BIDDING DOCUMENT

For

THE PROCUREMENT OF

Planning, Design, Engineering, Procurement, Construction, Commissioning and Five Years of Service Operation & Maintenance of One Double Lane Standard Highway Tunnel, Rock shed Structure, Rock Fall Mitigation and Road Works of Siddababa Tunnel Project on Engineering Procurement Construction (EPC) basis all complete;

International Competitive Bidding (ICB)

Single-Stage: Two-Envelope Bidding Procedure

Department of Roads
Quality Research and Development Center
Chakupat, Lalitpur

Issued on:

Issued to: All perspective Bidders

Invitation for Bids No.: IFB-2077-78-10

ICB No.: ***DOR_QRDC/EPC/ICB/STP/077/78-05***

Abbreviations

BD ... . Bidding Document
BDF ... . Bidding Forms
BDS ... . Bid Data Sheet
BOQ ... . Bill of Quantities
COF ... . Contract Forms
DB ..... Design and Build
DP ... . Development Partners
ELI .... Eligibility
EPC…… Engineering, Procurement and Construction
EQC ... . Evaluation and Qualification Criteria
EXP ... . Experience
FIN .... Financial
GCC .... General Conditions of Contract
GoN ... . Government of Nepal
ICC ... . International Chamber of Commerce
IFB ……Invitation for Bids
ITB ..... . Instructions to Bidders
JV .... Joint Venture
LIT .... Litigation
LS…… Lump Sum
NCB ..... . National Competitive Bidding
ICB... ..... . International Competitive Bidding
PAN .... Permanent Account Number
PPA .... Public Procurement Act
PPMO ..... . Public Procurement Monitoring Office
PPR .... Public Procurement Regulations
PL ... . Profit & Loss
PRS…… Price Schedule
PAS …… Payment Schedule
SBD ... . Standard Bidding Document
SCC ... . Special Conditions of Contract
TS ... . Technical Specifications
VAT .... Value Added Tax
WRQ ... . Works Requirements

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Invitation for Bids

Government of Nepal

Ministry of Physical Infrastructure and Transport

Department of Roads

Quality Research and Development Center

Invitation for Bids for the **Siddababa Tunnel Project**

Contract Identification No: **DOR_QRDC/EPC/ICB/STP/077/78-05**

Date of publication:

1. The Government of Nepal [GoN] ***has allocated funds*** from ***GoN*** towards the cost of Siddababa Tunnel Project and intends to apply part of the funds to cover eligible payments under the Contract ***for Planning, Design, Engineering, Procurement, Construction, Commissioning and Five Years of Service Operation & Maintenance of One Double Lane Standard Highway Tunnel, Rock shed Structure, Rock Fall Mitigation and Road Works of Siddababa Tunnel Project on Engineering Procurement Construction (EPC) basis all complete, Contract No. DOR_QRDC/EPC/ICB/STP/077/78-05.*** Bidding is open to all eligible as per Section V of bidding document.

2. ***Department of Roads, Quality Research and Development Center*** invites electronic bids from eligible bidders for the construction of ***One Double Lane Standard Highway Tunnel, Rock shed Structure, Rock Fall Mitigation and Road Works*** through Engineering Procurement Construction (EPC) mode under **International Competitive Bidding-Single Stage Two Envelope Bidding procedures.**

   Only eligible bidders with the following key qualifications should participate in this bidding:

- Minimum Average Annual Construction Turnover of the best 3 years within the last 10 years: ***[NRs 2264.00 Million]***
- Minimum Work experience of similar size and nature:
  - One EPC/Turnkey/DB Contract within the last ten (10) years, with a value of at least **NRs** ***3019.00*** Million that includes Planning, Design, Engineering, Procurement and Construction, Commissioning and at least two years of Service Operation and Maintenance of double lane Road Tunnel (minimum 3 m of one lane each) of length not less than 1.0 km that consist of i) emergency cross passage, ii) tunnel ventilation, iii) electrification and lightening iv) Installation of Monitoring and Emergency Facilities
  - One Construction Contract within last ten (10) years with value of at least ***NRs. 1887.00 Million*** that have been successfully or substantially completed
- Understanding of the Project and Proposed Design

3. Under the Single Stage, Two Envelope Procedure, Bidders are required to submit the Technical Bid and the Price Bid, as per the provision of ITB 21 of the Bidding Document.

