as specified will be paid at the contract prices included in the Payment Schedules (Bill of Quantities). Prices and payments shall be valid independent of the final amount of work on each item compared to the quantities listed in the Bill of Quantities. No other payments will be approved.

9 CHAPTER 9: ROCK EXCAVATION

9.1 SCOPE

9.1.1 *Coverage*

This Chapter specifies requirements for all underground and above ground open cut rock excavation works. Any excavation method that would fulfil the specified requirements may be used, i.e. drill and blast method and mechanical excavation methods.

The Contractor shall provide all material, labour and equipment and carry out all works, temporary works and tests required for completion of excavation.

The Contractor shall assume full and sole responsibility for safe working conditions in all excavations, and the health and safety of all workers and visitors to the worksite. See also definition in Chapter 10 CHAPTER 10: Rock Support. In addition to any special provisions for safety included in these specifications, all of Contractor's operations shall conform to all applicable laws and regulations.

9.1.2 *Classification and Definition*

9.1.2.1 General

Rock is defined as all materials, which require blasting, or the use of drilling, or the use of mechanical breakers for their removal, and which cannot be extracted by a thirty tons excavator with backhoe with teeth, or equivalent equipment

Boulders larger than 1 m3 shall be classified as rock. Boulders less than this shall be classified as soil.

All types of materials found in rock formations underground shall be classified according to the rock mass quality classification listed below.

The Engineer shall decide if the material shall be classified and measured as Rock, and his decision shall be final.

9.1.2.2 Rock Mass Quality Classification

During excavation of rock, a rock mass quality classification will be performed by the Engineer or Engineer's geologist after each blast to facilitate the decision of the permanent rock support work required. This classification is only for the Engineer's use and has no contractual implication.

Tentative rock Classification has been done based on data available from construction of test adit-5. The actual rock mass classification and corresponding r ock support shall be determined during tunnel excavation stage after consultation and approval of the Engineer.

The rock mass quality will be grouped into five classes, R1 – R5 as defined below.

R1 "Very Good"

R 2 "Good"

R 3 "Fair"

R 4 "Poor"

R 5 “Extremely Poor”

Rock mass classification may be done by the rock mass classification of Q value system or RMR system as required.

9.2 SUBMITTALS BY THE CONTRACTOR

9.2.1 *General*

Submittals that the Contractor is required to make to the Engineer are described below.

The issue time defines the date that the Engineer shall receive the first issue of the documents:

XF = X number of weeks prior to start of manufacture/work as applicable.

XT = X number of weeks after completion of test/inspection/work as applicable.

9.2.2 *Documents*

The Contractor shall prepare and submit documents in accordance with Table 9-1.

Table 9-1: Documents for submittal - rock excavation.

Documentation	Issue for approval	Issue for info.	Issue time
Organisation plan for the rock excavation work showing the responsibilities and the qualifications of the personnel	*		6F
Data sheets for explosives and detonators		*	6F
Excavation procedure for each stretch, including intended rock excavation, removal and deposit method, time schedule and sequence for excavation, rock support and monitoring	*		6F
Description of blasting procedure, including position and depth of holes, types of explosives, size of charges, timing and firing sequences	*		6F
Procedures for geometric control		*	6F
Weekly progress report for excavation, showing planned progress versus actual progress (cut off Sunday at 24:00 hours)		*	1T
Monthly documentation of correct setting out of the excavation contours (cut off last Sunday each month at 24:00 hours)		*	1T

The Engineer's approval does not relieve the Contractor of his sole responsibilities for efficient and successful execution of the work.

9.3 ROCK EXCAVATION

9.3.1 *General Requirements*

Prior to commencement of the work, the Contractor shall submit to the Engineer a plan showing manpower and equipment for excavation and support work intended to be used, spare parts and supplies on the Site, and the expected advance rate of excavation and tunnelling including time for support work. Only experienced supervisors, foremen and well-trained tunnelling crews shall be employed for the work.

The Contractor shall be responsible for the management and sorting of all excavated materials to enable the placement and disposal of materials in accordance with the Contract. Excavated materials shall, according to their nature and to the Contractor's materials management plan, be placed as fills in their final locations in the Works, stockpiled for later placement, used for aggregate production, or removed to a nominated or approved spoil disposal area. All excavated materials belong to the Client and no material shall be removed from the Site without the written approval of the Engineer.

Excavation in rock shall achieve stable, reasonably regular rock slopes and surfaces with as little over-break as possible.

The methods to be used for excavation and support shall be subject to the Engineer's approval.

The Contractor may choose his own methods for drilling, blasting and transporting the rock. Except where otherwise specified, perimeter blasting shall form the final surfaces in underground openings. Charging of drill holes as well as type of ignition, drilling patterns etc., shall be according to modern methods and recognised good practice.

The Contractor shall observe and carry out all excavation work according to rules and regulations regarding the import, transport, storage and use of explosives issued by and public authority having jurisdiction in respect of the same. Detailed records shall be kept by the Contractor and submitted daily to the Engineer giving the types and quantities of explosives used, delivered and in stock. The Contractor shall not later than 6 weeks ahead of start of blasting works, provide the Engineer with a list of blasting licence holders. Only qualified persons shall be permitted to conduct blasting operations.

Where firing is carried out electrically the Contractor shall take all precautions necessary to prevent premature explosions. During thunderstorms and other electrical disturbances charging and firing is not permitted and warning shall be given to all operators when charging is in progress.

An instrument measuring static electricity levels shall be installed at the tunnel portal. The instrument shall be connected to an easily visible warning device.

All metal mains, ducts and tracts shall be properly earthed at the tunnel entrance.

After excavation of soil material, the rock surface shall be sufficiently cleaned for drilling and placing of explosives to the satisfaction of the Engineer. The cleaning shall be done to at least 1.5 m outside theoretical rock contour lines or 1.0 m outside actual contour lines.

The design theoretical rock contour lines and levels of excavations are defined as those shown on the Drawings or specified in the Contract, or as adjusted at site or otherwise determined by the Engineer.

Excavations shall follow the theoretical rock contour lines and levels or such other limits as the Contractor may require enabling him to construct the Works in accordance with the Contract considering collaring accuracy and hole deviation specified. Excavation beyond the theoretical rock contour lines and levels made without the Engineer's direction or approval, including but not limited to, excavation to provide working space and excavation below approved stripping levels, shall be backfilled with concrete at the Contractors expense unless otherwise specified or approved.

The Contractor is responsible for covering and required protection in connection with blasting. Debris from blasting and spill from transportation are not allowed outside the excavation area. The Contractor has to clean up such material as the Engineer finds it necessary. The Contractor shall regularly inspect the excavated faces of all works under his jurisdiction, including temporary and permanent access roads and shall forthwith remove and dispose of any material, which the Engineer and/or the Contractor deem loose or unsafe.

Blasting in the vicinity of completed, or partially completed, concrete structures shall be subject to the Engineer’s consent. Normally, blasting shall not take place in the vicinity of newly concreted structures until 10 days after concreting. The restriction does not apply to blasting close to installed rock support in underground openings.

Before commencing the rock excavation work, the Contractor shall prepare and present to the Engineer a quality assurance plan that ensures that the rock excavation work is performed according to the Contract requirements.

The rock surface shall be inspected after each blast, and action for immediate securing at the face shall be taken as required. The Engineer shall have access to the face and, if considered appropriate, carry out mapping of the rock conditions revealed. In cases of adverse rock conditions or significant deterioration of the conditions the Engineer shall be notified immediately.

9.3.2 *Ventilation*

The ventilation system shall be efficient and reliable during the excavation period in order to provide a safe and comfortable working environment inside tunnels and caverns.

When reaching and penetrating carbonaceous rock the Contractor shall perform measurement of methane gas levels and provide sufficient protection and ventilation against such gases.

Air velocity shall always be higher than 0.3 m/s in the cross sectional area of tunnels and caverns. The air breathed by persons shall contain not less than 19% of oxygen by volume.

The environment inside the tunnel will be governed by seasonal variations in temperature, humidity, rock temperature and by work activities ongoing within the tunnel.

The fan shall be robust and efficient and be capable of providing variable airflow to suit the construction sequence and activity level inside the tunnel as work progresses. The fan shall be supplied complete with all necessary components for commissioning and use.

All components of the duct system shall be non-flammable.

The ducting shall be of a safe robust material. Flexible ducting shall have a high tear resistance and shall be appropriately reinforced and maintained.

The Contractor shall submit detailed information on the systems to be used for the Engineer's review and approval.

9.3.3 *Illumination, Communication and Roadways*

The Contractor shall install and maintain illumination as required for safe and efficient working conditions and inspection of the work executed.

The Contractor shall install and maintain a system of telecommunication at the work fronts.

The Contractor shall maintain all temporary and permanent transport roads in good and dry conditions to facilitate efficient and quick transportation aboveground as well as under-ground.

9.3.4 *Survey*

All surveying shall be carried out as specified in Chapter 5 5: SURVEYING WORK.

9.3.5 *Lightning during Construction*

1. More than 70 lux light level shall be advisable for direct tunneling sites. The clear contrast between light and darkness shall not be made. The Contractor shall supply and install every component associated in order to maintain lighting more than 70 lux. Besides the general lighting system, where any work is being executed or where it is necessary to inspect a part of the underground excavation.
2. The minimum 10 lux light level shall be maintained in the passages in order to secure workers' safe passage and vehicles.
3. Power and lighting wires shall be installed on one side of the tunnel, and the detonator wires shall be installed on the opposite side of communication system. Whenever blasting charges are being prepared, all electric wiring shall be removed for a distance of at least 15m.
4. The warning beacons or signal lamps shall be installed at hazardous places.

9.3.6 *Care of water during construction*

The Contractor shall construct and maintain all neccesary dicersion, conduits and piping, flumes, drains, swamps and other diversion and intercepting works for water supply or drainage works in surfacce and unsedground works and shall furnrish all materials there of.

The Contractor shall also furnish, install, maintain and operate all necessary pupming, piping and other watering and dewatering equipments for construction activities. All parts of surface and underground works shall be maintained free of water as required or instrcuted by Engineer.

Care of water during construction of any volume and discharge in tunnels and also in open cut shall be maintained for the safe working condition by the Contractor. Appropriate handling of water that may

arises during excavation shall be made by the Contractor by adequite pumping or any other draining provision. The payment shall be as per chapter 12.

9.4 OPEN CUT EXCAVATION

Excavation beyond the theoretical rock contour shall wherever possible be backfilled with approved concrete, unless otherwise directed by the Engineer.

The slopes of permanent batters are assumed to be vertical unless other slopes are given on the Drawings or directed by the Engineer.

In the Bill of Quantities rock excavation is divided into the following categories:

- Bulk rock excavation, and
- Trench/ditch rock excavation with bottom width less than 2.0 m

9.5 UNDERGROUND EXCAVATION

Underground excavation comprises excavation of the tunnel as shown on Drawings or as directed by the Engineer. Any recesses, trenches, enlargements etc. required by and for the Contractor sole use will not be measured for payment.

The excavation procedure shall always be adapted to the local rock mass conditions. When traversing weakness zones or other areas of heavily jointed or otherwise incompetent rock, pilot tunnelling, dividing of the section, and/or advancing with shorter pull than normal may become necessary. Spilling, immediate application of sprayed concrete, reinforced sprayed concrete lining, pressure grouting or other support measures, further described in Chapter 8 and Chapter 10, may also be required. The methods to be used for excavation and support shall be subject to the Engineer's approval.

A rigid template of the same shape and dimensions as the theoretical cross-section shall pass through. Deviation of the theoretical cross section from the centre line will not be approved.

Any subsequent slashing, wedging or re-drilling of rock that may be necessary in order to meet the above requirements is the responsibility and cost of the Contractor.

Control of compliance with the design requirements shall be carried out by the Contractor at regular intervals as directed by the Engineer.

9.6 OPEN CUT AND UNDERGROUND EXCAVATION METHODOLOGY: DRILLING/BLASTING

9.6.1 *General*

Prior to starting rock at the tunnel portal the Contractor shall, after notifying the Engineer, carry out a survey of the surface of the rock as agreed by the Engineer. (See also Chapter 5 5: SURVEYING WORK)

Before commencing any drilling and blasting the Contractor shall submit for the Engineer's approval the drilling-, charging- and ignition patterns he proposes to use. Such approval shall, however, not exempt the Contractor of the full liability of any blasting operations.

The drilling equipment shall include a device for measuring the direction of drilling.

In order to minimise over-break and requirements for rock support, perimeter blasting (soft blasting smooth contour blasting technique) shall be used on all final rock surfaces.

The length and size of blast rounds shall be regulated according to the prevailing rock conditions. When deemed necessary from stability considerations, the Engineer can order reduced round lengths and/or subdivision of the cross section.

When deemed necessary from stability considerations, the Engineer can order change in excavation shape, both the arch height and the symmetry, within the given cross-sectional area.

Design drawings show the theoretical rock contour. Special rock mass conditions may require cross-section adjustments, which shall be decided and/or approved by the Engineer.

9.6.2 *Excavation Tolerances*

The excavated area shall at no point be less than the theoretical area for each section given on the Drawings. Rock protrusions inside theoretical contour lines are not accepted.

If the Contractor considers it necessary to request for excavation outside theoretical contour to obtain access for his own purpose, such request shall be forwarded to the Engineer and the work shall be at the Contractor's own cost and time.

9.6.3 *Drilling Accuracy*

The general requirements for drilling accuracy are as shown in Table 9-2.

Table 9-2: Drilling Accuracy

Excavation	Drill holes/row	Collaring	Alignment
Aboveground	Contour holes	100 mm	2% of depth of hole
Aboveground	Next rows	200 mm	2% of depth of hole
Underground	Contour holes	100 mm	4% of depth of hole
Underground	Next rows	200 mm	6% of depth of hole

9.6.4 *Perimeter Blasting*

9.6.4.1 General

Perimeter blasting shall be applied on contours in order to ensure smooth final surfaces, minimise over-break and reduce the subsequent support measures. Smooth blasting shall be applied.

As a general rule the distance between the perimeter and the nearest row of holes of the main round shall be 1.3 times the spacing of perimeter holes for smooth blasting. The selection of these and other pertinent parameters shall be based on experience gained from the initial rounds, and shall be subject to the approval of the Engineer.

9.6.4.2 Smooth Blasting

The result of smooth blasting is governed by the following parameters:

- diameter of contour holes
- spacing of contour holes

- distance between the row of contour holes and next row of holes (burden)
- type and size of charges used
- ignition pattern

The method is based on closely spaced contour holes, with reduced charges to be fired as a final clean-blast after the main round on the last number of delays. The method shall prevent extensive fracturing of the rock mass beyond the contour.

9.7 UTILISATION OF MATERIALS

Excavated materials shall be used for forming of fills and in road body or placed in approved spoil tip. Some of the materials are to be processed for use as filter and erosion protection. Unless designated by Drawings or by the Engineer spoil areas shall approved by the Engineer. Treatment and works at fill and/or spoil areas are covered under Chapter 6 CHAPTER 6: Earthworks.

9.8 MEASUREMENT AND PAYMENT

9.8.1 *General*

The rock excavation prices shall be based on the evaluation of the rock conditions. Excavation and rock support procedures shall be adapted to the rock mass conditions encountered in the tunnel and outside the tunnel i.e. in open cut. When traversing unfavourable rock masses, suitable combinations of excavation methods and rock support methods described in the Contract shall be used. The rates given in the Bill of Quantities include all problems related to this and no price or time adjustments will be approved.

The cost of explosives and explosive management, including the supply, transportation, storage, and handling of explosives required for earthwork excavation by blasting, is included in the relevant BoQ item and is payable as a Lump Sum (LS) item in chapter 14.

The rates for excavation shall also include, but are not limited to:

- Survey, scaling and cleaning necessary for drilling and supply and delivery and placing (charging) of explosives
- The use of non-electric ignition system
- Normal over-break
- Any required slashing or wedging of rock protrusions inside the theoretical rock contour.
- Excavation beyond the theoretical contour and backfilling of the same with approved concrete or otherwise as the Engineer may direct unless the excavation is ordered by the Engineer or caused by abnormal overbreak (applicable in areas that are to be concrete lined).
- Mucking out and transport of excavated material (including over-break, scaled materials or other materials) to fill and/or spoil deposit areas. Work at the fill and/or spoil deposit areas are covered by Chapter 6 Earthworks

- All shaping, cleaning, neat and safe working fronts and tunnel behind face and care of water in tunnels, access to tunnel face if not otherwise specified in bill of quantity shall be maintained by the Contractor own cost.
- Construction and maintenance of temporary services such as adequate roadways, drainage including all pumping as necessary, all pipes, cables, ventilation, illumination, lightning protection, earthing and fire protection, communication systems etc. except if separate pay item is included in the Bill of Quantities.
- Scaling and surveying as required after each round before mucking out.
- Scaling as required after mucking out (See definition below)
- Weekly inspection and scaling as required of previously excavated openings as a regular safety precaution (See definition below)
- Removal of all temporary service installations with fixtures after completion of works
- All required surveying works.

9.8.2 *Abnormal Over-break*

Extra payment for excavation shall only be made for abnormal over-break as defined below.

Abnormal over-break shall mean which in the opinion of the Engineer cannot be prevented in spite of reasonable care by the Contractor. Abnormal over-break shall be measured as volume in its natural state beyond the limits stated above of the theoretical rock contour except that abnormal over-break in the floor of open cuts, tunnels or other excavations inclined at less than 30º shall not be measured. The rate shall cover all works required, such as loading, transport and tipping etc. Filling of over-break, which is approved as abnormal, shall be paid for in addition.

9.8.3 *Smooth Blasting*

Blasting with contour hole spacing of 450 mm shall be included in all excavation rates. For blasting with contour hole spacing less than 450 mm, instructed by the Engineer, the payment for the additional length (m) of contour holes at the given rates applies.

9.8.4 *Open Cut Excavation*

Rock excavation shall be measured by volume in its natural state as bulk excavation or as trench/ditch excavation. Rock excavation shall be measured based on surveying of the exposed and cleaned rock surface and to the theoretical contour shown on the Drawings or as directed by the Engineer.

Trench excavation shall apply for rock excavation with a bottom width less than 2.0 m.

Foundation excavation will unless otherwise shown on drawings or instructed by the Engineer be measured as defined above. Bracing of the sides if required will not be measured and shall be included in the rate for the excavation.

Rock excavation for mobilisation areas and Contractor temporary works/facilities will not be measured for payment.

No extra payment will be made for water handling, including keeping all excavation fronts dry and free of water.

All subdivision of rounds, all construction and maintenance of temporary services and all scaling and cleaning of slope and foundation surfaces shall be included in the unit price for rock excavation if separate items for such work are not listed.

9.8.5 *Underground Excavation*

Measurement and payment underground excavation shall be made on the basis of excavated volume in cubic meters in its natural state determined by the specified dimensions with the payline with actual surveyed as shown drawing and as directed by the Engineer. The pay line shall be considered as maximum +100 mm from the excavation line.

Tunnels with uniform cross-section shall be measured by net length along the centre lines, not horizontal length. At intersection of under-ground openings the larger opening shall be measured through to the branch, and the branch shall be measured from the imaginary wall of the larger opening.

The volume measured for excavation of other underground openings shall be calculated to the theoretical contour shown on the Drawings or, if no theoretical contour is shown, to the net dimensions of the volumes to be excavated.

Rock excavation for mobilisation areas and temporary works for the Contractor's own purpose will not be measured for payment.

Payment for care of water will be made for water handling, including keeping all excavation fronts and access dry and free of water under chapter 12 Care of water during Construction.

9.8.6 *Haulage, transportation and disposal of excavated materials*

The Contract Unit Rate for excavation shall be deemed to include mucking, loading, hauling, unloading, and disposal of excavated material

All loading, transportation to fill or spoil areas, and all works required at the designated disposal site shall be deemed included in the relevant excavation BoQ item.

No separate payment shall be made for these activities.

10 CHAPTER 10: ROCK SUPPORT

10.1 SCOPE

10.1.1 *Coverage*

This Chapter comprises all work intended to support and stabilise the rock whether of initial or permanent nature, in Portal, open cuts or in underground openings.

The Contractor shall provide all material, labour and equipment and carry out all works, temporary works and tests required for completion of the work.

The Contractor shall assume full and sole responsibility for safe working conditions for all excavations and the health and safety of all workers and visitors to the work during the construction period. In addition to provisions for safety included in these specifications and elsewhere in the Contract, all of Contractor's operations shall conform to all applicable laws and regulations.

10.1.2 *Classification and Definition*

10.1.2.1 General

Support work shall be carried out in accordance with the following definitions:

"Initial rock support" shall mean support work necessary to ensure safe working conditions and to maintain the shape of the rock excavation during the construction period.

"Additional rock support" shall mean all support work necessary to ensure the permanent long-term stability of the excavations.

"Support work at the face" shall mean all support work interrupting the normal excavation cycles, except that all support work carried out in caverns and above ground, in open cuts etc., shall be regarded and measured as support work behind the face.

"Support work behind the face" shall mean all support work not being measured as carried out at the face.