4. Eligible Bidders may obtain further information and inspect the Bidding Documents at the office of ***Department of Roads, Quality Research and Development Center, Chakupat, Email:*** dorqrdc@gmail.com or may visit PPMO e-GP system ***www.bolpatra.gov.np/egp.***

   Bidder submitting their bid electronically shall download the bidding documents for e-submission from PPMO's e-GP system www.bolpatra.gov.np/egp. Bidders, submitting their bid electronically, should deposit the cost of bidding document in the Project's Rajaswa (revenue) account as specified below.

   Information to deposit the cost of bidding document in Bank:

   Name of the Bank: Nepal Bank Limited, Gabahal, Lalitpur

   Name of Office: Quality Research and Development Center, Chakupat

Office Code no.: 337013406 Office Account no.: 00101000000001001001

Rajaswa (revenue) Shirshak No: 14229

5. Pre-bid meeting shall be held at ***Quality Research and Development Center Chakupat*** at ***13:00 hours on 13th June 2021.***
6. Electronic bids must be submitted through PPMO's e-GP system www.bolpatra.gov.np/egp *on or before 12:00* ***hours*** on ***7th July 2021.*** Bids received after this deadline will be rejected.
7. The bids will be opened in the presence of Bidders' representatives who choose to attend at 13:00 hours on ***7th July 2021*** at the office of ***Quality Research and Development Center, Chakupat***. Bids must be valid for a period of ***120 days*** after bid opening and must be accompanied by scanned copy of the bid security in pdf format amounting to a minimum of ***NRs. 207.00 Millions*** which shall be valid for 30 days beyond the validity period of the bid ***[4th December 2021].***
8. If the last date of purchasing and /or submission falls on a government holiday, then the next working day shall be considered as the last date. In such case the validity period of the bid security shall remain the same as specified for the original last date of bid submission.

Part I: BIDDING PROCEDURES

Section I: Instructions to Bidders

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Section I: Instructions to Bidders

A. General	
1. Scope of Bid	1.1 In connection with the Invitation for Bids indicated in the Bid Data Sheet (BDS), the Employer, as indicated in the BDS, issues this Bidding Document for the procurement of Works as specified in Section VI (Works Requirements). The ***name, identification, and number*** of Contracts of the International Competitive Bidding (NCB) are **provided in the BDS.**
	1.2 Throughout this Bidding Document: (a)the term "in writing" means communicated in written form, delivered against receipt and received through e- GP system or email or fax or courier ; (b) except where the context requires otherwise, words indicating the singular also include the plural and words indicating the plural also include the singular; and (c) "day" means calendar day.
	1.3 Multiple Contract shall be applicable and shall be grouped as **specified in the BDS**
2. Source of Funds	2.1 GoN Funded: In accordance with its annual program and budget, approved by the GoN, the implementing agency **indicated in the BDS** plans to apply a portion of the allocated budget to eligible payments under the contract(s) for which this Bidding Document is issued. Or Public Entities' own Resource Funded: In accordance with its annual program and budget, approved by the public entity, the implementing agency **indicated in the BDS** plans to apply a portion of the allocated budget to eligible payments under the contract(s) for which this Bidding Document is issued. Or DP Funded: The GoN has applied for or received financing (hereinafter called "funds") from the Development Partner (hereinafter called "the DP") **indicated in the BDS** toward the cost of the project named in the BDS. The GoN intends to apply a portion of the funds to eligible payments under the contract(s) for which this Bidding Document is issued.
	2.2 DP Funded: Payment by the DP will be made only at the request of the GoN and upon approval by the DP in accordance with the terms and conditions of the financing agreement between the GoN and the DP (hereinafter called the "Loan/Grant Agreement"), and will be subject in all respects to the terms and conditions of that Loan/Grant Agreement. No party other than the GoN shall derive any rights from the Loan Agreement or have any claim to the funds.
3. Fraud and	3.1 Procuring Entities as well as Bidders, suppliers and contractors and