The rock support consists of combinations of scaling, rock bolts, sprayed concrete, several forms for reinforcement for the sprayed concrete including lattice girders and full concrete lining.

10.1.2.2 Rock Mass Quality Classification

During excavation a rock mass quality classification will be performed by the Engineer after each blast, ref. Section 9.1.2.2

10.1.2.3 Rock Support Classification

The basic Rock Support resources (RS) used for each rock mass category (R) are in principle listed as follows:

R1 => RS 1: Scaling, spot bolts and steel fibre or welded wire mesh reinforced sprayed concrete.

R2 => RS 2: Scaling. Spot bolting for smaller cross-sections. Pattern bolting in the crown and applied fibre or welded wire mesh reinforced sprayed concrete.

R3 => RS 3: Scaling. Pattern bolting and minimum one layer of fibre or welded wire mesh reinforced sprayed concrete in crown and walls for smaller cross-section. For larger cross-sections number/length of bolts and thickness of sprayed concrete depend on the cross-section.

R4 => RS 4: Pattern bolting and a minimum of two layers of fibre or welded wire mesh reinforced sprayed concrete in crown and walls for smaller cross-section. Occasionally (i.e. on 10 - 20% of the length) reinforced ribs of rebars/lattice girders and sprayed concrete or concrete lining. Occasionally, concreting of the invert at face. For larger cross-sections number/length of bolts and thickness of sprayed concrete depend on the cross-section. Also applies to short blasting rounds and subdivision of rounds depending on cross-section.

R5 => RS 5: Pattern bolting and spiling bolts. Fibre reinforced shotcrete or two layers of wiremesh and sprayed shotcrete. Application of reinforced ribs of rebars/lattice girders/ I-beam and sprayed concrete at the face and concrete lining behind the face as required. Reinforced ribs may be omitted if concrete lining is cast at the face. Concreting of the invert at face. Number/length of bolts and the thickness of sprayed concrete as well as the distance between the lattice girders depend on the cross-section. Also applies to systematic short rounds for small cross-sections and subdivided rounds or multiple drifts for larger cross-sections.

Note that in categories RS 1, RS 2 and RS 3 safety considerations dictate a thickness as per Drawings or welded wiremesh reinforced sprayed concrete in roof and abutments in caverns and other relevant underground openings.

In unstable rock masses of category R5, designated for permanent support by concrete lining, temporary support may be provided by welded or bolted steel arches of 150mm I-beam for later embedment in the concrete lining. The steel arches shall be installed on concrete foundations to rock.

The general rock support classification according to the above support categories shall be as per specified in the drawings. However, Contractor shall propose the support system as per the requirement of the sites based on the principle, practice, as specified in drawing and shall be subject to Engineer approval. Any additional support requirement shall be as instructed by Engineer and Contractor shall purpose the additional support if required shall be substantiated by instrumentation results made by Contractor on own costs or other site and safety evidences and subject to Engineer approval.

10.2 REFERENCE STANDARDS

The work shall be performed according to relevant standards, or if no standards exist, according to recognised practice approved by the Engineer.

10.3 SUBMISSIONS BY THE CONTRACTOR

10.3.1 *General*

Submissions, which the Contractor is required to make to the Engineer are described in below.

The issue time defines the date that the Engineer shall receive the first issue of the documents:

XF = X number of weeks prior to start of manufacture/work as applicable.

XT = X number of weeks after completion of test/inspection/work as applicable.

10.3.2 *Documents*

The Contractor shall prepare and submit documents in accordance with Table 10-1.

Table 10-1: Submittals of Documents - Rock support

Item	Issue for approval	Issue for info	Issue time
Detailed work plan showing procedures for rock support application	*		3F
Data sheets and samples for rock bolts and anchors including accessories, rock straps, ready mixed mortars and admixtures for grout.	*		3F
Data sheets for equipment for application of sprayed concrete		*	3F
Data sheets and samples for the different types of cement, fibres, lattice girders, chemical admixtures and micro silica	*		3F
Detailed plan showing design and instalment of steel arches for temporary support	*		3F
Rock bolting and sprayed concrete reports including all records of rock bolting and sprayed concrete performed		*	3T

The Engineer's approval does not exempt the Contractor of his sole responsibilities for efficient and successful execution of the work.

10.3.3 *Test Reports*

The Contractor shall make tests and prepare and submit test reports in accordance with Table 10-2.

Table 10-2: Submittals of Test Reports

Item	Issue for approval	Issue for info	Issue time
Pre-construction test reports as specified		*	6F
Test reports for all tests during construction		*	4T

10.3.4 *Certificates*

The Contractor shall submit manufacturers' and suppliers' certificates of compliance with the relevant standards.

10.4 GENERAL

10.4.1 *Inspection of Tunnel, Marking of Chainage, Wash-down*

The Contractor shall inspect the rock face jointly with the Engineer as soon as practical after excavation of each round of blasting. Further, inspections with use of a mobile platform shall be done with no longer intervals than 2 weeks and shall cover the sections/areas where the Contractor has completed the bi-weekly scaling during this period.

The Contractor shall clearly mark the chainage of the tunnels for every 10 m. The chainage marking shall be done with red spray paint on the right tunnel wall, 1.5 - 2.0 m above the invert. The accuracy of the chainage marking shall be within ±250 mm. The maximum distance between the tunnel face and the last chainage mark shall be 25 m. If the marking due to wear and dirt becomes difficult to read, it shall be washed and/ or repainted.

Wash-down of excavated surfaces by water flushing shall be done after mucking of each round.

The Engineer's/ Employer's geologist will regularly after blasting perform geological mapping of the rock mass. This mapping will normally be done after mucking and will not disturb the Contractor's work. In special cases, the Engineer will order suspension of excavation works in order to perform more thoroughly mapping or investigations.

10.4.2 *Rock Support*

The aim of rock support is both to provide safe working conditions during construction and a sufficient long-term stability of the access tunnel. Safe working conditions, which are the responsibility of the Contractor, are to be taken care of by the initial rock support. For long-term stability, extent of additional rock support will be decided by the Engineer.

The terms initial rock support and additional rock support are used only for a classification of rock support works in regard to responsibility for decision making, and may both occur at the face and behind the face and shall not influence on measurement and/or payment. The terms "at the face" and "behind the face" are used for differentiation of payment of rock support works.

Initial rock support will normally consist of scaling, end anchored and/or fully grouted rock bolts, rock straps, wire mesh, sprayed concrete or combination of these methods. In cases of very poor and extremely poor rock mass quality lattice girders in combination with sprayed concrete will be needed.

Additional rock support will normally consist of cement grouted rock bolts and/or sprayed concrete with various reinforcement methods. Cast in place concrete lining might also be required. For additional long-term support fully grouted rebar bolts (dowels) may be used.

The initial support shall be incorporated in the long-term support. Materials for initial rock support shall therefore be of a long-term quality. The Contractor shall inspect rock surfaces jointly with the Engineer as soon as practical after blasting/excavation and shall recommend to the Engineer the type and extent of initial support. The type, extent and details of support to be installed shall be subject to the Engineer's consent. The Engineer may consent to the Contractor's proposals or may direct the

Contractor to increase the amount of support or change the type of support as part of the additional rock support. The Engineer will define additional rock support prior to completion of the excavation work.

The failure of the Engineer to consent to the Contractor's recommendations on rock support does not exempt the Contractor of his responsibility for the safety of the work. No statement in this Specification shall be exempted the Contractor from the sole responsibility for safe working conditions in the underground openings or from liability for injuries or to deaths of persons or to damage to property. Consent to a reach as unsupported shall in no way exempt the Contractor of responsibilities or liabilities and will not preclude the Engineer from requiring supports in the reach at a later stage if signs of instability of the rock mass are indicated.

If at any time the Contractor has reason to believe that additional support, beyond that previously consented to by the Engineer, may be necessary for the safety and integrity of any rock surface, the Contractor shall promptly bring the matter to the Engineer's attention together with the Contractor's recommendation as to the type and extent of additional necessary support with supporting clarification and evidences.

The scheduling for installation of rock support shall be the responsibility of the Contractor, and is subject to the consent of the Engineer. Additional rock support of long-term duration shall be installed behind the tunnel face where the work does not cause delays in the excavation progress. The Engineer might in special cases request such support to be applied at or immediately behind the working face.

If the Contractor considers it necessary to request excavation outside the theoretical contour to obtain access for his own purposes, such request shall be forwarded to the Engineer, and the work, including all initial as well as all additional support, shall be at the Contractor's cost and time. The Engineer may also require such excavations backfilled with concrete, at the Contractor's cost and time.

10.5 SCALING

10.5.1 *General*

Scaling works are classified into basic scaling and additional scaling.

Both the basic scaling and the additional scaling are to be performed in accordance with the best prevailing practice. It is required that the Contractor keeps available equipment in efficient working order for the scaling works, such as:

- scaling rods
- scaling platform to be mounted on shovel
- hydraulic scaling hammer to be mounted on the boom of an excavator
- equipment for cleaning/scaling by high-pressure water flushing

10.5.2 *Basic Scaling*

Basic scaling is included in the excavation procedure and covers scaling at the face, bi-weekly scaling and final scaling as follows:

a) Scaling at the face:

Defined as a routine scaling after each blasting round, in order to comply with the safety requirement and requirement of surface treatment, before application of sprayed concrete.

b) Bi-weekly scaling:

All scaling needed in walls and roof for the section excavated during the last 2 weeks, plus an overlap of 30 m of the former bi-weekly scaling section. A measure for completed scaling is that there are no stones larger than 0.001 m3 (1 dm3) which are possible to remove by manual use of scaling rods, or as instructed by the Engineer. If the bi-weekly scaling is not performed satisfactorily, the Engineer may request the blasting works stopped until the scaling is found acceptable.

c) Final scaling:

Before handing over the Works, a final scaling shall be performed prior to release of the work site for other activities. The required level for completed scaling is as described under b).

10.5.3 *Additional Scaling*

Additional scaling is scaling ordered by the Engineer.

a) Extra scaling:

Extra scaling comes in addition to the basic scaling in order to comply with the requirement defined under b), at the face or behind the face.

b) Invert cleaning and scaling:

Removal of temporary road dressing material, scaling of rock with scaling rods, and high-pressure water flushing, 20 mm nozzle and minimum pressure 10 bar. Max. 0.001 m3 remaining loose materials accepted per 5 m2 of tunnel invert.

c) Chisel scaling:

All loose and drummy rock (hollow sound) is to be removed to the degree, which is possible by chisels.

d) High-pressure water flushing of rock surface:

All loose rock is to be removed to the degree possible by high-pressure flushing with combined water and air, 20 mm nozzle and minimum pressure 10 bar.

10.6 ROCK BOLTS AND ACCESSORIES

10.6.1 *Materials*

(a) Rock bolts of the following types may be used as per Bill of Quantity, specified drawing, and as instructed by Engineer:

- 4 m long 25mm dia rock bolt
- 5 m long 25mm dia rock bolt
- 6 m long 25mm dia rock bolt

(b) Rockbolts shall be of the type shown on the Drawings or an equivalent approved by the Engineer.

(c) The Contractor shall furnish with each rockbolt all accessories including a chemical or mechanical anchor, a steel bearing plate, a ball-washer, a machine washer, a hexagonal nut and where cement

grouting is required a rubber plug and accessories for grouting. The bearing plate shall have a bearing area of not less than 225 square centimetres per bolt and minimum thickness of 10 mm. Where cement or other approved grouting is required the bearing plate shall have two holes suitable to permit grouting and venting operations and shall be suitably located to ensure the whole length of the rockbolt can be fully encapsulated in grout.

(d) Where rockbolts are required for permanent support, the bearing plate, the nut, and the ball and machine washers shall be coated by hot-dip galvanising and the mass of the coating shall be not less than 0.6 kg/m2.

(e) The Contractor shall supply test certificates for each batch of each size and type of rockbolts manufactured and delivered to site. In addition, one bolt in every 100 of each size and type shall be tested by the Contractor in the presence of the Engineer to the ultimate strength of the bolt. When tests show satisfactory results the number of tests may be reduced, and if failures occur then additional tests, which may include testing each bolt, will be required. All failed bolts shall be replaced.

The cement mortar used for grouting of rock bolts shall comply with the following requirements:

- Shall not react chemically with zinc coating
- Expansion 1 - 3 %, to be completed before completed hardening of the grout
- Max. grain size 0.5 mm
- Compressive strength min. 45 MPa at 28 days

Resin end anchored bolts shall be hot-dip zinc and epoxy coated. Fully grouted rock bolts shall as a minimum be hot dip zinc coated. Additional epoxy coating will be required unless the grouting material for bolting has been verified not to cause undesired chemical reactions with the zinc coating.

The tensioning of all the rock bolts in the corresponding reach shall be checked as part of the bi-weekly scaling. In case of loose bolts, the bolts shall be re-tensioned. In case of overbreak around other bolts ends, re-drilling and/or resetting of bolts shall be done.

10.6.2 *Patterns of Installation*

(a) The patterns in which the rockbolts are installed for permanent and temporary support shall be as required to ensure stability of the excavation.

(b) The types of rockbolts in surface excavations, together with specified loads are shown in the following table. The Contractor shall furnish bars with threaded ends not less than 180 mm in length for use as rockbolts.

Rockbolt Type	Minimum Yield Strength	Minimum Thread Diameter (mm)
Grouted	500 MPa	24

(c) The types of rockbolts in underground excavations, together with specified loads are shown on the following table. The Contractor shall furnish bars with threaded ends not less than 180 mm in length for use as rockbolts.

Rockbolt Type	Minimum Yield Strength	Class of Support	Mimimum Thread Diameter (mm)
Grouted/ungrouted	500 MPa	Temporary/ permanent	24

(d) The Contractor shall use only rockbolts that meet the requirements of this Technical Requirements. The method of installation shall be in accordance with the requirements of this Technical Requirements or the manufacturer's recommendation after approval by Engineer.

(e) The Contractor may nominate the use of:

- Rockbolts which are longer than 10 m, in which case the Contractor may fabricate the lengths on site provided the steel type and diameter meet the specific requirements and the couplers comply with the manufacturer's specification. The couplings shall have a centre stop so that each section of the rockbolt is connected by an equal length of thread. The diameter of the drilled hole shall be increased to ensure the coupler is embedded in the same thickness of grout as is the approved rockbolt without couplers.
- Flat steel plates and rolled steel sections fastened by rockbolts.

5.1.1 Methods of Installation

(a) The rockbolts and methods of installation, including the details of the equipment necessary to drill the hole, to clean out the drilled hole, to anchor the rockbolt in the hole and test the anchorage, to tension the rockbolt to the specified axial load and to grout the rockbolt, if required, shall be in accordance with the manufacturer's instructions.

(b) In surface excavations the Contractor shall plan its operations so that routine installation of rockbolts, including grouting and the erection of steel mesh reinforcement and steel reinforcing fabric, unless otherwise approved, can be performed as the excavation proceeds. Excavation shall not proceed more than 2 m below the level of any designed or directed rockbolts until the rockbolts are installed, and grouted.

(c) In underground excavations the Contractor shall plan its operations so that routine installation of rockbolts, including grouting, can be carried out up to the face.

(d) Holes for rockbolts shall be drilled accurately to the depths and at locations and orientations

shown on the Drawings. Hole diameters shall be compatible with the rockbolt diameter and in accordance with the manufacturer's recommendations. Hole orientations shall be within 3 degrees of those specified. Where resin anchorages are used, the hole length shall not exceed the placed length of the bolt by more than 100 mm.

(e) When rockbolt support is required, the hole shall be drilled and cleaned out immediately and the rockbolt shall then be installed and tensioned without any further delay.

(f) Each rockbolt shall be tensioned to the specified axial load using a calibrated hydraulic jacking system. The nut shall be done up until the gauge on the jack registers that the nut has began to take the load of the jack. The jack shall then be released smoothly. The Contractor shall provide calibration curves and test certificates for the jack. The calibration check must have been performed within the last twelve months by an independent testing authority acceptable to the Engineer. Recalibration shall be performed at least once every twelve (12) months or sooner if considered by the Engineer to be necessary for any reason. If a calibrated torque wrench is used, the wrench shall be tested daily by approved means. If a torque wrench is used, all threads and washers shall be clean and greased to ensure that friction is the same for each rockbolt. If any discrepancy is found in the daily calibration then the rockbolts tested on the previous day shall be retested.

(g) Where rockbolts have been installed and tensioned within 12 m of any blasting work, the tension of each bolt will be checked and each bolt retensioned, if necessary, to achieve the specified load.

(h) Immediately prior to grouting each rockbolt in place the Contractor shall check that the required tension in each bolt has not been relaxed. Grouting shall not commence until all loosened bolts have been retensioned to the required axial load.

10.6.3 *Accessories*

The Contractor shall provide all necessary accessories, additional boreholes where required or other items necessary for installation and anchoring or grouting of the bolts.

Chain linked mesh, welded wire fabric and steel straps with necessary accessories will be required in special cases. Such accessories shall have double corrosion protection (combi-coat or equivalent), complying with clauses above.

The dimensions are (in millimetres):

Welded wire fabric (wire mesh):	100 x 100 x 4.75

10.6.4 *Execution*

10.6.4.1 Drilling and Installation of Resin End-anchored Bolts

Resin-end anchored bolts shall be installed in accordance with the manufacturer's issued written instruction.

The bolts shall have an anchored length of minimum 250 mm in high strength rock types (unconfined compressive strength, UCS, >150 MN/m2) and 500 mm in medium strength rock types (50<UCS< 150 MN/m2). For low strength rock types the minimum anchored length shall be 1 m. The diameter of the boreholes' inner end shall be 10 to 12 mm larger than the bolt diameter.

The bolts may be installed in a systematic, predetermined pattern, or as spot bolts.

10.6.4.2 Drilling and Installation of Fully Cement-grouted Bolts

Fully grouted deformed steel bars with or without expansion shell end anchoring shall be installed in accordance with the following instructions:

1) Rock bolts may be installed in a systematic and predetermined pattern, or as spot bolts as directed by the Engineer. Rock bolts shall be installed perpendicular to the rock perimeter, or otherwise as directed by the Engineer.
2) The diameter of the drill holes shall be minimum 13 mm and maximum 38 mm larger than diameter of the rock bolt.
3) Drill holes shall be flushed with water in their entire length before grouting.
4) Rock bolts shall be cleaned to remove dirt, grease or any other impurities before installation.
5) The entire hole shall be filled with mortar (grout) before installation of the bolt.
6) In upward slanting boreholes measures shall be taken to prevent loss of mortar. The bolt shall then be secured by wedges or other means to prevent movement during hardening of the mortar.
7) Bolt ends shall not protrude more than 50 mm outside nuts if not otherwise decided by the Engineer.
8) Anchor plate, washers and nuts may be located outside or within the reinforced sprayed concrete. In conjunction with welded wire fabric or rock straps, the rock bolts shall be installed in depressions of rock surface if possible.
9) The nut of grouted rock bolts shall be tightened to achieve a force at anchor plate of approximately 20 kN. Tightening can be carried out when minimum 2 MPa grout strength has been obtained.
10) For grouted expansion-shell bolts, the maximum working load shall be limited to 50% of the ultimate load, when pre-stressed before grouting.

10.6.5 *Testing*

Documentation of properties of grouts to be used for grouting of rock bolts shall be submitted to the Engineer. The grout properties to be documented will comprise, but are not limited to, consistency, setting time, strength after 1, 7 and 28 days, porosity, expansion and permeability of hardened grout.

The Contractor shall fill in Quality Control forms which state type of rock bolts and accessories, condition of corrosion protection, installation method and tensioning.

The Contractor shall perform quality control of rock bolt installation according to the Quality Control Procedure described by the Engineer. The Engineer's control Engineer shall have free access to participate in the quality control.

End anchored rock bolts are to be tested by pull test. Installation procedure for grouted rock bolts is to be verified by test grouting of rock bolts in plastic tubes.

The following control categories shall be included in the Quality Control Procedure:

Category I - Visual control of bolts and accessories

Visual control of corrosion protective coatings on rock bolts and accessories to be carried out prior to installation. In case of any damage to epoxy/ polyester coating, mending is to be performed with a result complying with the requirements for epoxy/polyester coating. In case the damage penetrates the zinc layer, rock bolts or accessories will not be accepted.

Category II - Pull tests

Pull tests shall be carried out by use of hydraulic jack with a pull force of 80% of the yield strength. Required number of tests for a given bolted area and required number of acceptable results for approval of the bolted area are defined below.

Category III Test grouting of bolts in plastic tubes

This test shall be performed concurrent with bolting of a defined area or tunnel interval. Assessment of number of test bolts is described below.

Tubes with internal diameter equal to the drill hole diameter, are mounted in a rack, and test bolts inserted and grouted using the same grout and the same method as for the rock bolting.

After 10 hours of hardening, the plastic tube is removed. If less than 95% of the bolt surface within the tube turns out covered by grout, that specific bolt shall be rejected.

The number of accepted test bolts required for approval of the given area or tunnel interval is defined below.