Corruption	their sub-contractors shall adhere to the highest standard of ethics during the procurement and execution of such contracts. In pursuance of this:; (a) the Employer adopts, for the purposes of this provision, the terms as defined below: (i) "corrupt practice" means the offering, giving, receiving, or soliciting, directly or indirectly, anything of value to influence improperly the actions of another party; (ii) "fraudulent practice" means any act or omission, including a misrepresentation, that knowingly or recklessly misleads, or attempts to mislead, a party to obtain a financial or other benefit or to avoid an obligation; (iii) "coercive practice" means impairing or harming, or threatening to impair or harm, directly or indirectly, any party or the property of the party to influence improperly the actions of a party; (iv) "collusive practice" means an arrangement between two or more parties designed to achieve an improper purpose, including influencing improperly the actions of another party. v) "obstructive practice" means (a) deliberately destroying, falsifying, altering, or concealing of evidence material to an investigation; (b) making false statements to investigators in order to materially impede an investigation; (c) failing to comply with requests to provide information, documents, or records in connection with an investigation; (d) threatening, harassing, or intimidating any party to prevent it from disclosing its knowledge of matters relevant to the investigation or from pursuing the investigation; or (e) materially impeding GoN/DP's contractual rights of audit or access to information; and vi) "integrity violation" is any act which violates Anticorruption Policy, including (i) to (v) above and the following: abuse, conflict of interest, violations of GoN/DP sanctions, retaliation against whistleblowers or witnesses, and other violations of Anticorruption Policy, including failure to adhere to the highest ethical standard. (b) the Employer will reject a proposal for award if it determines that the Bidder recommended for award has, directly or through an agent, engaged in corrupt, fraudulent, collusive, coercive, or obstructive practices or other integrity violations in competing for the contract;
	(c) DP will cancel the portion of the financing allocated to a contract if it determines at any time that representative(s) of the GoN or of a beneficiary of DP-financing engaged in corrupt, fraudulent, collusive, or coercive practices or other integrity violations during

	the procurement or the execution of that contract, without the GoN having taken timely and appropriate action satisfactory to DP to remedy the situation. (d) DP will impose remedial actions on a firm or an individual, at any time, in accordance with DP's Anticorruption Policy and related Guidelines (as amended from time to time), including declaring ineligible, either indefinitely or for a stated period of time, to participate in DP-financed, -administered, or -supported activities or to benefit from an DP-financed, -administered, or -supported contract, financially or otherwise, if it at any time determines that the firm or individual has, directly or through an agent, engaged in corrupt, fraudulent, collusive, coercive, or obstructive practices or other integrity violations; and (e) The Contractor shall permit the GoN/DP to inspect the Contractor's accounts and records relating to the performance of the Contractor and to have them audited by auditors appointed by the GoN/DP, if so required by the GoN/DP.
	3.2 The Bidder shall not carry out or cause to carry out the following acts with an intention to influence the implementation of the procurement process or the procurement agreement : (a) give or propose improper inducement directly or indirectly, (b) distortion or misrepresentation of facts, (c) engaging in corrupt or fraudulent practice or involving in such act, (d) interference in participation of other competing bidders, (e) coercion or threatening directly or indirectly to cause harm to the person or the property of any person to be involved in the procurement proceedings, (f) collusive practice among bidders before or after submission of bids for distribution of works among bidders or fixing artificial/uncompetitive bid price with an intention to deprive the Employer the benefit of open competitive bid price, (g) Contacting the Employer with an intention to influence the Employer with regards to the bids or interference of any kind in examination and evaluation of the bids during the period from the time of opening of the bids until the notification of award of contract.
	3.3 PPMO, on the recommendation of the Procuring Entity may blacklist a Bidder for a period of one (1) to three (3) years for its conduct including on the following grounds and seriousness of the act committed by the bidder: (a) if convicted by a court of law in a criminal offence which disqualifies the Bidder from participating in the contract, (b) if it is established that the contract agreement signed by the Bidder was based on false or misrepresentation of Bidder's qualification information, (c)if it at any time determines that the firm has, directly or through an agent, engaged in corrupt, fraudulent, collusive, coercive, or obstructive practices in competing for, or in executing, a