10.6.6 *Criteria for Assessment of Test Numbers and Acceptance of Test Results*

The method for selection of test bolts shall comply with International Standard ISO 2859-1 “Sampling procedures and tables for inspection by attributes”. The Engineer will choose the areas or the tunnel reaches to be tested. The Engineer will define bolt groups in the range from 200 to 500 bolts as lots for inspection (testing). Number of test samples will be decided in accordance with ISO 2859-1, Table I, general inspection level II. A lot comprising 151 - 280 bolts require sample size G of 32 bolts for normal or tightened control, or 13 bolts for reduced control. Or as per Engineer approval

Evaluation of results will be in accordance with Table IIA (single normal control) or Table IIB (single tightened control), with Acceptable Quality Level AQL 4.0. With normal inspection (testing), only 2 test failures are acceptable for a size G sample. Upgrading from normal to tightened control regime is done (according to ISO 2859-1) “when two out of five or less tested lots have been non-acceptable on original inspection (that is, ignoring re-submitted lots or batches for this procedure)”. With tightened control only 1 test failure is accepted for sample size G. “When tightened inspection is carried out, normal inspection shall be reverted to when five consecutive lots have been considered acceptable on original inspection”. Procedures for switching from normal to reduced testing and from reduced to normal testing are described in ISO 2859-1.

10.6.6.1 Measures to be taken in Case of Rejection and Re-bolting

If the test results for a defined group of end anchored rock bolts do not satisfy the requirements, control of all bolts in the group will be demanded. Bolts, which do not pass the pull test with a pull force of 80% of the yield strength, shall be replaced by the Contractor at his own cost.

If the test results for a given group of grouted rock bolts do not satisfy the requirements stated by AQL 4.0 in ISO 2859-1, the payment for the bolts in that group will be reduced by 25%, and the Engineer will require additional bolting at the Contactor's cost to correct the deficiency in quality.

10.7 ROCK DOWELS

Rock dowels shall be applied in open cut rock excavation in portal area and other surface excavation and in slope protection. Deformed steel bars and plain steel bars shall conform to Minimum Yield Strength of 500 MPa.

The dowel shall be fully cement grouted and tightened by the base plate and nut bolts. The material for deformed bar, cement grouting, nut bolts, base plate shall be same as that of rock bolt as specified in the specification.

10.8 SPILES

1. Reinforcing of the rock mass ahead of the tunnel face with long rock bolts (spiles) is termed spiling. This support method may be applied for particularly unstable rock, to restrict deformation of the surrounding rock, and to prevent cave-ins following the subsequent rounds.
2. The spiling holes shall be drilled from the perimeter of the tunnel face, slanting outwards into the rock surrounding the tunnel stretch ahead. Deformed steel bars shall be placed in the holes.
3. Pipe roof method, consolidation grouting method, umbrella arch method (grouted pipe spiling) and fore-poling are applied for stabilization of the MAT crown. Rock bolts and shotcrete are applied to the tunnel faces and walls. In case where the above methods are applied as auxiliary methods, the Contractor's construction plans for auxiliary methods in view of safety, constructability and cost-effectiveness shall be approved by the Employer.
4. In case of pipe roof methods construction, pipes upto 12m length shall be driven below 5°. on the outside of steel supports when installed. Spacing of pipes shall be determined to install considering ground conditions, earth pressures, constructability, and excavation methods. Construction process shall be conducted within 2.0~3.5 times of outer pipe diameter except for very soft clay grounds.
5. In case where consolidation grouting method for the purpose of reinforcing fracture zones and cut-off for ground inflows is performed, the Contractor shall propose to determine grout materials, injection pressure and injection coverage, and injection methods. Pre-grouting construction plan shall include the aforesaid manners and management. In case when cement paste is incorporated as primary grout material, any blasting operations shall not be permitted within twenty-four (24) hours upon completion of the previous grouting.
6. In case when umbrella arch method (grouted pipe spiling) is conducted, the pipe materials shall withstand bending moment and loads. Installation spacing, in practice, is 0.3 m ~ 0.6 m, the

arrangements shall be efficiently made considering ground conditions. The construction methods for umbrella arch method (grouted pipe spiling) shall include the Specification of pipe materials, grout materials category, test results, injecting pressure and injection quantity along with its management.

7. In case when forepoling method is adopted, reinforcing bars, round steel bars up to 6m length may be incorporated into the forepoling system. If the forepoling angle is higher than required, the ground stabilization effect would diminish thereafter. Thus, forepoling angles shall be 5°-7°. In order to enhance stabilization effect of crown, pipes support shall be effectively overlapped for heading directions. The overlapping length shall be pre-approved by the Engineer.
8. In order to secure the face stability, rock-bolts may be installed horizontal to faces. Spacing of rock bolts and lengths shall be determined by geological conditions at the sites.
9. In case where shotcreting is performed in order to mitigate stress concentration and increase shear strength at face, the shotcrete process shall be made prior to the ground relaxation. If excavation is suspended in the long term, shotcreting to faces shall be made.
10. The further details on auxiliary methods shall be subject to the relevant special specification.

    Spacing and inclination of the spiles shall be as agreed upon by the Engineer. Rock straps shall be combined with the radial bolts for securing protruding ends of spiles against vibrations and over-break.

    Spiles are subject to quality requirements as specified for rock bolts above.

10.9 SPRAYED CONCRETE (SHOTCRETE)

10.9.1 *General*

General specifications for concrete works are given in Chapter 13 “CHAPTER 13: Concrete works”. Supplementary specifications relating to rock support are given below.

Sprayed concrete shall be applied plain or reinforced with steel fibres as directed by the Engineer. All plant and methods for spraying shall be approved by the Engineer. Application of sprayed concrete shall be carried out by experienced operators only.

The Contractor shall keep well suitable equipment at site for catching and measuring the quantity (by weight) of rebound material.

For scheduled work the Contractor shall give the Engineer at least 12 hours notice about the location of areas planned for spraying. When sprayed concrete is as initial tunnel support, the Engineer shall be informed at the latest 1 hour in advance.

When a major part of the surface is to be covered, sufficient time shall be allowed for the Engineer to record the geological features before concrete is sprayed.

10.9.2 *Sprayed concrete (Shotcrete)*

10.9.2.1 Composition

1) Portland Cement Type I, complying with ASTM C 150 Portland Cement, shall be used. Requirements are given in Subsection 13.5.1 Cement. The minimum cement content for a

particular environmental condition shall be as required by EFNARC Section 6.4 and EN 206. The total Alkali content in the mix shall be less than 5.0 kg/m3.

2) Micro silica (silica fume) may be included in the mix for better pumpability and to improve cohesive consistency, restricted to 10% by weight of the Portland clinker content. This limit also applies to other admixtures with high pozzolanic effect, and also to the total content of such materials. The total contents of such materials and other types of pozzolana directly mixed into the cement and added during concrete production shall not exceed 25% of the total weight of Portland cement and pozzolanic materials, including silica fume. Fly ash, if used, shall meet the requirements in ASTM C618, and shall be tested and reported accordingly. Pozzolana shall be ordered, handled and stored similarly to cement.
3) When sulphate content in ground water exceeds 150 ppm, sulphate resistance may be achieved by use of micro silica (minimum 5 percent, maximum 10% of the cement weight) and a low ratio ((≈0.45) of: (water)/(cement + silica)). The amount of water in the concrete includes added water, sand moisture and water from additives, silica slurry etc.
4) The aggregate shall be well-graded sand with a maximum content of 10 % (by weight) of grains of size larger than 8 mm. Particle size shall not exceed 16 mm. The aggregate shall meet the requirements given in Subsection 13.5.3 Aggregates.
5) Admixtures and other materials for concrete shall be so selected that the total content of chlorides does not exceed 0.4% by weight of the Portland clinker. The admixtures shall meet the requirements given in Subsection 13.5.5 Admixtures. Full account should be taken to effects of admixtures to the finished sprayed concrete and there should be sufficient data about their suitability, including previous experience with the actual admixtures. Records concerning details of the performance of such admixtures shall be maintained.
6) To avoid damage due to alkali-silica reaction one of the two following measures shall be taken:
   - Using aggregate, which by testing at an approved laboratory has proved not to be susceptible to destruction by alkalis.
   - Limiting the alkali content of the concrete mix, accumulated from all sources to 3.0 kg/m3 of Na2O equivalent.

   As early as possible, the required sprayed concrete trial mix design shall be batched, applied and tested according to the standards referred to below for the Engineer's approval of the mixes and methods to be used.

10.9.2.2 Requirements for Sprayed Concrete

The sprayed concrete mix shall be designed by the Contractor in accordance with EFNARC Section 7.

Unless otherwise specified, the sprayed concrete shall meet the requirements of concrete strength class C25 and the condition of environmental exposure shall be Moderate, both according to EN

206-1. To determine that the concrete meets the requirements to compressive strength, the in-situ strength requirements given in Table 9.1.2 of the EFNARC Specification shall be met, which are based on a 50 mm diameter by 100 mm long core and include a 0.85 reduction factor to allow for effects of in-situ curing, the sprayed concrete operation itself and the use of accelerator (rapid hardening agent).

Unless otherwise specified, the rate of hardening should be:

At 24 hours: 30 percent of final strength

At 7 days: 60 percent of final strength

At 28 days: 100 percent of final strength

Fibre reinforced sprayed concrete of strength class C25 used for ordinary rock support shall have a flexural strength of minimum 3.95 MPa as specified in EFNARC Section 9.2.

The toughness requirements of the fibre reinforced sprayed concrete of strength class C25 shall comply with residual strength class 2 as given in Figure 9.3.1 and Table 9.3.1 of the EFNARC Specification. Testing shall be in accordance with the description of the beam test as given in EFNARC Section 10.

The Engineer may order adjustment of the mechanical parameters of sprayed concrete. Documentation of these properties will then be required.

10.9.2.3 Methods/Execution

Sprayed concrete shall be applied plain or reinforced as shown in the drawings or agreed between Contractor and the Engineer.

Before commencement of work the crew shall be instructed so as to obtain a sprayed concrete quality, which is in accordance with the Specification and requirements made.

The Engineer may require that a volume estimate shall be made prior to application of sprayed concrete an area, based on the specified average thickness and the roughness of the rock surface. The roughness is defined by an empirical factor which gives an overall characteristic of the actual surface. It takes into consideration the volume required to fill hollows and cracks. Furthermore, the roughness factor will vary with the sprayed concrete thickness, resulting in a higher value for thinner layers. The Contractor and the Engineer shall jointly, prior to spraying of the area, decide on the roughness factor and agree on the required volume to produce the specified thickness. The estimated volume shall also compensate for the assumed volume of rebound. Additional sprayed concrete shall be applied if measurements show that the rebound quantity is considerably higher than the pre-estimated value.

All surfaces to be sprayed shall be thoroughly scaled and then cleaned by water flushing and, if required, by sand blasting until all dust, traces of dirt, oil, grease, rebound material and other harmful matter have been removed. During spraying the nozzle position shall be at right angles to the rock surface. Any crevices shall be filled first. Before spraying additional layers curing membranes that may affect the bond strength shall also be removed. Surface preparation may be omitted in very poor rock.

The surface shall be kept moist, but not wet, until the sprayed concrete is applied. Water seepage on the surface to be sprayed that may be detrimental to the quality of the work shall be controlled by drainage or grouting before spraying starts.

The sprayed concrete shall be kept moist for at least 7 days by water sprinkling or covering. On final surfaces a curing membrane shall be used if the curing conditions are deemed unsatisfactory. Any curing compound shall comply with EN 206. Rapid drying at the end of the curing period is to be avoided. Natural curing may be considered if the atmospheric conditions surrounding the sprayed concrete are satisfactory, i.e. sufficient high relative humidity.

All rebound sprayed concrete and all overspray shall be removed upon completion of the sprayed section.

10.9.2.4 Thickness

When thickness is stated, the sprayed mean thickness shall be at least the specified thickness. The sprayed minimum thickness on protruding rock shall be at least 50 % of the specified thickness and minimum 30 mm.

10.9.2.5 Testing and Control

Testing of sprayed concrete with or without steel fibre reinforcement, applied for general rock support, shall be carried out as Normal Control Class according to the methods and with frequencies as specified in EFNARC Sections 10 and 11, if not otherwise specified or instructed. Quality control and documentation of sprayed concrete applied for this purpose shall be executed in accordance with EFNARC Section 11.

No differentiation is made between sprayed concrete used for initial or permanent support.

The bond shall be checked at random by knocking on the sprayed concrete with a scaling rod. A dull response (hollow sound) indicates areas of no bond. The control shall be documented by a written report and carried out at a frequency of at least one knock per 5 m2. Areas of dull response shall be clearly marked and the Engineer shall make an assessment of additional support required, which shall be performed at the Contractor's expense. The checking shall be carried out covering the total area of sprayed concrete. The bond requirement does not apply in fault zones and in highly weathered rock mass.

The thickness shall be checked by drilling through the hardened concrete in a grid of 2.0 x 2.0 m. Drilling shall be performed in hollows as well as at high points. The number of s for each check shall be at least 25. The frequency of thickness testing shall be at least once per each 1,500 m2 of sprayed surface.

The control of fibre content shall be carried out from cored specimens in accordance with EFNARC Section 10.9.1. The test shall be carried out for each sprayed volume of 100 m3 fibre-reinforced sprayed concrete.

10.9.2.6 Documentation

A minimum of 2 weeks before commencement of sprayed concrete work, the Contractor shall submit for the Engineer's approval applicable data for fibres, cement and admixtures for the sprayed concrete.

Reports on testing shall be executed according to the applicable standards (and the agreed Quality Plan).

10.9.3 *Reinforcement of Sprayed Concrete*

10.9.3.1 Materials

The following types of reinforcement for sprayed concrete may be used:

Steel fibres

Steel fibres of approved type conforming to ASTM A 820, with a minimum fibre length of 18 mm and an aspect (length/thickness) ratio >40. The length of the steel fibres shall not exceed 0.7 of the internal diameters of the pipes or hoses used unless a test has proven that longer fibres can be sprayed without blockage.

Wiremesh

Welded wire fabric (wiremesh) shall be of dimension 100 x 100 x 4.75 mm. Corrosion protection and concrete cover thickness to be specified in each particular case.The quality of wiremesh shall be as per the relevant International standard equivalent.

Reinforcement for sprayed concrete ribs

Reinforcement for sprayed concrete ribs shall be one of the following two types:

- Deformed rebars of minimum 16 mm diameter tied together by transverse pieces of deformed rebars of minimum 20 mm diameter. The transverse ties shall be fixed to radial rock bolts.
- Prefabricated lattice girders made from deformed rebars shall be bolted to the rock surface. The girders shall comply with the following requirements:

  Section modulus: $W_x > 75$ cm3

  Height: $h_{max} = 200$ mm

  Chain linked mesh is not accepted as sprayed concrete reinforcement.

10.9.3.2 Method/Execution

Steel fibres shall be added according to the achieved results from the testing of trial mixes complying with the specified toughness/flexural tensile strength requirements. Steel fibres shall be stored in a dry environment. Corroded steel fibres shall not be used.

Before mounting welded wire fabric the first layer of sprayed concrete shall be applied in order to smooth the surface. Welded wire fabric shall be installed so that it follows irregularities of surface closely and with one pitch of overlap. Additional bolts shall be installed for fixing of welded wire fabric with at least one fixing point per 2.5 m2. For two layers of welded wire fabric reinforcement separate bolts shall be installed for each layer. Minimum one layer of sprayed concrete is required between two layers of wire mesh. Welded wire fabric shall be covered by a minimum 50 mm thick sprayed concrete layer to provide satisfactory corrosion protection.

Rib- or lattice girder reinforcement shall be installed in accordance with given profile lines and as close to the actual rock surface as possible. Prior to installation, the rock surface shall be covered by a minimum 60 mm thick layer of fibre reinforced sprayed concrete. Girders shall be fixed to the rock by means of rock bolts. The girder sections shall be bolted together.

Sprayed concrete shall be used to ensure a good and evenly distributed load transfer. Blocking and wedging will not be permitted.

10.10 MEASUREMENT AND PAYMENT

10.10.1 *General*

The Bill of Quantities of rock supports indicates the expected quantities of the various rock support works. These quantities and types of work are indicative based on available data and information of ground conditions. The actual conditions encountered in the tunnel may result in work and quantities different from indicated in the Bills of Quantities. Geological information provided for the design of the project will be made available as unwarranted information on request to the Client and shall only be regarded as guidance.

Unit rates for rock support shall not change with variation in quantities and/or design/layout of tunnels and caverns.

Any combination of rock support methods included in the Bill of Quantities shall be paid by adding the rates for the individual methods.

Rock support is specified as either at the tunnel work face or behind the tunnel work face.

Down-time of workforce and machinery due to scaling/rock support works required at the tunnel face shall be incorporated in the unit prices.

Any extra cost incurred by the Contractor by disturbance in his work cycles due to scaling/rock support works shall be included for in the Contractor's unit rates and/or prices or sums.

Initial and additional rock support will be paid for provided materials, machines, methods and installation as required are in accordance with the Specifications.

Quality control as specified shall be included in the unit prices listed. In case of rejection of work due to breach of quality requirements, correction measures as determined by the Engineer shall be performed at the Contractor's cost and time.

Payment for the measured quantities shall include all deliveries, work, drilling, flushing holes, installation, grouting of holes, with all materials, manpower and equipment all complete and other requirements described in the Specifications, shown on the Drawings or directed by the Engineer and as required for the rock support to be installed as specified.

Backup storage of all materials and equipment required for rock support shall be kept ready for use and in an amount sufficient to avoid delays, unless otherwise agreed with the Engineer. Complete outfit for spraying concrete shall be available. The formwork for concrete lining shall be designed for easy transport in the tunnels, minimum installation time, and the bracing shall allow for passing of transport and excavation equipment as far as possible. The reserve of materials shall at all times be minimum 10

% of the contract volumes given in the Bill of Quantities. Should the supplies necessary for installation of rock support in a timely manner not be maintained, the Contractor shall be responsible for provision of such temporary support as may be required for the safety and protection of the work. The temporary support shall be exchanged with the initially intended support as soon as possible, or the tunnel advance may be stopped. Cost for any temporary rock support work done with materials which do not meet the quality defined in the contract, will not be compensated.

10.10.2 *Additional Scaling*

No separate payments shall be made for basic scaling and additional scaling.

10.10.3 *Wire mesh, Rock Bolts, Rock Dowels and Accessories*

Wire mesh

Wire mesh or Chain-linked mesh or welded wire fabric shall be as per specification and measured by installed area same as that of wire mesh heading specified in Bill of Quantities. The rates include the drilling if required, short steel wires and rods and grouting if required for anchoring, supply delivery and installation chain link mesh or wire mesh with necessary overlap. The rates also include removal of mesh/fabric not covered by sprayed concrete. No separate payment will be made for overlap.

Rock Bolts

Rock bolts are to be measured in number with diameter and length of bolts installed as prescribed and complying with specifications. The length of bolts is measured as the length from the end of the bolt in the hole to the rock surface. The rates and prices given in payment Schedules/Bills of Quantities are to be valid for any bolt numbers and orientation decided by the Engineer.

The payment for rock bolts shall be made in number of diameter meter of the bolts and length of bolts installed under the item rates specified in Bill of Quantities. The rates include the drilling in required length and diameter as specified, flushing of holes, installation and grouting with specified grouting materials and mixes and supply and installation with base plate, 3m long Swellex anchors (if required) with washer and nut as well as testing, tensioning as specified in specification including re-drilling, re-tensioning and re-grouting (if required) all complete as required.

Rock Dowels

The payment for rock dowels shall be measured in number with diameter and length of bolts installed as prescribed and complying with specifications . The rates include the drilling in required length and diameter as specified, flushing of holes, grouting with specified mixes and supply and installation with base plate, with washer and nut as well as testing, tensioning as specified in specification including re-drilling, re-tensioning and re-grouting (if required) all complete as required.

Measures to be taken in case of rejection of bolts when tested are as described below:

If the test results for a defined group of end anchored rock bolts do not satisfy the requirements, control of all bolts in the group will be required. All bolts, which do not pass the pull test, with a pull force of 80 % of the yield strength, will have to be replaced by the Contractor at his own cost.

If the test results for a given group of grouted rock bolts do not satisfy the demands defined by AQL 4.0 in ISO 2859-1, the rates and prices for the bolts in that group will be reduced by 25 % and the Engineer will require additional bolting in order to correct for the deficiency in quality at the Contractor's own expense and time.

10.10.4 *Sprayed Concrete*

Sprayed concrete (shotcrete) and fibre reinforced sprayed concrete shall be measured in square metres with thickness specified on the Drawings and based the excavation lines shown on the Drawings or as directed by the Engineer. The rates include mixing, transport, pumping, spraying and all rebound, curing and testing as per specification all complete.

Unless otherwise specified, the strength grade of sprayed concrete shall meet the requirements of concrete strength class C25 (cylindrical strength 32 MPa and Cube strength 40 MPa) as specified in EN 206-1 or equivalent. The core cylindrical strength sprayed at site in panel of size 60*60*15 cm shall not be less than 85 % of cylindrical strength as specified above. The core size shall be 5 cm diameter and 10 cm long core sample. The condition of environmental exposure shall be Moderate. Fibre reinforced sprayed concrete of strength class C2 5used for ordinary rock reinforcement shall have a flexural strength of minimum 3.95 MPa as specified in EFNARC Section 9.2.

The Engineer will present a system for the control of sprayed concrete volume delivered at the work site. Use of accelerator or other additives is to be included in the unit prices.

Cleaning of the rock surface by high pressure water flushing or in special contaminated areas with sand blasting prior to spraying is to be included in sprayed concrete unit prices given in Bills of quantities. This also applies when new layers of sprayed concrete are applied as additional support at the end of the construction period. If more than one layer is to be sprayed, the costs for cleaning of any coating, rebound matter or other loose material before spraying of the next layer are to be included for in the sprayed concrete unit prices.

Drainage of water leakages is to be included in the sprayed concrete unit prices. The cost of cleaning after completed spraying is to be included in the sprayed concrete unit prices.

Rebound losses of sprayed concrete will be accepted if they are within following limits, measured as dry-weight %:

	Walls	Roof
Without steel fibres	8 %	12 %
With steel fibres	6 %	8 %

When required by the Engineer, the Contractor shall prove that the rebound losses are within the given limits. If the losses exceed the given limits, the measured sprayed concrete volumes are to be reduced accordingly. The control is done at the Contractors expense.

Welded wire fabric/ Wiremesh for reinforcement of plain sprayed concrete is measured by installed area and paid as specified above.

Lattice girders and deformed rebars shall be bent to suit different tunnel arches and divided into sections to suit subdivision of cross sections. Lattice girders and deformed rebars are measured as weight of ribs as pre-fabricated (lattice girders) or weight of deformed rebars erected and supplied by order of the Engineer, plus separate item for the meters of ribs installed. Rock bolts and sprayed concrete are paid additionally.

10.10.5 *Spiling Rod or Fore-poling:*

The Measurement of Pipe roof method/umbrella arch method, fore-poling shall be done in number.

10.11 STEEL RIB SUPPORTS

10.11.1 *Materials*

Subject to approval of the Engineer, steel for tunnel support sets and blocking and lagging shall be maintained at the site of the Works. The steel for the support sets need to be bent as per Drawings or directed by the Engineer, however, sufficient steel shall be on hand before starting underground excavation, to make at least 15 support sets with invert struts.

1. All materials for steel support sets shall be subject to approval of the Engineer before the order is placed.
2. Material for steel supports shall be equal to or stronger than ASTM A36 or IS 2062 or equivalent steel. All bearing plates, beams, posts, blocking, wedging, general hardware and all lagging required shall be of sound material free from defects that will affect structural strength when used in conjunction with the structural steel support systems.
3. Steel supports shall consist of steel ribs, foot-plates, concrete foot blocks, lagging, liner plates, and other suitable structural steel members, complete with bolts, nuts, wedges, tie rods and spreaders, and other accessories required for assembling the steel supports and supporting them in place.
4. Wedges, lagging, and blocking may be timber; however, fibre reinforced shotcrete shall be used to replace traditional wedges, lagging, and blocking to the maximum practicable extent.

10.11.2 *Execution*

1. Steel ribs with or without struts shall be installed where approved, as soon as practicable following excavation. Ribs shall be set on foot blocks which shall rest on suitable foundations. Ribs shall be securely wedged into place using fibre reinforced shotcrete or bags of fast-set mortar. Where fibre reinforced shotcrete or bags of fast-set mortar are inadequate for this purpose, additional supports consisting of lagging, blocking wedges, bars and the like shall be installed against the rock face as required to transfer the rock load to the steel ribs.
2. Wedges not covered by shotcrete shall be periodically checked and tightened and such checking and tightening shall also be done immediately before placement of the concrete lining.
3 Steel ribs shall be set to provide a minimum concrete clearance of 200 mm, and shall be left in place permanently.

10.11.3 *Measurement and Payment*

1. Steel support sets will be measured for payment by weight in Tons installed as approved.
2. Steel support sets will be paid per ToN as quoted in the Bill of Quantities. The price paid shall include full compensation for fabrication, supply, delivery, furnishing and installing the steel supports, regardless of size, together with all steel wedges, all blocking and lagging, tie rods and bracing, and other miscellaneous steel required, except for spile bars. No adjustment of unit price will be made on account of variations in the size, weight, or section of members due to the Contractor's method of excavation or the approval of tunnel dimensions or configurations different from those shown on the Drawings.

11 CHAPTER 11: INVESTIGATION AND INSTRUMENTATION DURING CONSTRUCTION

11.1 CONTRACTOR ASSISTANCE IN CONNECTION WITH GEOLOGICAL MAPPING AND INVESTIGATION DURING CONSTRUCTION

Tentative layout and location of construction Main Access Tunnel is based on information on geological conditions obtained from surface geological mapping and has been done based on data available from construction of test adit-5

The Contractor is responsible for providing necessary assistance and information in connection with geological mapping, surveying and rock stress measurements, conducted by the staff of the Engineer. Contractor himself shall prepare a geological logical and mapping of the tunnel face at each blasting on their own cost. A copy of this logging and mapping shall be provided to the Engineer whenever required. Sufficient information about the geological conditions along the tunnel is depending on access for the geologist for mapping of geological features before the tunnel surface is covered by sprayed concrete. This means that there will be stop periods to allow access for the geologist for doing his mapping, or for doing other investigations.

To obtain the necessary information for making design decisions in due time, it is important that necessity of these works is understood and that the Contractor contribute to smooth operation. The Contractor shall contribute to efficient preparations and accomplishment of the investigations by close collaboration with the Engineer. The Engineer's geologist shall be given access to the tunnel face for a period of 30 minutes for each blast round, after mucking and prior to commencement of concrete spraying at the face. Additional stops may be instructed by the Engineer.

11.2 PREPARATORY WORKS

The Contractor is obligated to review the Executive summary of Geotechnical Report of MAT () provided by the Engineer before the commencement of Tunnel Works. Additionally, the test Adit Report (AD5) which is located in parallel to MAT will be shared for information as provided in drawing .

If discrepancies are identified between actual site conditions and the provided geotechnical reports, the Contractor shall immediately notify the Engineer, submit documented findings, and propose corrective measures. Work shall proceed only after review and explicit direction from the Engineer.

11.2.1 *Investigation and Monitoring during Construction*

1. During the construction period, the Contractor shall make best efforts to analyse discrepancies from provided geotechnical report.
2. The Contractor shall monitor the existing geological and peripheral site conditions during the construction period.
3. The monitoring of the geological conditions at the work front and its correlation with corresponding necessary support mechanism in line with the identified rock mass classification shall be documented.

4. The Contractor shall conduct overall site environments Monitoring, i.e. water supply, temperatures, and ventilation on a regular basis.
5. The Contractor shall perform, when deem required, probe-hole test, horizontal boring, geological survey on the inside of the tunnel. Such results of the survey shall be properly documented and submitted to the Engineer for approval.

11.3 INSTRUMENTATION DURING CONSTRUCTION

This instrumentation and monitoring for the tunnel in order to determine its structural stability from excavation to the completion of concrete lining (if necessary), including

- Multipoint Borehole Extensometers (MPBX)
- Total stations (minimum 1" accuracy or better), Profiler Robotic Total Station (minimum 1" accuracy of better) it is best recommended.
- Digital levels (Precision ±1.5 mm/km or better)
- Reflector's and prisms
- Rock Bolt Load Cells (RBLC)
- Convergence Monitoring System
- Associated cabling, accessories, and monitoring equipment

  The Instrumentation and monitoring plan shall be submitted to the Engineer subject to the Construction Plans. The submittals shall be submitted to the Engineer as follows:

  (1) Monthly Report for Tunnel Instrumentation and Monitoring

  (2) General Report for Tunnel Instrumentation and Monitoring

11.3.1 *General*

1. The tunnel instrumentation and monitoring programs shall be classified into regular monitoring program and precision monitoring program. The regular monitoring category consists mainly of visual observation on the tunnel, measuring displacement of tunnel faces, measuring crown settlement (vertical displacements). The precision monitoring program is made up of measurements for surface and underground settlement, shotcrete stress, underground displacement, and axial force of rockbolts.
2. The Contractor shall pr
3. epare instrumentation and monitoring plans before tunnel construction inclusive of further details as follows: precision, reading range, functionality, and temperature range are incorporated into the plan, encompassing statements on specification of instrumentation equipment, instrument calibration with management, data and records management (forms, analysis scope and methods) with evaluation, evaluative methods for displacement, and tunnel convergence. Such plans shall be submitted

4. to the Engineer
5. The Contractor shall collect to analyze ground displacement data from tunnel instrumentation and monitoring programs before commencement of tunnel construction in order that the tunnel construction can be safer and cost-effective.
6. The Contractor shall prepare instrumentation and monitoring equipment specified in the given design and the submitted plans or as per instruction of Engineer. The instrumentation and monitoring equipment shall be deployed by the relevant experts as planned.
7. The Contractor shall maintain instrumentation and monitoring equipment without disruption of recording data.
8. The Contractor shall report results of instrumentation and monitoring together with behavior of tunnel spatial movements to the Engineer, incorporated into the monthly report.
9. At the commencement of the Works all testing equipment shall be calibrated to ensure accuracy of the testing in accordance with the relevant Standards. The Contractor shall perform additional calibration from time to time to ensure correctness and accuracy of the equipment and shall ensure that all equipment is kept in good working order.

11.3.2 *Frequency of Measurements*

The measurement items and frequency may be adjustable under the conditions of sites and grounds which shall be confirmed by the Engineer in accordance with Table 11-1.

Table 11-1: Frequency of Measurement Categories

Category	Item for Measurement	Frequency of Measurement 1)		
Division	Item for measurement	0 ~ 15 days	15 ~ 30 days (8 ~ 14 days)	30 days ~ (15 days ~)
Measurement A (Regular Measurement)	bservation of Inside tunnel	Every Tunnel Face	Every Tunnel Face	Every Tunnel Face
Measurement A (General measurement)	lacement of Tunnel Face	1～2 times/day	2 times/week	1 time/week
Measurement A (General Measurement)	age monitoring			
Measurement A (General measurement)	Settlement of Crown	1～2 times/day	2 times/week	1 time/week

Measurement A (General measurement)	ll-out Test of Rock bolts	As per IS 11309	As per IS 11309	As per IS 11309
Measurement B (Precision Measurement)	Surface Settlement, Underground	1 time/day	1 time/week	1 time/2 weeks
Measurement B (Precise measurement)	Stress of Shotcrete	1 time/day	1 time/week	1 time/2 weeks
Measurement B (Precise measurement)	Underground Displacement	1～2 times/day	1 time/2 days	1 time/week
Measurement B (Precise measurement)	Axial Force of Rock bolts	1～2 times/day	1 time/2 days	1 time/week

11.3.3 *Procedures*

11.3.3.1 Observation of the Tunnel

(1) The purpose of observation of the tunnel is to assess geologic conditions and performance of supports in the tunnel as a basis of the tunnel design, construction and measurements. The observation category is broken down into tunnel faces, rock bolts, shotcrete, steel supports and etc.

(2) The Contractor shall verify the interplay based on observation results and behavior of ground movement by measurements to ensure the tunnel contraction process. The Contractor shall keep the records of observation results-related drawings and photographs.

11.3.3.2 Measurement of Surface and Underground Settlement

(1) Scope

- In case when the depth of topsoil (earth cover or the depth from ground) is within three times of the tunnel diameter, the Contractor shall ensure stability of the on-ground structures and grounds by monitoring vertical displacements.
- Despite the above 1, In case when there are critical damages to the on-ground structures are forecasted due to any vertical displacements, measurement of surface and underground settlement shall be made.
- The surface settlement measurements shall be maintained within +1.0mm ~ - 1.0mm margin of error by leveling surveying method. The identical Benchmark point used in crown settlement measurement shall be shared in order to crosscheck the results.

- The measurements for both underground settlement and surface settlement shall be conducted together. The same accuracy with the measurement of vertical displacements as per depths shall be ensured.

(2) Position and Arrangement

- The positions of instrumentation equipment shall be determined, considering ground surface/ underground conditions, size of the tunnel, construction methodologies dependent on the effects of tunneling.
- The line for surface settlement measurement shall be positioned along the center line of the tunnel on the basis of 20 m~40 m intervals. In case of stretches where 50 meter-section at the tunnel portals and depth of topsoil is within two times of the tunnel diameter, the aforesaid line shall be positioned along the center line of tunnel on the basis of 10 m interval in view of the terrains.
- The line for surface settlement measurement may be adjusted to the cases in which ground conditions are good and the stability of installed construction is confirmed. In case where obstructions, e.g. mountains, rice paddies and obstructive structures exist, the intervals of measurement line may be longer, and such interval may be shortened under the unfavorable ground conditions and geologically variable terrains therewith convergence ensured.
- The measurement coverage for surface settlement shall be from the left and right corner of tunnel bottom to a 45° inclining upward point forming a triangular shape. Such measurement shall be conducted at 5 m~10 m intervals. In presence of the distinctive stratification, foliation, and joints where influence of excavation exceeds the existing measurement coverage, the extended measurement coverage shall be conducted.
- The extensometer shall be installed at the places where required to measure settlement progress or grounds to support structures to monitor critical situations.
- The bottom measurement point among the underground settlement points shall be preferably installed at the nearest area of tunnel crown without being damaged by overbreak, rock bolts, inclined bolting in the process of tunneling.

(3) Installation Timing

The early measurement readings from the surface settlement system and extensometer for underground settlement shall be taken, starting from the installed point up to the point where equivalent to three times of tunnel diameter. In case where tunneling effects are forecasted to influence the distances exceeding three times of tunnel diameter, early measurement shall be made before displacements occur.

(4) Duration of Measurement

The duration of measurement for displacement of tunnel face and crown settlement shall begin from installation of equipment until the confirmation of identifiable convergence. The final confirmation requires further verification on convergence status for minimum 30 days.

11.3.3.3 Measurement for Displacement of the Tunnel Section and the Crown Settlement

(1) Scope

- The Measurement for the displacement tunnel faces and crown settlement shall be conducted in order to identify tunnel behaviors, measuring from displacement of the tunnel walls for safety.
- The margin of error in measurements of displacement of the tunnel faces and crown settlement shall be within -1.0 mm ~ +1.0 mm.
- The measurement of the crown settlement shall be conducted on the basis of a Benchmark outside of tunnel, relatively compared with measured values of surface settlement.

(2) Arrangement

- The measuring points for displacement of tunnel faces and crown settlement shall be installed at the identical cross section; the measurement line shall be installed along the tunnel center line on the basis of 20 m~40 m intervals. In case of stretches where 50 meter-section at tunnel portals and depth of topsoil is within two times of the tunnel diameter, the aforesaid line shall be positioned along the center line of tunnel on the basis of 10 m-interval.
- The case where the ground condition is good and ground stability is confirmed by the measurements, the intervals on measurement may be adjusted longer than other interval. In case where the ground condition is poor or variable, the measuring interval shall be shorter to ensure convergence from the results of measurement.
- The arrangement of the measurement lines shall be 3 lines in full face excavation method, 4 lines in bench cut excavation method as a standard. The arrangement may be adjustable in view of ground condition, excavation method, and area of excavation section.
- Three-dimensional measurement methods may be applied to the case where the displacement of tunnel face is excessive or critical geologic conditions e.g. fracture zones, folds, faults, coal ground, and uneven pressures or widening sections, approaching section and critical sections exist.
- The absolute coordinates are preferably applied. Control point may be used in long stretch tunnels or curved tunnel.
- The automatic total station, 3D recording equipment, laser scanning may be applied as 3 D measurement.
- If required, reliability of measurement may be augmented by automated measurement.

(3) Installation Timing

The measuring points for displacement of the tunnel faces and crown settlement shall be installed upon the completion of sealing concrete placement. The displacements made by tunneling shall be measured for the maximum coverage.

(4) Duration of Measurement

The duration of measurement for displacement of tunnel face and crown settlement shall begin from installation of equipment until the confirmation of identifiable convergence. The final confirmation requires further verification on convergence status for minimum 30 days.

11.3.4 *Measurement of Underground Displacement*

(1) Scope

- The rod extensometer shall be installed in order to measure displacement of radius-direction as per depth of ground in proximity to the excavated tunnel faces. The range of ground relaxation is identified from the result of measurements.
- The measuring points for rod extensometers shall be fixed firmed to the ground to reflect ground displacements. The margin of error for the measurement shall be within -1.0 mm ~ +1.0 mm.

(2) Arrangements

- The rod extensometer shall be installed at places where deemed necessary under the circumstance of size of the tunnels and ground conditions. The measuring points for displacement of the tunnel faces and crown settlement shall be installed at the identical cross section for general analysis.
- The rod extensometer shall be installed at 3 positions with the left, right and the tunnel crown of the measurement section for 3~5 points of multiple measurement points as per depth. The measuring points may be increased as per tunnel size or ground conditions.
- The measuring points of rod extensometer shall be arranged to the extent of 0.5 time of tunnel diameter from the tunnel wall or forecasted relaxation distance.

(3) Installation Timing

The rod extensometer shall be installed upon the completion of the initial 1st shotcrete placement. The early measurement for initial values shall be conducted prior to the progress of the tunnel faces. The displacements made by tunneling shall be measured for the maximum coverage.

(4) Duration of Measurement

The duration for measurement of extensometer shall continue from installation of equipment until the confirmation of identifiable convergence. The final confirmation requires further verification on convergence status for minimum 30 days.

11.3.5 *Measurement of Axial force of Rock bolts*

(1) Scope

- The rock bolt stress-meter shall be installed to ensure the performance and capacity of tunnel supports by measuring axial forces of rock bolts affected by the tunnel radius-direction the displacements.
- The rock bolts stress-meter shall be fixed firmly to the ground to reflect changes of axial forces at the installation points as per ground displacements. The level of accuracy shall be more than 1 kN.
- The rock bolt materials used in tests, e.g. material properties, specification, and sealing, shall be identical to the actual materials for construction.
- Crown settlement shall be installed at the identical cross section for general analysis.

- The axial force measurement shall be made at actual rock bolt installation positions by the identical method. The measurement positions shall be the left and right side of the tunnel walls and the tunnel crown with 3~5 numbers of rock bolts for measurement.
- Measurement intervals for measurement of rock bolt axial force shall be 0.5 m~1.0 m.

(2) Arrangements

The rock bolt stress-meter shall be installed at places where deemed necessary under the circumstance of size of tunnels and ground conditions. The measuring points for underground displacement, shotcrete stress, displacement of the tunnel faces and

(3) Installation Timing

The rock bolt stress-meter shall be installed upon the completion of the initial 1st shotcrete placement. The early measurement for initial values shall be conducted prior to the progress of tunnel faces. The displacements made by tunneling shall be measured for the maximum coverage.

(4) Duration of Measurement

The duration for measurement of rock bolt stress-meter shall continue from installation of equipment until the confirmation of identifiable convergence. The final confirmation requires further verification on convergence status for minimum 30 days.

11.3.6 *Measurement of Shotcrete Stress*

(1) Scope

- The shotcrete stress-meter shall be installed to ensure durability and soundness by comparing the allowable stress with the measured stress arising from accompanied displacement of the perimeter of the tunnel.
- The shotcrete stress-meter shall have maximum 10 kPa in margin of error, being able to measure the stress greater than expected maximum stress.
- The shotcrete stress-meter in the tunnel radius direction shall be fixed firmly to the ground in order to transfer any stress irrespective of drying shrinkage of shotcrete.

(2) Arrangements

- The shotcrete stress-meter shall be installed at places where deemed necessary under the circumstance of size of the tunnels and ground conditions. The measuring points for underground displacement, rock bolt axial force, displacement of the tunnel faces and the crown settlement shall be installed at the identical cross section for general analysis.
- The measurement positions shall be the left and right side of the tunnel walls and the tunnel crown with 3~5 numbers of shotcrete stress-meter for measurement in in order to ensure any occurred stresses to shotcrete, level of back-side ground pressure and their distribution for overall analysis.
- Preferably two (2) stress-meters shall be installed to measure stresses from tunnel radius-direction and tangent-direction at each measuring point where installed perpendicular to tunnel radius-direction and tangent-direction.

(3) Installation Timing

The shotcrete stress-meter shall be installed in the process of shotcreting operation. The early measurement for initial values shall be conducted prior to the progress of the tunnel faces. The displacements made by tunneling shall be measured for the maximum coverage.

(4) Duration of Measurement

The duration for measurement of shotcrete stress-meter shall continue from installation of equipment until the confirmation of identifiable convergence. The final confirmation requires further verification on convergence status for minimum 30 days.

11.3.7 *Investigation of Impact on Deformation of Adjacent Structures*

(1) The Contractor shall conduct the advance survey by video photographing and video recording prior to the constructions in order to assess impact on deformation of adjacent structures arising from the tunnel construction.

(2) In case any deformations occur due to tunnel constructions, relevant measures and constant monitoring shall be taken accordingly.