	GoN/DP-financed contract. (d) if the Successful Bidder fails to sign the Contract.
	3.4 A bidder declared blacklisted and ineligible by the GoN, Public Procurement Monitoring Office (PPMO) and/or the DP in case of DP funded project, may be ineligible to bid for a contract during the period of time determined by the GoN, PPMO and/or the DP. 3.5 In case of a natural person or firm/institution/company which is already declared blacklisted and ineligible by the GoN, any other new or existing firm/institution/company owned partially or fully by such Natural person or Owner or Board of director of blacklisted firm/institution/company; shall not be eligible bidder.
	3.6 Furthermore, Bidders shall be aware of the provisions of GCC (GCC 33.4 and 79.2(f).
4. Eligible Bidders	4.1 A Bidder may be a natural person, private entity, or government owned entity subject to ITB 4.5 or any combination of them in the form of a Joint Venture (JV) under an existing agreement, or with the intent to constitute a legally-enforceable joint venture. In the case of a JV: (a) all partners shall be jointly and severally liable for the execution of the Contract in accordance with the Contract terms. Maximum number of JV and other provision for JV shall be as per specified in the BDS. The qualification requirement of the parties to the JV shall be as specified in Section III: Evaluation and qualification Criteria, and (b) the JV shall nominate a Representative who shall have the authority to conduct all business for and on behalf of any and all the parties of the JV during the bidding process and, in the event the JV is awarded the Contract, during Contract execution.
	4.2 A Bidder, and all parties constituting the Bidder, shall have the nationality of an eligible country, in accordance with Section V (Eligible Countries). A Bidder shall be deemed to have the nationality of a country if the Bidder is a citizen or is constituted, or incorporated, and operates in conformity with the provisions of the laws of that country. This criterion shall also apply to the determination of the nationality of proposed sub-contractors or suppliers for any part of the Contract including related services.
	4.3 A Bidder shall not have a conflict of interest. A Bidder found to have a conflict of interest shall be disqualified. A Bidder may be considered to be in a conflict of interest with one or more parties in this bidding process, if any of, including but not limited to, the following apply: (a) they have controlling shareholders in common; or (b) they receive or have received any direct or indirect subsidy from any of them; or (c) they have the same legal representative for purposes of this bid; or (d) they have a relationship with each other, directly or through common third parties, that puts them in a position to have access to material information about or improperly influence the Bid of another Bidder, or influence the decisions of the Employer regarding this bidding process; or

	(e) a Bidder participates in more than one bid in this bidding process either individually or as a partner in a joint venture. This will result in the disqualification of all Bids in which it is involved. However, subject to any finding of a conflict of interest in terms of ITB 4.3 (a)-(d) above, this does not limit the participation of the same subcontractor in more than one bid; or (f) a Bidder or any of its affiliated entity, participated as a consultant in the preparation of the technical specifications or employer's requirements of the works that are the subject of the Bid; or (g) a Bidder was affiliated with a firm or entity that has been hired (or is proposed to be hired) by the Employer as Engineer for the Contract.
	4.4 A firm that is under a declaration of ineligibility by the GoN in accordance with ITB 3, at the date of the deadline for bid submission or thereafter, shall be disqualified. A firm shall not be eligible to participate in any procurement activities under an DP-financed, -administered, or -supported project while under temporary suspension or debarment by DP pursuant to the DP's Anticorruption Policy (see ITB 3), whether such debarment was directly imposed by the DP, or enforced by other DPs pursuant to the Agreement for Mutual Enforcement of Debarment Decisions. A bid from a temporary suspended or debarred firm will be rejected. The list of debarred firm is available at the electronic address specified in the BDS.
	4.5 Enterprises owned by Government shall be eligible only if they can establish that they are legally and financially autonomous and operate under commercial law, and that they are not a dependent agency of the GoN.
	4.6 Bidders shall provide such evidence of their continued eligibility satisfactory to the Employer, as the Employer shall reasonably request.
	4.7 Firms shall be excluded in any of the cases, if (a) by an act of compliance with a decision of the United Nations Security Council taken under Chapter VII of the Charter of the United Nations, Nepal prohibits any import of goods or Contracting of works or services from that country or any payments to persons or entities in that country. Where Nepal prohibits payments to a particular firm or for particular goods by such an act of compliance, that firm may be excluded; (b) DP Funded: as a matter of law or official regulation, Nepal prohibits commercial relations with that country, provided that the DP is satisfied that such exclusion does not preclude effective competition for the supply of goods or related services required; (c) DP Funded: a firm sanctioned or temporarily suspended by the DP in relation to their guidelines or appropriate provisions on preventing and combating fraud and corruption in projects financed by them.
	4.8 In case a prequalification process has been conducted prior to the

	bidding process, this bidding is open only to prequalified Bidders.
5. Eligible Materials, Equipment and Services	5.1 The materials, equipment and services to be supplied under the Contract shall have their origin in any source countries as defined in accordance with Section V (Eligible Countries) and all expenditures under the Contract will be limited to such materials, equipment, and services. At the Employer's request, Bidders may be required to provide evidence of the origin of materials, equipment and services.
	5.2 For purposes of ITB 5.1 above, "origin" means the place where the materials and equipment are mined, grown, produced or manufactured, and from which the services are provided. Materials and equipment are produced when, through manufacturing, processing, or substantial or major assembling of components, a commercially recognized product results that differs substantially in its basic characteristics or in purpose or utility from its components.
B. Contents of Bidding Documents	
6. Sections of Bidding Document	6.1 The Bidding Document consist of Parts I, II, and III, which include all the Sections indicated below, and should be read in conjunction with any Addenda issued in accordance with ITB 8. PART I Bidding Procedures Section I Instructions to Bidders (ITB) Section II Bid Data Sheet (BDS) Section III Evaluation and Qualification Criteria (EQC) Section IV Bidding Forms (BDF) Section V Eligible Countries PART II Requirements Section VI Employer's Requirement (ERQ) Section VII Activity Schedule (ACS) PART III Conditions of Contract and Contract Forms Section VIII General Conditions of Contract (GCC) Section IX Special Conditions of Contract (SCC) Section X Contract Forms (COF)
	6.2 The Invitation for Bids issued by the Employer is not part of the Bidding Document.
	6.3 The Employer is not responsible for the completeness of the Bidding Document and their Addenda, if they were not obtained directly from the source stated by the Employer in the Invitation for Bids.
	6.4 The Bidder is expected to examine all instructions, forms, terms, and specifications in the Bidding Document and to furnish with its bid all information and documentation as is required by the Bidding Documents. Failure to furnish all information or documentation required by the Bidding Document may result in the rejection of the bid.
7. Clarification of Bidding Document, Site Visit, Pre-Bid	7.1 A prospective Bidder requiring any clarification of the Bidding Document shall contact the Employer in writing at the Employer's address **indicated in BDS** or raise any question or curiosity during

Meeting	the pre-bid meeting if provided for in accordance with ITB 7.4.The Employer will respond in writing to any request for clarification, provided that such request is received within the period as mentioned in ITB 7.5. The Employer shall forward copies of its response to all Bidders who have acquired the Bidding Document in accordance with ITB 6.3, including a description of the inquiry but without identifying its source. Should the Employer deem it necessary to amend the Bidding Document as a result of a request for clarification, it shall do so following the procedure under ITB 8 and ITB 22.2.
	7.2 The Bidder is advised to visit and examine the Site of Works and its surroundings and obtain for itself, on its own risk and responsibility, all information that may be necessary for preparing the bid and entering into a Contract for construction of the Works. The costs of visiting the Site shall be at the Bidder's own expense.
	7.3 The Bidder and any of its personnel or agents will be granted permission by the Employer to enter upon its premises and lands for the purpose of such visit, but only upon the express condition that the Bidder, its personnel, and agents will release and indemnify the Employer and its personnel and agents from and against all liability in respect thereof, and will be responsible for death or personal injury, loss of or damage to property, and any other loss, damage, costs, and expenses incurred as a result of the inspection.
	7.4 The Bidder's designated representative is invited to attend a pre-bid meeting, if **provided for in the BDS**. The purpose of the meeting will be to clarify issues and to answer questions on any matter that may be raised at that stage.
	7.5 The Bidder is requested, to submit any questions in writing, to reach the Employer as **mentioned in BDS.**
	7.6 Minutes of the pre-bid meeting, including the text of the questions raised, without identifying the source, and the responses given, together with any responses prepared after the meeting, will be transmitted promptly to all Bidders who have acquired the Bidding Document in accordance with ITB 6.3. Any modification to the Bidding Document that may become necessary as a result of the pre-bid meeting shall be made by the Employer exclusively through the issue of an addendum pursuant to ITB 8 and not through the minutes of the pre-bid meeting.
	7.7 Non-attendance at the pre-bid meeting will not be a cause for disqualification of a Bidder.
8. Amendment of Bidding Document	8.1 At any time prior to the deadline for submission of bids, the Employer may amend the Bidding Document by issuing addendum.
	8.2 Any addendum issued shall be part of the Bidding Document and shall be communicated in writing to all who have obtained the Bidding Document from the Employer in accordance with ITB 6.3.
	8.3 To give prospective Bidders reasonable time in which to take an