11.3.8 *The followings activities are consisting of the activity "measurement":*

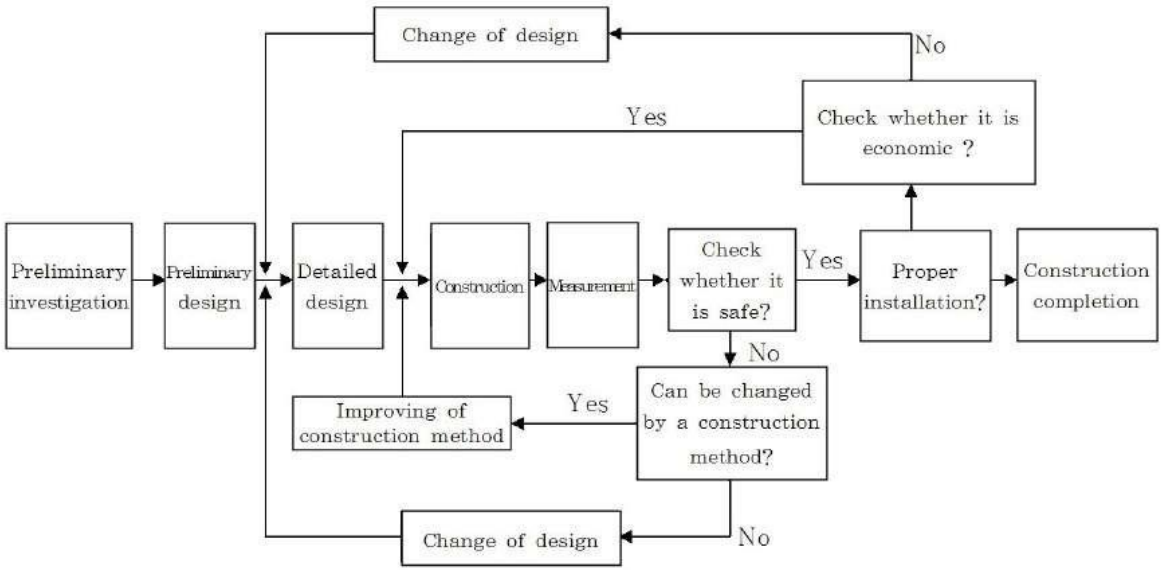
Measurements of ceiling settlement	ea	10
Measurement of internal displacement	ea	10
Rock bolt axial force measurement	ea	50
Underground displacement measurement	ea	10
Shotcrete stress measurement	ea	10
Measurement of surface subsidence	ea	10

11.4 PROCEDURE OF INSTRUMENTATION AND MONITORING

11.4.1 *Feedback of Measurement for Construction*

All the results of measurements from the organized instrumentation and monitoring shall be directly incorporated into design and construction in order to satisfy safety, cost-effectiveness and constructability with the procedure.

Figure 11-1 Feedback Flows



11.4.2 *Management of Measurement Records*

The measurement records shall be well-kept to provide and reflect feedback on regular construction management and future construction plans.

11.4.3 *Report on Measurement Results*

The report on measurement results shall be made immediately. In cases when significant or critical displacements arise and the pace of displacement exceeds the standard threshold or out of convergence case, the Contractor shall immediately report the status to the Engineer, followed by relevant actions in accordance with the Engineer's instruction.

11.4.4 *Treatment of Equipment*

(1) The measurement equipment shall be treated with special care in order to prevent any damage during the installation and transport. When any damage occurs, it shall be immediately reported to the Engineer for further instructions.

(2) The measurement equipment shall be immediately installed prior to the excavation or upon the excavation.

11.5 QUALIFICATION OF INSTRUMENTATION ENGINEER

1. The Contractor may operate his/her own instrumentation and monitoring teams or source such tasks for better performance.
2. The person in charge of instrumentation and monitoring shall have a degree of geotechnical Engineering or geology or equivalent geotechnical Engineering experience. Such personnel shall have understanding of ground and behavior of the tunnel supports.

11.6 UTILIZATION OF INSTRUMENTATION RESULTS

1. All the construction process shall be done based on the measured data. The result analysis of the comparison with design shall be reported to the Engineer.
2. The Contractor shall utilize data taken from instrumentation and monitoring for measurement of construction process and maintenance which later shall be the reference at the stage of design.

11.7 MEASUREMENT AND PAYMENT

This price remunerates, for each MPBX, Load Cell and Tunnel convergence Monitoring Station (5-point array) including the costs of all materials, labor, equipment necessary for the installation, delivery of materials and instruments. The rate shall also include drilling, sampling, casing removal, installation, function testing, replacement or repair of damaged instruments, initial readings, deep and surface reclamation, free access to the Engineer to readings, as well as all the work necessary to carry out the measurements for continuous monitoring as required in specification.

12 CARE OF WATER DURING CONSTRUCTION

12.1 SCOPE:

The Contractor is responsible for taking care water from the surface as well as from tunnel and shall take necessary measures to adequately drain off. It shall include surface water draining from the hillside above from entering the tunnel and divert any potential flow away from the tunnel entrance as necessary. The necessary handling and pumping of water from tunnels completed and from working face shall be maintained by the Contractor. Adequate drainage channel and drainage facilities shall be maintained by the Contractor during construction.

Also, water needed for drilling cleaning and other construction works shall be adequately maintained by Contractors.

He shall implement necessary measures for drainage and minimise erosion of tunnel spoil deposits from draining water. This shall also include measures to safely carry water away from the areas to minimise erosion and eroded materials being carried into water courses.

The Contractor shall maintain and repair all drainage facilities, drainage channels, well, pumps, pipes slopes, and slope protection structures so that they operate as required for protecting the works and surrounding areas.

12.2 MEASUREMENT AND PAYMENT:

The work shall be measured and paid as Lump Sum (LS) upon completion of all required water-control and drainage works during construction, as approved by the Engineer. No separate measurement shall be made for individual drainage channels, pumping, diversion, or other water-management activities.

The rate shall include all labour, materials, equipment, tools and incidentals required for care of water in tunnels and on the surface, construction and maintenance of gravity-flow drainage channels, diversion and disposal of water, pumping/dewatering where required, maintenance and cleaning of drainage facilities, and all associated works necessary to keep the construction area adequately drained and workable throughout the construction period all complete.

13 CHAPTER 13: CONCRETE WORKS

13.1 COVERAGE

This Chapter contains requirements for:

- manufacture, transportation, placement, finishing, curing and repair of concrete
- supply and placing of reinforcement
- formwork
- joints, joint materials, joint treatment and bearing pads
- all other work associated with cast-in-place and pre-cast concrete

13.2 REFERENCE STANDARDS

Particular standards relevant for this chapter are listed below.

Unless otherwise specified, concrete materials, production, sampling, testing and acceptance shall comply with the Indian Standards specified herein. Where no applicable Indian Standard is specified, the referenced ASTM standard shall apply. Where a particular component is specifically governed by EN/EFNARC requirements, those requirements shall apply to that component.

If no standards exist, the work shall be performed according to recognised practice approved by the Engineer.

American Association of State Highway and Transportation Officials (AASHTO)

AASHTO M 307	Standard Specification for Silica Fume Used in Concrete and Mortar

American Concrete Institute (ACI)

ACI 207.1R	Mass Concrete
ACI 211	Standard Practice for Selecting Proportions for Normal, Heavyweight and Mass Concrete
ACI 301	Standard Specification for Structural Concrete
ACI 304R	Guide for Measuring, Mixing, Transporting and Placing Concrete
ACI 305R	Hot Weather Concreting

American Society for Testing and Materials (ASTM)

ASTM A 82	Standard Specification for Steel Wire, Plain, for Concrete Reinforcement
ASTM A 184M	Standard Specification for Fabricated Deformed Steel Bar Mats for Concrete Reinforcement
ASTM A 185	Standard Specification for Steel Welded Wire Fabric,

	Plain, for Concrete Reinforcement
ASTM A 615M	Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
ASTM A 767M	Standard Specification for Zinc-Coated (Galvanised) Steel Bars for Concrete Reinforcement
ASTM A 775M	Standard Specification for Epoxy-Coated Reinforcing Steel Bars
ASTM C 29	Standard Test Method for Unit Weight and Voids in Aggregate
ASTM C 31	Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C 33	Standard Specification for Concrete Aggregates
ASTM C 39	Standard Test Method for Compressive Strength Of Cylindrical Concrete Specimens
ASTM C 40	Standard Test Method for Organic Impurities in Fine Aggregates for Concrete
ASTM C 42	Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
ASTM C 88	Standard Test Method for Soundness Of Aggregates By Use Of Sodium Sulfate or Magnesium Sulfate
ASTM C 94	Standard Specification for Ready-Mixed Concrete
ASTM C 117	Standard Test Method for Materials Finer Than 75-µm (No. 200) Sieve in Mineral Aggregates By Washing
ASTM C 125	Standard Terminology Relating To Concrete and Concrete Aggregates
ASTM C 127	Standard Test Method for Specific Gravity and Absorption Of Coarse Aggregate
ASTM C 128	Standard Test Method for Specific Gravity and Absorption Of Fine Aggregate
ASTM C 131	Standard Test Method for Resistance To Degradation Of Small-Size Coarse Aggregate By Abrasion and Impact in the Los Angeles Machine
ASTM C 136	Standard Method for Sieve Analysis Of Fine and Coarse Aggregates
ASTM C 138	Standard Test Method for Unit Weight, Yield and Air Content (Gravimetric) of Concrete

ASTM C 142	Standard Test Method for Clay Lumps and Friable Particles in Aggregates
ASTM C 143	Standard Test Method for Slump Of Portland Cement Concrete
ASTM C 150	Standard Specification for Portland Cement
ASTM C 151	Standard Test Method for Autoclave Expansion of Portland Cement
ASTM C 171	Standard Specification for Sheet Materials for Curing Concrete
ASTM C 172	Standard Method Of Sampling Freshly Mixed Concrete
ASTM C 173	Standard Test Method for Air Content Of Freshly Mixed Concrete By the Volumetric Method
ASTM C 186	Standard Test Method for Heat of Hydration of Hydraulic Cement
ASTM C 192	Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory
ASTM C 227	Standard Test Method for Potential Alkali Reactivity of Cement-Aggregate Combinations (Mortar-Bar Method)
ASTM C 231	Standard Test Method for Air Content Of Freshly Mixed Concrete By the Pressure Method
ASTM C 260	Standard Specification for Air Entraining Admixtures for Concrete
ASTM C 289	Standard Test Method for Potential Reactivity of Aggregates (Chemical Method)
ASTM C 309	Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C 441	Standard Test Method for Effectiveness Expansion of Concrete Due to the Alkali-Silica Reaction
ASTM C 494	Standard Specification for Chemical Admixtures for Concrete
ASTM C 566	Standard Test Method for Total Moisture Content Of Aggregate By Drying
ASTM C 595	Standard Specification for Blended Hydraulic Cements
ASTM C 617	Standard Practice for Capping Cylindrical Concrete Specimens
ASTM C 618	Standard Specification for Fly Ash and Raw or Calcined

	Natural Pozzolana for Use as a Mineral Admixture in Portland Cement Concrete
ASTM C 989	Standard Specification for Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars
ASTM C 1017	Specification for Chemical Admixtures for Use in Producing Flowing Concrete
ASTM D 75	Standard Practice for Sampling Aggregates

British Standards Institution (BS)

BS 812	Testing Aggregates Part 105. Methods for Determination of Particle Shape. Flakiness Index
BS 812	Testing Aggregates Part 117. Methods for Determination of Water Soluble Chloride Salts
BS 812	Testing Aggregates Part 118. Methods for Determination of Sulphate Content
BS 4871	Approval Testing of Welders Working to Approval Welding Procedures
BS 5135	Metal-arc Welding of Carbon and Carbon Manganese Steel

13.3 FORMWORK

13.3.1 *General Requirements*

The Contractor shall take full responsibility for the adequacy, performance and safety of the formwork.

All formwork, moulds, false work, supports and staging shall be of suitable quality and of such accuracy, strength and rigidity as to prevent any springing or distortion throughout the placing, compaction and setting of the concrete. No timber less than 20 mm thick shall be used without the specific approval of the Engineer. All joints in formwork and reinforcement passing through forms shall be accurately adjusted to prevent any loss of fine materials or mortar during compaction of the concrete.

All joints in the formwork shall be either horizontal or vertical, end formwork being square across the mass of concrete. The design of the formwork shall be such as to permit removal without damage to the concrete.

Where concrete is to be deposited at a slope steeper than 15° to the horizontal, top formwork shall be used to enable the concrete to be properly compacted. Top formwork shall be counterweighted or otherwise braced and tied to maintain exact position and shape.

To prevent concrete adhering to the formwork surface against which it is to be deposited, the surface of the formwork shall receive a thin coat of lime-wash, mould oil or other approved non-staining

material in order to secure slippage of the concrete surface. Care must be taken to keep reinforcement, inserts and any adjacent previously poured concrete free from any coating material.

Ties or bolts supporting the formwork shall be capable of being removed in whole or in part without any damage to the concrete so that no part remaining embedded in the concrete shall be closer to the surface of the concrete than the specified cover to the reinforcement. In liquid-retaining structures such bolts shall remain embedded, and the bolts shall be fitted with a welded steel collar of 100 mm diameter positioned in the middle of the concrete.

All recesses as a result of ties or bolts after removal of the formwork shall be sealed with a cement/sand mortar filling well rammed in with a steel tool and finished off flush. For liquid-retaining structures such mortars shall also contain an approved waterproofing or expanding cement additive.

13.3.2 *Classes of Finish*

On formed surfaces the following classes of finish shall be used:

Class A finish is for surfaces prominently exposed to view where good appearance, uniform colour and alignment are of special importance. To achieve this finish, which shall be free of board marks, the formwork shall be faced with plywood or equivalent material in large sheets. The sheets shall be arranged in an approved, uniform pattern. Wherever possible, joints between sheets shall be arranged to coincide with architectural features, sills, window heads, or changes in direction of the surface. All joints between panels shall be vertical and horizontal unless otherwise directed. Suitable joints shall be provided between sheets to maintain accurate alignment of the sheets. Unfaced wrought boarding or standard steel panels will not be permitted for a Class A finish.

Class B finish is for surfaces, which are permanently exposed to view but where the highest standard of finish is not required, or for other specified surfaces. Forms to provide a Class B finish shall be faced with wrought and thick boards with square edges arranged in a uniform pattern. Alternatively, plywood or metal panels may be used if they are free from defects likely to detract from the general appearance of the finished surface. Joints between boards and panels shall be such as to require no general filling of surface pitting, but surface discolouration and other minor defects shall be remedied by approved methods.

Class C finish is for surfaces, which will be backfilled or concreted. Formwork shall consist of sawn boards, sheet metal or any other material that will prevent the loss of material from the concrete when it is compacted.

On unformed surfaces the listed types of finish will be required:

Class UA is a hard, smooth steel-trowelled finish for surfaces of concrete paving, tops of walls, copings and other members exposed to weathering, surfaces of beds and slabs to receive thin flexible sheet, tile pavings bedded in adhesive, or seatings for bearing plates and the like where the metal is in direct contact with the concrete. Trowelling shall not start until the moisture film has disappeared and the concrete has hardened sufficiently to prevent excess laitance from being worked to the surface. The surfaces shall be trowelled under firm pressure and left free from trowel marks.

Class UB is a floated finish for surfaces of beds and slabs for receiving mastic pavings or block or tile pavings bedded in mastic, and for exposed surfaces of pavings where a hard-smooth steel-trowelled surface is not required. It is also the first stage for finish UA. Floating shall be done only after the concrete has hardened sufficiently, and may be done by hand or machine. Care shall be taken that the concrete is worked no more than is necessary to produce a uniform surface free from screed marks.

Class UC is a screeded finish for surfaces of roads or of foundations, bed, slabs and structural members to be covered by backfill, subsequent stages of construction, bonded concrete topping or cement mortar beds for receiving pavings, and on exposed surfaces or paving where a superior finish is not required. It is also the first stage for finishes UA and UB. The finishing operations shall consist of levelling and screeding the concrete to produce a uniform, plain or ridged surface, surplus concrete being struck off by a straight edge immediately after compaction.

Unless otherwise specified the formwork shall be of grade Class B

13.3.3 *Removal of Formwork*

The Contractor shall give the Engineer 24 hours' notice of his intention to remove any formwork.

After the concrete has reached sufficient strength the formwork shall be carefully removed in such manner as not to impair safety or serviceability of the structure. No formwork shall be removed before the concrete has a strength sufficient to withstand any stresses to which the structure may then be subjected.

The time at which the formwork is struck shall be the Contractor's responsibility but the minimum periods, which must elapse, unless otherwise approved by the Engineer, between the completion of the concreting operations and removal of the formwork for various parts of structures are given in Table 13-1. The stated periods are valid for Ordinary Portland Cement. Compliance with Table 13-1 shall not relieve the Contractor from his obligation to delay removal of the formwork until the concrete has gained sufficient strength. The Contractor shall be held responsible for, and shall make good, all injury and damage to the concrete arising from premature removal of the formwork. A small portion of concrete shall be exposed and inspected to ensure that it has sufficient strength before the whole formwork is removed.

Table 13-1: Removal of Formwork

Item	Minimum period before removal
Vertical formwork for beams, walls, columns, etc.	2 days
Slab soffit forms (props left under)	3 days
Beam soffit forms (props left under)	7 days
Props to slabs	21 days
Props to cantilevers	28 days

13.4 REINFORCEMENT

13.4.1 *Steel*

Steel reinforcement shall unless otherwise specified, be deformed high yield steel bars to ASTM Specifications or equivalent, having a minimum yield-point stress 500 N/mm2 as shown on the Drawings.

Plain round mild steel bars and fabric reinforcement to ASTM specifications or equivalent having a minimum yield-point stress of 240 N/mm2 shall be used only where specifically specified or shown on the Drawings.

The Contractor shall obtain from his suppliers certificates of the mechanical and physical properties of the reinforcement and shall submit them to the Engineer for approval.

13.4.2 *Bending and Fixing*

Steel reinforcement shall be fixed in accordance with the detailed Drawings.

The Contractor shall provide facilities on the Site for cutting and bending reinforcement whether he is ordering his reinforcement pre-cut and bent or not, and shall ensure that a sufficient amount of straight bars is available on the Site for bending.

Before being fixed in position all reinforcement shall be cleaned of all mill scale, rust, dried grout, paint, oil, grease, earth or any other substance, which may impair the bond between the reinforcement and the concrete.

The bars shall be bent cold in strict accordance with the relevant ASTM Specifications and the bending schedules. No bar except links and stirrups shall be bent to a smaller radius than four times its diameter. After bending, reinforcement shall be securely bundled and labelled with weatherproof tags or shall be marked with other approved signs by which it can readily be identified.

The reinforcement shall be fixed in strict accordance with the Drawings as regards cover, spacing and position, and suitable precautions shall be taken by the Contractor to prevent the displacement of reinforcement during the placing and compaction of concrete. Where required to support and retain the reinforcement in its correct position the Contractor shall provide templates, pre-cast concrete blocks, stools or other supports to ensure the correct cover thickness. Pre-cast concrete support blocks shall be manufactured from 2:1 sand/cement mortar. They shall be well cured before use and carefully stored on the Site to avoid contamination.

All intersections of bars in walls and slabs, all connections between binders or links and main bars in columns or beams and all concrete blocks or other supports shall be tied with soft iron wire ties or with fixing clips which shall not be allowed to make contact with the formwork or to project materially into the specified cover.

All bars, which are lapped to secure continuity, shall, unless otherwise stated, overlap not less than 40 times the diameter of the smaller bar to be lapped. Where not specifically detailed on the Drawings the laps of reinforcement shall be staggered so that they do not fall on one plane. Special care must be taken to comply with this requirement when using sliding formwork.

Unless shown on the drawings, or permitted by the Engineer, welding of bar reinforcement at intersections or for the joining of bars is prohibited. Where permission is granted, the steel shall be of weldable quality and welding shall be carried out in accordance with the recommendations of the Institute of Welding for the welding of reinforcing bars for reinforced concrete construction.

Where galvanized reinforcement or anchor bolts are used, any damage to the galvanizing shall be made good by application of an approved galvanizing formulation before concrete placing is commenced. If the cement used in the concrete is de-chromatized, one of the following measures shall be taken:

- The concrete mortar in contact with the galvanized steel should be added Natrium Dichromate in the mix (0.5 l/m3 of 10% NaCr2 solution), or
- The galvanized steel should be covered by a suitable material, which prevents direct contact between the concrete mortar and the steel.

  Where specified, reinforcement intersections shall be insulated by approved materials and methods, e.g. by a short length of rubber or plastic hose on one of the bars so as to prevent metallic contact between the bars.

  The permissible tolerance on the specified cover is minus 0 mm and plus 10 mm.

13.5 CONCRETE

13.5.1 *Cement*

Cement for concrete shall, unless otherwise specified, comply with relevant Indian Standards (IS) equivalent to ASTM C 150 Type I. Cement Type II and III to ASTM C 150 or use of flyash cement shall be used only on approval from Engineer. Unless the concrete aggregates are proved to be completely innocuous as to alkali reactions, all cement shall be of the low-alkali type with a maximum alkali-content of 0.6 % expressed as sodium-equivalent (Na2O + 0.658 K2O).

The Contractor shall as soon as possible after the Commencement Date notify the Engineer from which mill or mills he intends to purchase cement and whether the cement will be supplied in bulk or bags. Purchase orders or contracts for supply of cement shall contain quality requirements and quality control procedures to be approved by the Engineer, and factory test certificates shall be delivered with all shipments.

Cement shall be fresh when delivered to Site and the consignments shall be used in the order of their delivery. The Contractor shall mark the date of delivery on each consignment and each consignment shall be stored separately and, in such manner, as to be easily accessible and identifiable. Cement that has not been used within three (3) months from the date of initial sampling shall not be used in the Works unless it has been retested and is shown to conform to the specified requirements.

No cement in bags or other containers shall be used unless these and the manufacturer's seals are intact at the time of mixing. If the cement is delivered in bags it shall be stored in a waterproof shed or building at a temperature of not less than 8ºC and the bags shall be placed on dry boards above the floor to prevent deterioration or contamination from any cause. Bulk cement may be used providing it is stored in an approved waterproof container.

The Contractor shall not use cement, which has hardened into lumps, but subject to removal of the lumps by screening, the Engineer may allow such cement to be used in non-structural concrete mixes. Cement having been stored on the Site for more than four months shall not be used unless proved to be satisfactory.

The Contractor shall obtain test certificates from his suppliers of all consignments and shall submit them to the Engineer for approval.

13.5.2 ***Pozzolana Not applicable.***

13.5.3 ***Aggregates***

13.5.3.1 General

(a) Fine and coarse aggregates shall conform to IS 383 and to the requirements of this Technical Requirements.

(b) The term fine aggregate is used to designate aggregate in which the maximum size of particles is 5 mm. Fine aggregate for concrete, mortar and grout shall be furnished by the Contractor and shall be natural sand, manufactured sand, a blend of natural sands or a blend of natural and manufactured sands.

(c) The term coarse aggregate is used to designate aggregate in which the minimum nominal size is 5 mm and which is reasonably well graded from 5 mm to the largest size required in the work in which the material is being used. Coarse aggregate for concrete shall be furnished by the Contractor and shall consist of natural gravel, a mixture of natural and crushed oversize gravel or manufactured aggregate.

(d) At least sixty (60) days before placing any concrete the Contractor shall submit test results from representative samples of the proposed aggregates.

13.5.3.2 Tests

(a) Aggregate shall be tested in accordance with the provisions of this Technical Requierments..

Deleterious Substances

(a) Aggregates shall consist of hard, dense, durable, uncoated rock particles and shall be free from organic matter and the amounts of dust, clay lumps, soft or flaky particles, shale, alkali, loam and other substances considered deleterious by the Engineers, shall not exceed the values in the following table:

MAXIMUM AMOUNTS OF DELETERIOUS SUBSTANCES

Item	Maximum Percentage by Mass	
	Fine Aggregate	Coarse Aggregate
Material passing 0.075 mm sieve	2.0	0.5

Lightweight material	2.0	2.0
Organic matter	Zero	Zero
Clay lumps	1.0	0.5
Other deleterious substances	2.0	1.0

(b) The sum of the percentages of all deleterious substances in aggregate as delivered to the mixer, shall not exceed three (3) per cent for fine aggregate and two (2) per cent for coarse aggregate.

(c) Aggregate which, when tested in accordance with relevant Indian Standards (IS) equivalent to ASTM C289, Figure 2, is considered deleterious, will be rejected.

Particle Shape

(a) The aggregates shall consist substantially of particles of satisfactory shape. A particle of satisfactory shape is defined as a particle having a maximum dimension not greater than three (3) times the minimum dimension.

Grading of Fine Aggregate

(a) The fine aggregate as batched shall be well graded and when tested shall conform to the limits specified.

(b) The grading of the fine aggregate shall be so controlled that at any time the fineness moduli of at least nine (9) out of ten (10) consecutive test samples of finished fine aggregate will not vary more than 0.20 from the average fineness modulus of the ten (10) test samples.

(c) Where fine aggregates from different sources are being used at the one batching plant at the same time, they shall be so blended to ensure uniform grading and colour in successive batches.

GRADING OF FINE AGGREGATE

Sieve size (mm)	Percentage of total mass passing sieve
9.50	100
4.75	95-100
2.46	80-100
1.18	50-85
0.60	25-60
0.30	10-30
0.15	2-10
Pan	2-5

Nominal Size Range and Grading of Coarse Aggregate

(a) The coarse aggregate as batched shall be separated into nominal sizes and shall be well graded such that when tested by the sieves designated in the following table the minimum amounts of intermediate sizes are:

NOMINAL SIZE RANGES OF COARSE AGGREGATE

Designationof Aggregate size (mm)	Nominal size range (mm)	Minimum percentage of total mass retained on sieve indicated
10	5 to 10	Not applicable
20	10 to 20	25 on 16.0 mm
40	20 to 40	25 on 32.0 mm
80	40 to 80	25 on 63.0 mm

(b) Separation of the coarse aggregate into the specified sizes shall be such that when the aggregate, as batched, is tested by the sieve designated in the following tabulation, the materials passing the undersize test sieve shall not exceed two (2) per cent by mass, and all materials shall pass the oversize test sieve.

Designationof Aggregate Size (mm)	Size of Square Opening in Sieve	
	For undersize test	For oversize test
10	4.0	11.2
20	8.0	22.4
40	16.0	45.0
80	32.0	90.0

Other Properties

(a) Aggregate which does not comply with the following may be rejected.

	Fine Aggregate	Coarse Aggregate
Minimum specific gravity	2.56	2.56
Aggregate strength (on fraction greater than 9.5 mm) · Minimum wet strength · Maximum wet/dry strength variation	 N/A N/A	 80 kN 35%

Maximum weighted loss of a portion retained on an 0.300 mm sieve when subject to 5 cycles of sodium sulphate test	8% by mass	10% by mass
Maximum loss in Los Angeles abrasion test	N/A	35%
Maximum sum of flakiness and elongation indices	N/A	60%
Minimum fineness modulus	2.10	N/A
Maximum fineness modulus*		
natural sand	3.10	N/A
manufactured sand	2.80	N/A
*For a mixture of natural sand and manufactured fine aggregate the maximum fineness modulus shall have a value between 3.10 and 2.80 in proportion to the constituent materials.		

13.5.4 *Water*

Water for concrete, mortar, grout or curing shall be clean, fresh and free from matter in solution or suspension that may adversely affect the strength, durability or appearance of the Works or cause corrosion on reinforcement and embedded items.

13.5.5 *Admixtures*

Admixtures to be used shall be approved by the Engineer. Trial mixes and continuous monitoring of the concrete properties are necessary to determine quantities and type of water reducers and retarders to be used. The use of calcium chloride or admixtures containing chloride shall not be permitted.

13.5.6 *Water/Binder Ratio*

The binder may consist of only Portland cement or a mix of Portland cement and pozzolana. The water binder ratio is calculated as follows:

w/b = w/c

where:

w = total amount of water in the mix, including water contents of aggregates, kg/m3

b = total amount of binder, defined as (c + k.p)

c = amount of cement in the mix, kg/m3

13.5.7 *Classes of Concrete*

The classes of structural concrete to be used in the permanent Works shall be designed mixes with requirements as shown in **Error! Reference source not found.**13-1 unless otherwise approved by the Engineer.

Classes of Concrete

- M10 Lean Concrete
- M15 Concrete
- M20 Concrete
- M25 Concrete

Table 13-1

Concrete Grade	Application	Characteristic Strength at 28 Days	Maximum w/b Ratio	Typical Nominal Aggregate
M10	Lean/blinding concrete	10 MPa	0.60	20/40 mm
M15	PCC/non-structural concrete	15 MPa	0.55	20/40 mm
M20	Structural/general concrete	20 MPa	0.50	20 mm
M25	Structural/higher durability concrete	25 MPa	0.45	20 mm

13.5.8 *Production and Transport*

Aggregates and cement shall be proportioned by weight-batching and water shall be proportioned by volume. Subject to the prior approval of the Engineer volume batching of aggregates may be used for small sections of work, but volume batching of cement will in no case be accepted. The Contractor may, however, so proportion the mix that each batch shall use whole bags of cement, the weight of which is known precisely. Where permission has been given for volume batching of aggregates, all gauge boxes shall be accurate and strongly constructed and due allowance shall be made for bulking of the aggregates in assessing the correct volume to be used.

Batch mixing machines shall be provided in such numbers and of such capacity as to ensure a continuous supply of freshly mixed concrete with at least one standby unit at all times during construction. Continuous mixing machines shall not be used.

The aggregates and the cement shall be thoroughly mixed in a clean mechanical mixer until a uniform mixture is obtained and the water added on basis of the approved mix design. The mixing shall continue for at least 1 1/2 minutes after all the water has been added.

Mixers shall be completely emptied before receiving materials for the succeeding batch. Mixers must be kept clean and shall be washed out after stopping work and at the end of each shift.

On commencing the work with a clean mixer the first batch shall contain only two thirds of the normal quantity of coarse aggregate for the batch to compensate for the fine material and cement which adheres to the drum. This batch shall also be mixed for at least one minute longer than the normal specified time. This batch shall be used in Permanent Works only if approved by the Engineer.

Concrete must be so transported and placed that contamination, segregation or loss of the constituent materials does not occur. During transport concrete shall be carried in purpose-made agitators operating continuously.

13.5.9 *Preparations for Placing of Concrete*

13.5.9.1 General

No concrete shall be placed until all formwork, reinforcement, fixings and surfaces, on which the concrete is to be placed, have been inspected and approved by the Engineer. The Contractor shall give the Engineer a minimum of 24 hours' notice of his intention to place concrete. Concrete shall not be placed in any part of the structure without consent. If concreting has not been started within 24 hours of consent being given, consent must again be obtained.

Concrete shall not be placed in water except with the written consent of the Engineer, nor shall any concrete be subjected to running water until the concrete has hardened.

All faces against which concrete is to be placed shall be clean and free from oil, dirt, mud, saw dust, shavings or other debris. Formwork, reinforcement and inserts, which may have become encrusted with mortar or grout during previous placing of concrete, shall be cleaned of all such mortar and grout.

Immediately before placing of concrete commences, all surfaces against which concrete is to be placed shall be moistened and hosed down by the use of high velocity air/water jets. Temporary openings in the formwork shall be provided to drain off excess water and any debris.

Where required, sufficient drains or dewatering plant shall be provided to keep the area where concreting is in progress free from running or standing water. Such drains, hoses, pipes, pumps or other plant shall be securely fastened to prevent disruption during placing of concrete.

13.5.9.2 Concrete against Rock

Rock surfaces against which liquid-retaining structures are to be constructed shall be cleaned of all loose rock fragments by means of mechanical plant, scaling bars, wedges, and high velocity air/water jets until only sound rock without any loose material remains and to the satisfaction of the Engineer.

Where other structures than liquid-retaining structures are to be placed, preparation of rock surfaces for concreting may be relaxed to removal of all loose material by means of high velocity air/water jets only, if approved by the Engineer.

Rock surfaces shall be kept continuously moistened for at least 24 hours before placing of concrete. Rock surfaces sloping less than 15° shall immediately before placing of concrete commence be treated with a thin layer of mortar of the same cement/water ratio as that of the concrete to be placed.

13.5.9.3 Concrete against Soil or Rock Fills

Where directed, all structural concrete shall be placed upon a 50 mm thick layer of sufficiently cured blinding concrete.

13.5.10 *Placing of Concrete*

13.5.10.1 General

Concrete shall as far as possible be placed directly in its final position and shall not be caused to flow so that the lateral movement will permit or cause segregation of the concrete.

Concrete when deposited shall have a temperature of not less than 5°C. It must be compacted in its final position within 30 minutes of discharge from the mixer unless carried in purpose-made agitators, operating continuously, when the time will be within 1 hour of the introduction of water to the mix and within 30 minutes of discharge from the agitator.

Concrete shall be placed continuously over the area between construction joints to uniform levels in layers not exceeding 500 mm in such a manner as to avoid segregation. In liquid-retaining structures the concrete shall not be allowed to rise faster than 0.5 m/h and not slower than 0.15 m/h.

Fresh concrete shall not be placed against in situ concrete, which has been in place for more than 30 minutes, unless approved retarders have been applied or a construction joint is formed. When in situ concrete has been in place for more than 4 hours, no further concrete shall be placed against it for a further 20 hours or such other period of time as directed.

Concrete shall not be dropped from a height greater than 2.0 m. If certain sections of the Works require concrete to be deposited from a greater height, the concrete shall be deposited through a tremie or other approved pipes or chutes.

Each concreting team shall include a competent steel fixer and a carpenter who shall check that the reinforcement, formworks, and other fittings are in the correct position before pouring, and who shall be in attendance to ensure that reinforcement, formworks and fittings remain in position while the placing and compacting of concrete is being carried out.

The time limits for placing and compacting concrete given above are based on a mix without any additives. The Engineer may relax those limits when approved plasticizers giving retardation or retarders are applied.

13.5.10.2 Compaction

Unless otherwise directed, all concrete shall be compacted by means of approved immersion type internal vibrators with a minimum immersed frequency of 120 Hz and sufficient amplitude to consolidate the concrete adequately. At least one spare vibrator shall be kept at the location of every pour during concrete placement.

Vibrators shall be operated in a near vertical position and shall not be used to transport concrete within the forms.

Each layer of concrete shall be carefully rammed and vibrated allowing the vibrator to penetrate into the previous layer until trapped air bubbles are released and stone pockets are eliminated and until a homogenous dense mass of concrete is obtained with no honeycombing, pitting or planes of weakness. Spatulas of adequate length shall be used to ensure that the concrete is well rammed between the reinforcement and the formwork, around embedded items and into the corners of forms. The number and

size of vibrators shall be such as to ensure vibration throughout the entire volume of the concrete and shall be applied to points uniformly spaced and at such distance apart that their cones of influence shall overlap and the whole mass of the concrete shall become plastic.

Care must be taken to ensure that the concrete is not over-vibrated causing excess water and laitance to form on top of the concrete. Any water accumulating on the surface of newly placed concrete shall be removed by approved means and no further concrete will be placed thereon until such water is removed.

Vibrators shall not be applied to, or have any contact with, reinforcement or formwork but shall be carefully inserted to avoid contact with reinforcement and formwork as far as is practicable.

13.5.10.3 Underwater Concreting

Normally, underwater concreting will not be allowed. In cases when it proves necessary to place concrete under water, the Contractor shall submit his method statement including the following data for the approval of the Engineer:

- Location of the pours
- Plant to be used
- Modifications to the approved concrete mixes
- Protection of fresh concrete against water currents etc.

Additives for underwater concreting shall be used to reduce segregation and wash-out of the concrete during casting. Concrete shall not be placed in flowing water. Underwater concrete shall be placed in position by a tremie or other approved pipelines. The casting should proceed continuously and with one casting front.

During and after concreting underwater, pumping or dewatering operations in the immediate vicinity shall be suspended until the Engineer permits them to be continued. Water shall not be allowed to flow over or exert any unilateral pressure against concrete until at least 48 hours after deposition.

13.5.10.4 Hot Weather

13.5.10.5 Concreting

Mixing and placing of concrete when the air temperature at the Site exceeds 35oC shall not be permitted unless approved by the Engineer.

The temperature in the concrete when placed shall always be as low as possible, and shall under no circumstances exceed the values of Table 13-2.

Table 13-2: Maximum Concrete Temperatures

Maximum concrete temperature	
Cement content (kg/m3)	Maximum concrete temperature
300	32°C
320	30°C
340	28°C

360	25°C
380	23°C
400	20°C

In order to maintain an adequate temperature of the concrete the following precautions shall be taken wholly or in part as needed:

a) All aggregate stockpiles, water lines and tanks as well as the mixer shall be protected from direct sunshine.
b) Coarse aggregate shall be cooled by constant watering where possible.
c) Mixing water shall be cooled by the addition of ice to the storage tanks. The Contractor shall have available at Site a suitable plant for ice production.

Where the above precautions are inadequate concreting shall be carried out during the cooler parts of the day or during the night as may be directed by the Engineer.

Ambient temperature, aggregate temperature, concrete transport length and type of vehicles will be influential as to what temperature the concrete should have when leaving the mixer. The Contractor shall provide sufficient transportation capacity to ensure a continuously casting. The Contractor is responsible for ensuring further cooling, if necessary. Heat reflecting rather than absorbing concrete containers should be used for transport. The Contractor shall describe in detail the means and equipment to be used.

The Contractor shall evaluate the effects of curing temperatures and thermal gradients, and take this into account in the construction. Thermal gradients greater than 30oC per 300 mm thickness are normally not acceptable. Severe thermal gradients shall be limited by providing cover and insulation of freshly exposed concrete.

In order to reduce premature drying of the concrete during transport and placing, all chutes, shuttering and reinforcement shall be cooled by watering when possible, or shall otherwise be shaded from direct sunlight. Any water so used shall be removed by setting with compressed air before placing the concrete.

13.5.10.6 Wet Weather Concreting

Concreting during periods of constant rain shall not be permitted unless aggregate stockpiles, mixers and transporting equipment, and the areas to be concreted are adequately covered and drained by diversion channels or by pumps.

During showery weather the Contractor shall ensure that, if permitted, the work can be concluded at short notice by the provision of stop ends. On no account shall work be terminated before each section, between one stop end and another, is complete. Adequate covering shall be provided to protect newly placed concrete from the rain.

13.5.11 *Curing of Concrete*

Newly placed concrete shall be protected from rain, drying winds, sun and contact with substances, which can adversely affect it.

No traffic or constructional loads shall be permitted on newly placed concrete until it has hardened sufficiently to take such traffic or load without surface damage or deformation.

A curing membrane shall be applied on horizontal surfaces continuously, after final levelling of the top surface. During the following curing period horizontal surfaces shall be protected from evaporation of water by either watering or covering with hessian, canvas or an impermeable sheet, as soon as covering can be performed without leaving prints on the surface.

Vertical surfaces shall be protected from excessive evaporation of water due to sun and wind by keeping the formwork in close contact with the concrete until continuous application of water or covering can be performed. Under extreme conditions covering and watering after stripping may prove necessary so that no damage occurs to the surface of the concrete. Covering with an absorbent material kept damp or an impermeable sheet close enough to the surface to prevent excessive circulation of air shall be used. Liquid curing membranes are not considered as sufficient alone.

Concrete shall be protected as described for at least seven days unless otherwise approved by the Engineer.

13.5.12 *Quality Control and Testing*

The Contractor shall present a QA-system in order to demonstrate his ability to produce, deliver and cast the concrete, as well as perform the tests and running control that are required for the present project. The quality control shall embrace all aspects of his concrete work including aggregates, cement, water, admixtures, mixing plant, and equipment for transport, placing and compaction. He shall supply all necessary labour, materials and equipment and carry out such tests as are necessary to ensure the specified quality of the concrete.

The QA-system is subject to approval from the Engineer, and shall contain:

- Organization plan showing position and responsibilities for persons who have influence on quality of the concrete and of the work. Record of past experience from similar demanding concrete work, and education in this respect, shall be given.
- Description of the facilities at disposal for producing and transport of the concrete (and its constituents, where relevant), and controlling its quality, to the extent necessary to demonstrate capability to comply with the requirements. Examples of what should be included are:
  - Transport, storage and dosage facilities for aggregates, cement, pozzolana, additives and water.
  - Cooling facilities for water. Ice production facilities. System, if needed, for cooling aggregates.
  - Mixers. Type and capacity. Means of controlling and recording actual mix data. Calibration of scales and volumeters. (Printout giving all mix data, planned and actual, shall follow each batch)
  - Concrete transport systems.
  - Aggregate production plant. Facilities for crushing, sieving, washing and storage.
  - Laboratory. Facilities, equipment and capacity.
  - Instruments, equipment for monitoring concrete temperature in the structure.
  - Backup facilities.

- Concreting equipment, vibrators etc.

  Description of the internal control system that the Contractor will propose for his activities, and of the system for reporting to the Engineer, that will ensure sufficient guarantee for meeting the requirements.

Testing shall be performed according to the relevant ASTM standards or other relevant standards. The Contractor's testing shall be carried out in the materials testing laboratory established at Site, ref. Chapter 15.

Test reports shall record all data required for sample and batch identification and test results shall be presented in a format approved by the Engineer and which shall include the location in the Works of the concrete presented by the sample. Two copies of each test result shall be submitted to the Engineer within 24 hours of the test being completed. In addition a weekly summary report of the main data shall be presented to the Engineer.

Testing shall be carried out as often as the Engineer considers necessary to confirm the conformance of the concrete work to the Contract. Unless otherwise approved, the minimum frequency of testing of the concrete shall be as specified in Table 13-3.

Table 13-3: Minimum Test Frequency for Concrete

Description of Test	Minimum Test Frequency
Unit Weight, Yield, Air Content	1 per 2000 m3
Bleeding	1 per 2000 m3
Permeability	1 per 2000 m3

Slump tests according to ASTM C 143 at the point of mixing and at the point of placing shall be carried out as often as necessary to verify and control consistency, and when required by the Engineer. Slump tests shall be made and recorded at least once for every section of concrete being placed.

For every 100 m^3 of concrete placed, or for every pour if less than 100 m^3, six samples shall be taken to be cured and tested in accordance with ASTM C 31 and 139, three samples being tested at 7 days and the other three samples at 28 days. The concrete cylinders tested at 7 days are intended to be indicative of the strength only, whereas the cylinders tested at 28 days shall be taken to represent the concrete placed in the Works. The concrete shall be accepted if the 28-day characteristic strength determined exceeds the specified compressive strength.

13.5.13 *Failure to meet Quality Requirements*

Any concrete, which fails to meet the standard of acceptance, shall be either further tested or condemned at the Engineer's sole discretion. Further tests shall be carried out in accordance with ASTM C 42 or equivalent.

Any such further tests or the removal of condemned concrete, replacement, including the removal and replacement of any satisfactory concrete necessarily removed as a result of the remedial measures directed by the Engineer, shall be at the Contractor's responsibility.

Before proceeding with concreting the Contractor shall submit, for the approval of the Engineer, details of the action proposed to ensure that the concrete still to be placed in the Works will comply with this Specification. If the strengths required are not attained, the Contractor shall redesign the mix and resubmit trial mixes to give a concrete which does comply with the requirements of this Specification.

13.5.14 *Repair of Concrete*

The quality of finish shall not be inferior to that described in this Specification.

If any portion of the facework should prove unsatisfactory upon removal of the formwork, it shall, without delay, be cut out and made good as directed. Sufficient amounts of such face concrete shall be removed to coincide with the panels in the formwork so that no patching effect occurs. No plastering of concrete surfaces will be allowed. At the discretion of the Engineer, boardmarks or minor discontinuities on exposed faces may be removed by rubbing down with carborundum, and pinholes, small voids or minor porosity of the surface, may be filled, by rubbing down with cement and sand mortar of the same richness as in the concrete. Treatment must be made immediately after removing the formwork but in any case, only after the Engineer has examined the facework.

Any concrete, the surface of which has been treated without prior approval, will be liable to rejection, and consequent removal.

13.6 JOINTS

13.6.1 *Waterstop and Jointing Materials*

Waterstop and jointing materials shall be obtained from an approved manufacturer. All waterstop and jointing materials, which are not required for immediate use, shall be stored at all times in a cool, damp environment.

Waterstop shall be manufactured from P.V.C. (polyvinyl chloride). The tensile strength shall be minimum 12.5 N/mm2 and elongation before rupture minimum 300 %. Unless otherwise specified, the waterstop shall be 200 mm wide.

No waterstop shall be shipped from the factory until certified test reports have been approved by the Engineer. Supplementary samples of the waterstop shall be taken after delivery to the Site and tested, at the Contractor's expense, in a laboratory approved by the Engineer.

Intersections and junctions shall be obtained prefabricated from the approved manufacturer. All site joints shall be welded strictly in accordance with the manufacturer's recommendations.

Waterstop shall be located and maintained accurately in position, and details of the proposed method of fixing shall be submitted to the Engineer for approval. On no account shall waterstop be secured by nails or by any other means involving puncture of or damage to the waterstop material. Waterstop shall, unless otherwise specified, have minimum 70 mm concrete cover.

Joint filler shall be manufactured of natural bonded cork or other approved material. Joint filler shall be cut and trimmed accurately to suit the joint profile and shall be maintained accurately in position by means of an approved adhesive.

Joint sealing compounds shall be approved rubber/bituminous compounds suitable for sealing joints in horizontal and vertical/sloping concrete surfaces as appropriate. Sealing compounds shall be applied strictly in accordance with the manufacturer's instructions and shall completely fill the joint recess.

Primers shall be applied as and if recommended by the manufacturer.

13.6.2 *Construction Joints*

Construction joints will be permitted only at the positions shown on the Drawings or as approved by the Engineer.

If further joints are required, the Contractor shall submit for approval proposals for the layout of construction joints before concreting is started.

Where vertical construction joints are required the joint face of the first cast concrete shall be finished against a stopping off board, or vertical end formwork suitably notched to pass the reinforcement. The surface film of the first cast concrete shall be removed before the concrete has hardened to expose the aggregate and leave a sound, clean irregular surface. Just before concreting is resumed, the roughened joint surface shall be thoroughly cleaned and freed from loose mortar, moistened and then treated with a thin layer of mortar of the same sand/cement ratio as the concrete to be placed worked well into the surface. The Contractor must take precautions to avoid segregation of the concrete along the joint plane and to obtain thorough compaction.

For horizontal joints a layer of mortar shall not be used, but the paste content shall be slightly increased in the first layer.

Horizontal construction joints shall have a gentle slope for drainage, and shall be left free from protruding rock, vibrator holes and other irregularities. Before concreting is continued, and as late as feasible, the weak surface paste, film and contamination shall be removed to expose a fresh, clean mortar and aggregate surface. This shall be done by use of high pressure water jet of at least 40 MPa (approx. 6000 psi), or, when necessary for concrete having reached higher strength, by sandblasting, as directed by the Engineer. Degreasing agents shall be used to remove any oily impurities, "Green cutting" i.e. removing of film and laitance when the concrete approaches final set, shall only be done when explicitly permitted by the Engineer, and shall be done with great caution so as not to damage the concrete and reduce the strength of the paste near the surface. After treatment, any loose material, sand and water shall be removed before concreting.

13.7 ROCK BOLTS

Where shown on the Drawings, concrete structures shall be anchored to sound rock by grouted rock bolts of deformed bars 500 N/mm2 and of specified diameter and length. The length of the bolt protruding from the rock into concrete shall be 40 times its diameter but minimum 1.0 m for all dimensions and the depth in rock as specified. Requirements to materials and execution of drilling and grouting shall be as specified for grouted rock bolts in Chapter 8.

13.8 MEASUREMENT AND PAYMENT

13.8.1 *Formwork*

Formwork shall be measured by the area of the surface of the completed concrete structure for all final surfaces of concrete which require temporary support during casting except where otherwise stated. The formwork shall be of Class B if not otherwise stated.

Formwork shall be measured for the side surfaces of in situ concrete cast within excavated volumes except where the concrete is required to be cast against an excavated surface. Upper surfaces of concrete inclined at an angle exceeding 15o to the horizontal shall be deemed to require temporary support during casting.

Formwork to temporary concrete surfaces shall be measured at locations where temporary surfaces are expressly required, but not where temporary surfaces are formed at the discretion of the Contractor. Formwork for blinding concrete shall not be measured.

13.8.2 *Reinforcement*

The mass of steel reinforcement if applicable measured shall be calculated in weight basis from the nominal diameter of the reinforcement and the net length of the reinforcing bars as detailed in the bending schedules, the mass of steel being taken as 0.785 kg/m per 100 mm2 of cross section. It shall be in kg or in tones.

No allowances shall be made for laps, splices, connectors, tying wire, templates, stools, blocks, ordinary spacers and other supports. No measurements of any cutting, bending or forming of shapes will be made. Measurement of fabric reinforcement shall be made in tonnes of material executed, calculated at the manufacturers kilogramme rate per square metre, for the area covered by the material, but without allowances for laps, bends, cutting, notching around obstructions, tying wires, templates, stools, blocks, spacers or other supports and without deductions for voids less than one square metre.

13.8.3 *Concrete*

Measurement of concrete shall be made in volumes in cubic metres placed in accordance with the line and levels indicated on the Drawings or as required by the Specifications, or directed by the Engineer. The rates include all materials including admixtures, mixing, and transportation, placing, curing and testing if required as per specification.

No deductions shall be made for the volume occupied by reinforcement, or individual voids or embedded materials less than 0.05 m3, rebates, fillets and the like. No additional measurement will be made for additives, admixtures, pouring restrictions or requirements, consolidation, curing materials or methods, tests or hand finishing or making good where directed.

Blinding concrete shall be measured by the net area, and the specified thickness shall be the minimum thickness.

The rates for concrete shall include costs for any admixture whether ordered by the Engineer or not.

If separate items are provided in the Bill of Quantities for finishing of top surfaces, the area measured shall be the net area shown on the Drawings or directed by the Engineer including holes and openings in the finished surfaces each less than 0.5 m2 in area.

14 CHAPTER 14: MANAGEMENT OF EXPLOSIVE

14.1 SCOPE

a. The scope of this part site clearance and preparation for the construction works for bunker house, grading, filling and levelling of the land in the given site as per the approved site plan. The Contractor may require supplying power to the Client and to the Army Camp at the bunker of explosives.

b. Only the authorized Contractor's explosive Engineer or qualified personnel (shot-firer or blaster-in-charge), shall treat explosives and detonators, receipt of quantities exceeding proposed daily usage shall not be permitted.

c. The explosives and detonators shall be kept separate in custody, the remainders after proposed use shall be returned to the authorities in charge or designated depository.

d. The Contractor shall plan storage for explosives pursuant to Nepalese applicable laws on Arms and Ammunitions, designating authorized personnel. The plan shall be approved by the Engineer and authorities.

e. The personnel, shot-firer or blaster-in-charge, designated by the explosive Engineer may transport explosives at the proposed sites in accordance with specified container and carriage methods.

f. The Contractor shall observe and carry out all excavation work according to rules and regulations regarding the import, transport, storage and use of explosives issued by and public authority having jurisdiction in respect of the same. Detailed records shall be kept by the Contractor and submitted daily to the Engineer giving the types and quantities of explosives used, delivered and in stock.

14.2 GENERAL REQUIREMENT:

(1) The procurement, transportation, storage, use, account and disposal of balance and defective explosive materials shall be strictly as per prevalent laws and ordinances applicable to the work site. Should there be any discrepancy found between procedures described hereunder and the prevalent laws and ordinance, the later shall supersede. Blasting shall be carried out in a manner that completes the excavation to the lines indicated on the Drawing or as directed by the Engineer, with the least disturbance to adjacent material. It shall be done only with the written permission of the Engineer. The Contractor shall adopt such method that is consistent with the safety and job requirements. Prior to starting any phase of the operation, the Contractor shall provide information describing pertinent blasting procedures, dimensions, and notes.

(2) Material, Tools, and Equipment: All the material, tools and equipment used for blasting operations shall be off approved type. The Engineer may specify the type of explosives to be allowed in special cases. The fuse to be used in wet locations shall be water-resistant and shall remain unaffected when immersed in water for 30 minutes. The rate of burning of the fuse shall be uniform and definitely known to permit such a length being cut as shall permit sufficient time to the firer to reach to a safe place before

explosion takes place. Detonators shall be capable for giving effective blasting of the explosives. The blasting powder, explosives, detonators, fuses, etc., shall be fresh and not damaged due to dampness, moisture or any other cause. They shall be inspected before use. The damaged articles, if any, shall be discarded totally and removed from the site immediately.

(3) Personnel: The blasting operation shall remain in the charge of competent and experienced blaster with legal license and thorough knowledge of handling explosives and blasting operations.

(4) Blasting Operations Explosives shall be used in the quantities and manner recommended by the manufactures. The written permission of the Engineer shall be obtained for each location or series of locations where the Contractor wishes to use more than 5 kg of explosives in one series of blast. Such permission shall not any way relieve the Contractor of his liabilities under the Conditions of Contract. The blasting shall be carried out during fixed hours of the day preferably during the mid-day luncheon hour or at the close of the work as ordered in writing by the Engineer. The hours shall be made known to the people in the vicinity. All the charges shall be prepared by the blaster only. The Engineer must be notified at least 24 hours in advance on any blasting operation. When blasting is to be carried out, the Contractor shall determine the danger zone likely to be created, and shall ensure that all personnel, vehicles and livestock are clear of the zone before and during the blast. In settled areas, the Contractor shall take steps to avoid damage to property from flying rock by using blasting mats or other suitable blanketing materials. The Contractor shall notify each public utility organization/company having structures in proximity to the site to the work of his intention to use explosives. Such notice shall be given sufficiently in advance to enable the companies to take such steps as they may deem necessary to protect their property from injury. Danger red flags shall be displayed prominently in all directions during the blasting operations. The flags shall be planted 200 m from the blasting site in all directions. People, except those who actually light the fuse, shall be prohibited from entering this area, and all persons including workmen shall be excluded from the flagged area at least 10 minutes before the firing, a warning siren being sounded for the purpose. The charge holes shall be drilled to required depths and at suitable places. Blasting shall be as light as possible consistent with thorough breakage of the material necessary for economic loading and hauling. Any method of blasting which leads to overshooting shall be discontinued. Not more than 10 charges shall be prepared and fired at a time. The man in charge shall blow a siren in a recognized manner for cautioning the people. The charges shall be lighted by the blasters only. The blaster shall count the number of explosions. He shall satisfy himself that all the charges have been exploded before allowing the workmen to go back to the work site. After blasting operations, the Contractor shall compact the loose residual material removed below sub-grade and replace the material removed below sub-grade with suitable material. When forming final cut faces, pre-split blasting techniques as recommended in the Specification for Road and Bridge (IRC) shall be carried out to ensure that blasting damaged to the cut face is minimized. Details of the pre-splitting technique to be used shall be notified to and approved by the Engineer at least 24 hours in advance of the blasting operation.

(5) Misfire In case of misfire, the following procedure shall be observed:

(a) Sufficient time shall be allowed to account for the delayed blast. The blaster shall inspect all the charges and determine the missed charge.

(b) If it is blasting powder charge, it shall be completely flooded with water. A new hole shall be drilled at about 450 mm from the old hole and fired. This should blast the old charge. Should it not blast the old charge, the procedure shall be repeated till the old charge is blasted.

(c) In case of charges of gelignite, the blaster shall gently remove the tamping and the primer with the detonator. A fresh detonator and primer shall then be used to blast the charge. Alternatively, the hole may be cleared of 30 mm of tamping and the direction then ascertained by placing a stick in the hole. Another hole may then be drilled 150 mm away and parallel to it. This hole shall then be charged and fired when the misfired hole should explode at the

(d) same time. The blaster shall at once report to the Contractor's office and the Engineer all cases of misfire, the cause of the same and what steps were taken in connection therewith. If a misfire had been found to be due to defective detonator or gelignite/dynamite, the whole quantity in the box from which defective article was taken must be sent to the authority as directed by the Engineer for inspection to ascertain whether all or art of the remaining materials in the box are also defective.

(6) A careful and day to day account of the explosive shall be maintained by the Contractor in an approved register and manner which shall be open to inspection by the Engineer at all times. Records must be kept by the Contractor of all drilling and blasting operations showing holes diameters and depths, drilling pattern, explosive charge and type per hole, detonator delay times and total charge per blast. These records must be submitted to the Engineer on completion of charging.

(7) The Employer shall be responsible for obtaining all necessary permits, clearances, and licenses required for the importation, transportation, storage, and use of explosives, including coordination with relevant Government Authorities, police, and military departments, and shall bear all associated costs for such permits, licenses, and approvals.

(8)The Contractor shall be responsible for the provision of on-ground transportation of explosives from the designated supply point to the Site, in compliance with applicable laws, and for deploying and maintaining the required security personnel at the Site and explosive storage areas, as per the prevailing regulations of the Government of Nepal (GoN) and shall bear all associated costs.

14.3 Measurement and Payments

The cost of explosives and explosive management, including the supply, transportation, storage, construction of bunker, and handling of explosives required for earthwork excavation by blasting, is included in the relevant BoQ item and is payable as a Lump Sum (LS) item and paid as per schedule approved by the Engineer. No separate payment shall be made under this heading in bunker house.

15 CHAPTER 15: CONTRACTORS SITE FACILITIES

15.1 GENERAL SITE ESTABLISHMENT REQUIREMENTS

The Contractor shall be entirely responsible for the provision, erection, maintenance and removal on completion of all temporary works and facilities that he requires to complete the Works including his offices, laboratory, workshops, stores, bunker houses and security accommodation for the same, accommodation, medical facilities, recreational facilities, services and the like, whether on or off the Site.

The whole of the Contractor's facilities on Site or within the Project Area shall be provided erected a nd maintained to the approval of the Engineer. Not later than 28 days before any facilities are to be established, the Contractor shall submit to the Engineer for consent sufficiently detailed drawings and proposals of all facilities to be established, including locations, types dimensions and operating information. Buildings and equipment to be provided by the Contractor shall be erected in the positions approved by the Engineer.

The Contractor shall maintain all temporary facilities in a condition fit for their purpose. Buildings shall be maintained in good condition and appearance for the duration of the Contract, and the site establishment areas shall be kept in a clean, sanitary and orderly condition and to the satisfaction of the Engineer.

The Contractor shall take all precautions necessary to ensure that natural water courses, groundwater and the natural ground soils are not contaminated by fuel, oil or other substances being handled or stored in any of his site establishment areas. The Contractor shall submit details of the measures he will institute for the prevention and control of spillages in these areas to the Engineer for approval.

The Contractor shall fence off all his designated site establishment areas and shall be responsible for the security of all buildings, equipment and materials within these areas. The Engineer and the Engineer shall nevertheless have full access to all temporary works and facilities at all reasonable times.

The Contractor shall handover all buildings and related facilities provided under this chapter 15 and which are no longer required by the Contractor, the Engineer or the Engineer. Prior to removal, the Contractor shall obtain the Engineer's consent for removal. After such removal the ground shall be reinstated to a condition similar to adjacent natural areas, if necessary, by means of the spreading of topsoil, all to the satisfaction of the Engineer.

15.2 CONTRACTOR'S SITE OFFICES, BUILDINGS, WORKSHOPS, YARDS AND PLANTS

15.2.1 *General*

The Contractor shall make his own arrangements regarding site offices, stores, warehouses, workshops materials yards, crushing and screening plant(s), and concrete batching plants; provided always that the permissible uses of each of the identified site establishment areas approved the Engineer.

Fuel, oils and liquid chemicals of all types shall be stored according to the requirements of the applicable codes in properly constructed tank certified as such. All installations containing "fuel, oil or liquid ch

emical storage shall be secure against unauthorized persons and shall be provided with all required measures to prevent spillages and control any leakages.

15.2.1.1 Minimum Availability Requirement for Equipment, Materials and Spares

The Contractor shall provide sufficient equipment, spares and materials to ensure continuity and proper completion of his operations, including, but not limited to power generating sets, earthwork equipment, concrete mixing and transportation equipment, grouting equipment, dewatering equipment and other key plant and equipment required to ensure progress in accordance with the Program of works.

The stock of general supplies and construction materials at Site shall always be sufficient for a minimum of one-month uninterrupted operation. But before rainy contract has to store materials for four months of rainy season and No separate payments shall be made for the stock of general supplies and construction materials.

15.2.1.2 Services for Contractor's Facilities and Work Sites

a. Electrical Power Supplies

   The Contractor shall be responsible for arranging for the supply of electric power and lighting as required for all his site establishment areas, compound, offices, workshops, storage and warehousing etc., and for all his working areas and construction sites throughout the Works. The Contractor shall supply power for his own use in accordance with the requirements.

   At the completion of the Works, the temporary power supply facilities arid temporary distribution lines shall be removed unless they are transferred to and taken over by the Engineer.

b. Water Supply

   The Contractor shall make all provisions for the supply and delivery of water required for the execution of the Works as well as adequate quantities of potable water for the Contractor's camps, offices, workshops etc. and at every place of working. The Contractor shall be responsible for ensuring that he has sufficient water to satisfy demand at all times. The temporary water supply systems shall be designed, constructed, operated and maintained by the Contractor throughout the construction period.

c. Sewerage and Sewage Treatment

   The sewerage system and facilities for the collection, treatment and disposal of wastewater which are to be designed, constructed, operated and maintained by the Contractor throughout the construction period to all the Contractor's own camps, offices, workshops etc.

d. Messing / Catering Facilities

   All messing and catering services shall comply strictly in all respects with the Contractor's agreed Health and Safety Plan and Environmental Management Plan.

e. Solid Waste Management

The Contractor shall implement an effective solid waste management system throughout the Contract period. All solid waste generated from construction activities, camps, offices, and workshops shall be

properly segregated, collected, stored, transported, recycled where practicable, and disposed of at approved disposal facilities in accordance with applicable environmental regulations and the Environmental and Social Management Plan (ESMP). Open dumping, burning, or disposal of waste in unauthorized locations shall be strictly prohibited and keep records of waste management activities for inspection by the Engineer. The Contractor shall maintain clean work areas, prevent pollution of land and water resources, and keep records of waste management activities for inspection by the Engineer.

The Contractor shall design, construct, furnish, equip, operate and maintain a site material testing laboratory for the duration of the Contract or until such time as the Engineer instructs the Contractor to remove it from Site. The Contractor shall during this period engage a qualified and well experienced material testing Engineer, as well as the required number of qualified technicians, for operating the laboratory.

The laboratory shall be operational on Site not later than the date at which the construction activities of the Contractor require the first such material testing to be carried out in accordance with the Specification, and in any case not later than 90 days after the Commencement Date.

The Contractor shall provide required testing equipment, tools, consumables, forms, etc. and shall have the responsibility of carrying out all tests required for the control of the quality of materials and workmanship in accordance with the Specification and as directed by the Engineer, and shall supply the Engineer with two copies of the results of each test on approved printed forms before submitting the respective materials or finished work to the Engineer for approval. A third copy of the results shall be retained in the laboratory. The Engineer will witness the testing at his own discretion.

The Engineer shall have access to the laboratory at all times to carry out his own control tests on workmanship and materials.

At the commencement of the Works all testing equipment shall be calibrated to ensure accuracy of the testing in accordance with the relevant Standards. The Contractor shall perform additional calibration from time to time to ensure correctness and accuracy of the equipment and shall ensure that all equipment is kept in good working order.

The Contractor shall provide all necessary auxiliary equipment, chemicals, test forms and other consumables.

In case tests required by the Specification cannot be carried out in the Contractor's laboratory, the Contractor may arrange for testing to be undertaken at an independent testing laboratory approved by the Engineer. These tests shall then be undertaken by the approved laboratory andall costs incurred thereby by the Contractor including all fees and charges shall be deemed to be included in the respective unit rates.

15.2.1.3 Laboratory Building

The Contractor shall submit drawings and full specifications of his proposed laboratory building, including all structural and architectural details, associated services, furnishings, fittings and equipment layouts, to the Engineer for approval in good time such that the deadline for becoming fully operational

can be met. The laboratory building shall be large enough to provide comfortably all space required for the specified equipment and testing.

The working areas of the laboratory shall have a section of floor constructed of reinforced concrete, and concrete plinths for the mounting of equipment shall be cast as required. The quality of finish of the remaining floor surfaces shall be not less than that of concrete with a smooth float finish.

The Contractor shall also provide treated water, electricity, telephone, sinks and sewage system.

The laboratory to be provided shall consist of the following minimum accommodation:

- Contractor's Materials Engineer's office;
- concrete cube room (with curing tanks);
- toilets with wash hand basins.

  Sufficient power points, furniture and appliances for all rooms in the laboratory shall be provided by the Contractor and be new and of good quality.

15.2.1.4 Minimum Testing Requirements

The Contractor may perform any tests on materials which he considers necessary, however as a minimum, it shall be equipped to perform the following tests in accordance with the IS (or equivalent) standards.

Provide factory testing and calibration of all applicable laboratory equipment and include test certificates with the equipment.

The Contractor shall carry out all necessary tests and shall report the results of all tests carried out to the Engineer before submitting the respective materials and finished work to the Engineer for approval.

15.2.1.5 Testing Equipment

The Contractor shall determine and propose to the Engineer for approval which testing equipment will be necessary to comply with the requirements of the Contract and with which (laboratory will be equipped accordingly. The list of equipment and item numbers to be supplied and installed in each laboratory shall be proposed by the Contractor in his Bid based on the specified tests and test frequencies.

The Contractor shall be responsible for keeping the list of necessary equipment under constant review and wh
ere necessary and with the agreement of the Engineer, amending it accordingly and providing any additional equipment which is necessary.

Equipment and installations which become unusable due to normal wear and tear shall be replaced. The Contractor shall always regularly check and re-calibrate all laboratory equipment to ensure that it indicates true and accurate readings.

The minimum laboratory equipment required shall include, but not be limited to, the following:

List of Equipment

S.N	Name of Equipment	Number	Remarks
1	Compression Testing Machine (CTM) – 2000 kN	1 set	Concrete cube/core strength
2	Slump Cone Set	1 set	Workability
3	Rebound Hammer	1 set	In-situ concrete assessment
4	Standard Sieve Set	1 set	Sieve analysis
5	Vicat Apparatus	1 set	Consistency/setting time
6	Rock UCS Testing Machine	1 set	Uniaxial compressive strength
7	Shotcrete Panel Mould	1 set	shotcrete
8	Grout/mortar Testing machine	1 set	grouting
9	Hydraulic Pull-Out/Pull Test Jack	1 set	Rock bolt pull test
10	Sample Storage Racks	1 set	
11	Laboratory Work Bench	1 set	
12	Computer & Printer	1 set	office
13	Equipment Calibration Tools/Certificates	1 set	certificate
14	Etc.		necessary for site

15.2.1.6 Laboratory Staff

All staff and labor for testing, operation and maintenance activities shall be provided by the Contractor. The Contractor shall provide and employ for carrying out testing and sampling of materials and workmanship only such Engineers, technical assistants or personnel as are skilled and experienced in their respective fields and are competent to give proper supervision to the work they are required to supervise and to carry out. Skilled, semi-skilled and unskilled labour as is necessary for proper and timely execution of the sampling and testing works and associated services shall also be allocated to the laboratory.

15.2.1.7 Removal of Laboratory and Disposal of Equipment

The laboratory building shall be removed, and the area reinstated in accordance with the relevant specifications at the completion of construction works on the approval of the Engineer. Furniture shall be handed over to the Engineer in its actual condition at that time. The equipment will remain the property of the Contractor.

15.3 ACCOMMODATION AND HOUSING

15.3.1 *General*

The layout and details of each accommodation compound and labor camp, buildings and any other facilities as may be required in connection with the accommodation shall be subject to the approval of the Engineer. The Contractor shall observe all applicable planning and building regulations and obtain any necessary approvals from the relevant authorities in connection with the establishing of such accommodation facilities.

At the end of the Contract and after receiving approval in writing from the Engineer the Contractor shall dismantle and remove all structures and facilities associated with accommodation and labour camps provided for his own use, including all buildings, facilities, furnishings, fittings and equipment, and shall restore the site, as far as practicable, to its original condition and leave it neat, tidy and stable to the satisfaction of the Engineer.

15.3.2 *Minimum Requirements for Contractor's Labor Camp Accommodation*

The Contractor shall at all times provide adequate accommodation and appropriate recreational facilities for his workforce. The Contractor shall construct adequate numbers of dormitory type accommodation units for the use of his labor. The Contractor shall furnish, equip, administer, maintain and operate all general labor accommodation for his own use.

15.4 INSTALLATION OF FIRE-FIGHTING ARRANGEMENT

15.4.1 *General*

15.4.2 *Scope of Work*

This specification shall be applied to the fire-fighting facilities (fire extinguisher) to be installed in the tunnel and Contractor workplaces.

15.4.3 *Related Acts*

These arrangements shall be made in accordance with the Fire-Fighting Act, the Enforcement Decree of the Same Act, Enforcement Rules, National Fire Safety Standard (NFSC 101), Rules on Standards, etc. of Facility on Installation and Maintenance of Fire-Fighting Facilities, Manufacture of Dangerous Substances, etc. and other Relevant Rules and Regulations or equivalent. The arrangement shall include portable dry chemical extinguishers. The equipment shall be supplied from a reputable manufacturer according to approved international standards.

15.4.4 *Fire extinguishers*

(1) The fire extinguishers shall be used as fire-fighting facility. In case the products are regulated to be inspected as per the related acts, they shall be approved and verified for their use.

(2) Unless otherwise specified on the devices and materials, the products approved for the type by inspection rules on machines, devices, etc. shall be used.

(3) The name plate marking the manufacture company, manufacture number, date of manufacture, approval of type, performance, etc. on the machines, devices, etc. shall be attached for their use.

(1) The fire extinguisher shall be installed as per approved standards.

(2) Fire-fighting box

The standard box of fire extinguishers shall be the STS of over 1.5 mm width reinforcing the required parts. The volume shall be also proper for containment of the required standard product and the dimension of type easy to fight the fire. The color of letter shall be red.

(3) Installation and maintenance of fire extinguisher

- The fire extinguisher shall be installed less than the height of 1.5m from the floor.
- The fire extinguisher shall be installed in the position where passages or escapes are not interfering, and it is easy to find out for its use.
- For the fire extinguisher, the protection measures shall be taken to prevent damage by falling down.
- The fire extinguisher shall be stored in the fire extinguisher box.

15.4.5 *Process and Inspection*

In case the related administrative agency needs to inspect the system caused by the construction of the fire-fighting facility, the process and inspection shall be carried out as early as possible to meet the general regulations.

15.4.6 *The Details of items includes in Firefighting System*

The followings items shall include in Firefighting System:

Dry chemical extinguisher		Extinguishing agent ABC powder, quantity 8 kg (5 Nos)
Heavy Duty 50 Kg ABC Powder Type Fire Extinguisher (Trolley Mounted)		1 Nos

15.5 CONTRACTOR'S OTHER TEMPORARY FACILITIES

Water Supply

The Contractor shall make all provisions for the supply of water required for the execution of the Works as well as adequate quantities of potable water for the Contractor's camps, offices, workshops etc. and at every place of working. The Contractor shall be responsible for ensuring the sufficient quantity and quality of water to satisfy demand at all times.

The temporary water supply system shall be designed, constructed, operated, and maintained by the Contractor throughout his work.

Sewerage System

The Contractor shall design, construct, operate and maintain throughout the period of his work a sewerage system from camps, offices, workshops etc. comprising collection, treatment and disposal fulling all compliance to the national and codes.

Solid Wastes

The Contractor shall make all provisions for collection and disposal of solid wastes from camps, offices, workshops etc. and all places of work. Methods of collection and disposal shall comply with relevant regulations and be subject to approval by the Engineer.

Communication

The Contractor shall be responsible for the installation, operation, and maintenance throughout the duration of the Contract of a reliable communication system for his own need on the Site. This shall include communication between the Site offices, between the offices and the workplaces, and externally to the public network. The Contractor shall arrange for the communication between the workers inside tunnel to the site office via wired/wireless intercom.

Similar telecommunication connections shall be provided in accordance with the requirements of the Specification also to the Employer's site offices to be established and maintained under this Contract.

The Contractor shall make his own arrangements with the authorities for fixed and mobile communication systems, and shall be solely responsible for:

- obtaining all permissions, licenses etc. from the relevant authorities for the establishment and operation of the satellite communications system and the radiotelephone system including walkie-talkie(8 nos) two(2) for Employer and two(2) for Engineers;
- the payment of all deposits, connection fees and all other charges which may be levied by the authorities in this connection in accordance with the laws and regulations in force in Nepal.

15.6 MEASUREMENT AND PAYMENT

The Contractor's construction camps, construction yards, and associated mechanical equipment required for the execution of the Works shall be measured and paid as a Lump Sum (LS) in accordance with the corresponding BOQ item. The Lump Sum rate shall include the supply, Construction, Furnishing and operation of all Contractors office camp, temporary facilities and equipment necessary for the construction of the Works. The rate should also include Contractor's laboratory, including its establishment, furnishing, calibration of equipment, operation, maintenance, testing facilities, and demobilization (if applicable). The Lump Sum rate shall include all costs necessary to perform the required quality control and quality assurance testing specified in the Contract.

The maintenance water supply and sanitation maintenance required for camp sites and construction sites and demobilization (if applicable) of all temporary facilities and equipment necessary for the construction of the Works shall be measured and paid as a Lump Sum (LS) in accordance with the corresponding BOQ item.

16 CHAPTER 16: VEHICLE ARRANGEMENT

16.1 SCOPE

The Contractor shall provide, operate, maintain, insure, and replace vehicles required for the proper administration, supervision, inspection, and management of the Works. Vehicles shall be made available for use by the Engineer, Employer's as specified.

16.2 VEHICLE REQUIREMENTS

The Contractor shall provide vehicles meeting at least the following requirements:

- 4 Nos of 4WD Double-Cab Pickup Toyota Hilux or Equivalent.
- Left hand Drive and shall have 3-5 Door types.
- Vehicle shall comply with Nepal vehicle Mass emission requirement and any other requirement applicable according to Nepalese Licensing Law.

16.2.1 *Age and Condition*

Vehicles shall be:

- In good mechanical and operating condition.
- Properly registered in Traffic office and licensed for use in the country of the Works.
- Equipped with valid insurance and all legally required documentation.
- Clean and maintained to a standard acceptable to the Engineer.

16.2.2 *Operation and Drivers*

The Contractor shall provide suitably licensed, experienced, and medically fit drivers. Drivers shall comply with:

- Applicable traffic laws and regulations.
- The Contractor's approved traffic and road-safety procedures.
- Site speed limits and safety requirements.
- Instructions issued by the Engineer concerning authorized use of the vehicles.

Drivers shall be responsible for routine vehicle inspections and shall immediately report defects or unsafe conditions.

16.2.3 *Fuel, Maintenance and Repairs*

Unless otherwise specified in the Contract, the Contractor shall bear all costs associated with:

- Fuel and lubricants.
- Routine and preventive maintenance.
- Repairs and replacement parts.
- Tyres and batteries.
- Insurance, registration, and road taxes.
- Vehicle cleaning.
- Replacement vehicles when a vehicle is unavailable due to breakdown, servicing, accident, or other cause.

16.2.4 *Safety Equipment*

Each vehicle shall be equipped, as applicable, with:

- First-aid kit.
- Fire extinguisher.
- Warning triangle/emergency warning equipment.
- Seat belts for all occupants.
- Spare tyre and necessary tools.
- Reflective vest(s).
- Emergency contact information.
- Other safety equipment required by applicable law or the Engineer.

Vehicles used on construction sites shall additionally comply with the approved site safety requirements.

16.2.5 *Availability*

Vehicles assigned to the Engineer shall be available [24 hours/day, 7 days/week / during normal working hours], including for site inspections, meetings, emergencies, and other activities reasonably associated with the Works.

The Contractor shall ensure that vehicles remain available throughout the Contract period and shall not use vehicles assigned exclusively to the Engineer for unrelated purposes without the Engineer's approval.

16.2.6 *Records*

The Contractor shall maintain vehicle records including:

- Vehicle registration and insurance.
- Maintenance and repair records.
- Daily inspection/checklists.
- Mileage and fuel consumption.
- Driver details and driving records.
- Accident and incident reports.

Such records shall be made available to the Engineer upon request.

16.2.7 *Compliance and Acceptance*

The make and model of vehicles shall be subject to the Engineer's approval. Approval shall not relieve the Contractor of any responsibility under the Contract for providing vehicles that are fit for purpose, safe, reliable, and suitable for the conditions of the Works.

16.2.8 *Payment*

The Contractor shall provide, operate, maintain, fuel, insure, and replace the vehicles specified in the Contract. Payment shall be made monthly in LS for each vehicle satisfactorily provided

and available for use. The rate shall be deemed to include all costs associated with providing the vehicle, including:

- vehicle hire;
- driver and driver's wages;
- fuel, lubricants and consumables;
- maintenance and repairs;
- tyres, batteries and spare parts;
- insurance and registration;
- taxes and statutory charges;
- cleaning and parking;
- replacement vehicle during breakdown or maintenance; and
- all other costs necessary for continuous and satisfactory provision of the vehicle.

No separate payment shall be made for fuel, driver, maintenance, repairs, insurance, registration, or replacement vehicle, as these costs shall be deemed included in the vehicle rate.

17 CHAPTER 17: INSURANCE AND PAYMENT SECURITY

17.1 GENERAL

17.1.1 *Scope*

The Contractor shall obtain, maintain, and comply with all insurance policies and payment security instruments required under the Contract, in accordance with the Conditions of Contract and the applicable laws of Nepal.

17.1.2 *Types of Insurance*

The Contractor shall, as a minimum, procure and maintain the following insurances:

(a) Contractor's All Risk (CAR) Insurance, covering:

- Physical loss or damage to the Works, Plant, Materials, and Temporary Works;
- Natural hazards, accidents, and unforeseen events;
- Third-party property damage arising from construction activities.

(b) Third-Party Liability Insurance, covering:

- Injury, loss of life, or property damage to third parties;
- Incidents arising out of or in connection with the execution of the Works.

(c) Workmen's Compensation Insurance, in accordance with prevailing labor laws, covering:

- Injury, disability, or death of Contractor's personnel;
- Medical treatment and compensation obligations.

(d) Contractor's Equipment Insurance, covering:

- Construction plant, machinery, and equipment deployed for the Works.

17.1.3 *Types of Guarantees*

The Contractor shall provide the following guarantees:

a. Performance Security

b. Advance Payment Guarantee (APG).

17.2 MEASUREMENT AND PAYMENT

17.2.1 *General*

Insurance and Advance Payment Guarantee (APG) shall be measured and paid as separate General Item in Lumpsum(LS) as specified in the Bill of Quantities (BoQ).

The rates quoted by the Contractor for these items shall be deemed to include all costs associated with:

- Procurement, issuance, and maintenance.
- Renewals, extensions, and endorsements.
- Bank charges, commissions, fees, and insurance premiums.
- Compliance with all Contract requirements for the entire duration of the Works, including any extended period.

17.2.2 *Payment for Contractor All Risk (CAR) Insurance*

Payment for Contractor All Risk (CAR) Insurance shall be made as per the relevant BoQ item upon submission to the Engineer of acceptable valid insurance policies.

No additional payment shall be made for:

- Extension or renewal of insurance policies due to delays or extensions of time.
- Increase in insurance premium rates.
- Additional coverage required due to extended construction duration.

17.2.3 *Payment of Performance Guarantee (PG)*

Payment for the Performance Guarantee shall be made as per the relevant BoQ item upon submission and acceptance by the Engineer of an unconditional and compliant Performance Guarantee in accordance with the Contract requirements. No additional payment shall be made for:

- Extension or renewal of the Performance Guarantee due to extension of the Contract period.
- Additional bank charges, commissions, or fees.
- Amendments to the guaranteed amount or validity period.
- Any increase in guaranteed costs arising from changes in market conditions or Contractor's financial arrangements.

The Contractor shall ensure that the Performance Guarantee remains valid and enforceable for the entire duration specified in the Contract, including any extensions, at no additional cost to the Employer.

17.2.4 *Payment for Advance Payment Guarantee (APG)*

Payment for APG shall be made as per the relevant BoQ item upon submission and acceptance of the guarantee.

No additional payment shall be made for:

- Extension or renewal of the APG due to extension of the Contract period.
- Additional bank charges, commissions, or fees.
- Amendments to the guaranteed value or validity.

18 CHAPTER 18: OPERATION AND MAINTENANCE OF SITE POWER SUPPLY FROM NEA SYSTEM

The Contractor shall be responsible for providing, installing, operating, and maintaining an uninterrupted power supply for all tunnel construction activities, including ventilation, lighting, drilling, dewatering etc.

The existing 11 kV transmission line from Khandbari to chhongrak (project site) is available and shall be used as a source of power supply. In the event of grid unavailability or power outages, backup or emergency power shall be ensured through the installation and operation of rental diesel generator (DG) set. The Deiseal Generator used for only MAT construction activities. The Generator shall be duly maintained and operated in a safe and smooth condition.

Power supply facilities		
Generator (500 kVA)	EA	1

A dual power supply mechanism incorporating both grid electricity and diesel-based electricity shall be maintained. In the event of grid unavailability or power outages, backup or emergency power shall be ensured through the installation and operation of diesel generator (DG) set.

18.1 MEASUREMENT AND PAYMENT

The rental cost of power supply facility from DG set shall be paid in monthly basis as specified in BoQ. The cost of power supply from 11 KV NEA grid line is already included in item rate. In the event of grid unavailability or power outages, the cost of power supply from DG set shall be based on measurement in (kWh) in separate energy meter as specified in BOQ. The cost shall include dual power supply mechanism (Automatic transfer switch NEA/DG changeover) all complete set, energy meter, measurement setup.

Power supply for Contractor's own needs and for general use in offices and for in all working areas shall be included in the Contract Price.

19 CHAPTER 19: TECHNOLOGY TRANSFER

At least Ten (10) Executives/Engineers in total of UAHEL will participate in Training/Study Tour for transfer of technology at any hydropower project in a neighbouring country as approved by the Client for total 100 man-days in minimum of Two groups. The training program shall include but not limited to the cost of training, training materials, lodging and food, international travel cost (in economy class) of the trainees and internal transportation cost in the country of training, insurance of the trainees for the entire training period and during travel and daily allowances of USD 200 per Person/Day including travel time shall be borne by the Contractor. During the training UAHEL participants shall be introduced to the latest technology related to the similar kind of the works under the contract. The Training/Study Tour program shall be approved by the Client and no separate payment shall be made for the Training/Study Tour program. The cost shall be deemed included in the Contract /Bid Price.

20 CHAPTER 20: TRANSFER OF OWNERSHIP

Prior to the Contractor's demobilization from the Site, the Employer shall notify the Contractor in writing of any assets, facilities, or equipment that the Employer intends to retain and take ownership of. Such assets may be included, but are not limited to:

1. The permanent diesel generator installation.
2. The tunnel illumination (lighting) system.
3. The tunnel ventilation system.

Where the Employer elects to retain any of the above facilities or equipment, ownership shall be transferred to the Employer upon completion of a joint inspection and valuation by the Engineer. The valuation shall take into account the equipment's age, condition, functionality, and depreciated value at the time of handover.

For the permanent diesel generator installation, the Contractor shall not be required to demobilize the equipment if the Employer decides to retain it. Compensation shall be paid based on the valuation determined by the Engineer.

20.1.1 *Measurement and Payment*

The Contractor shall hand over all equipment and facilities designated to remain as permanent works, including but not limited to the tunnel ventilation equipment, lighting systems and diesel generator, to the Employer in a fully operational and serviceable condition upon completion of the Works. The cost of supplying, installing, testing, commissioning, operating, maintaining, and handing over such equipment and facilities shall be deemed to be included in the respective BOQ items. No separate measurement or additional payment shall be made for the retained equipment or facilities.