	addendum into account in preparing their Bids, the Employer may, at its discretion, extend the deadline for the submission of Bids, pursuant to ITB 22.2
C. Preparation of Bids	
9. Cost of Bidding	9.1 The Bidder shall bear all costs associated with the preparation and submission of its Bid, and the Employer shall in no case be responsible or liable for those costs, regardless of the conduct or outcome of the bidding process.
10. Language of Bid	10.1 The Bid, as well as all correspondence and documents relating to the bid exchanged by the Bidder and the Employer, shall be written in the language **specified in the BDS**. Supporting documents and printed literature that are part of the Bid may be in another language provided they are accompanied by an accurate translation of the relevant passages in the language **specified in the BDS**, in which case, for purposes of interpretation of the Bid, such translation shall govern.
11. Documents Comprising the Bid	11.1 The Bid shall comprise the Technical Bid containing the documents listed in ITB 11.2 and the Price Bid containing the documents listed in ITB 11.3. 11.2 The Technical Bid shall comprise the following: (a) Letter of Technical Bid; (b) Bid Security in accordance with ITB 19; (c) alternative Technical Bid, at Bidder's option and if permissible, in accordance with ITB 13; (d) written confirmation authorizing the signatory of the Bid to commit the Bidder, in accordance with ITB 20.2; (e) documentary evidence in accordance with ITB 17, establishing the Bidder's qualifications to perform the contract; (f) Technical Proposal in accordance with ITB 16; (g) Bids submitted by a Joint Venture shall include a copy of the Joint Venture Agreement entered into by all partners. Alternatively, a Letter of Intent to execute a Joint Venture Agreement in the event of a successful Bid shall be signed by all partners and submitted with the Bid, together with a copy of the proposed agreement. The Joint Venture agreement, or letter of intent to enter into a Joint Venture including a draft agreement shall indicate at least the parts of the Works to be executed by the respective partners; and (h) any other required documents, which is not against the

	provision of Procurement Act/ Regulation /Directives and Standard Bidding Document issued by PPMO as specified in the **BDS**. 11.3 The Price Bid shall comprise the following: (a) Letter of Price Bid; (b) Priced Activity Schedule , in accordance with ITB 12 and ITB 14, or as stipulated in the BDS; (c) alternative price Bids, at Bidder's option and if permissible, in accordance with ITB 13; (d) Any other document required in the **BDS**.
	11.4 The Bidder is solely responsible for the authenticity of the submitted documents. 11.5 The Technical Bid shall not include any financial information related to the Price Bid. A Technical Bid containing such material or financial information shall be declared non-responsive.
12. Letter of Bid and Schedules	12.1 The Letters of Technical Bid and Price Bid, Schedules, and all documents listed under ITB 11, shall be prepared using the relevant forms in Section IV (Bidding Forms) and in Section VII (Priced Activity Schedule). The forms must be completed without any alterations to the text, and no substitutes shall be accepted. All blank spaces shall be filled in with the information requested.
13. Alternative Bids	13.1 Unless otherwise **specified in the BDS**, alternative bids shall not be considered.
	13.2 When alternative times for completion are explicitly invited, a statement to that effect will be **included in the BDS**, as will the method of evaluating different times for completion.
	13.3 When **specified in the BDS**, Bidders are permitted to submit alternative technical solutions for specified parts of the Works. Such parts will be **identified in the BDS** and described in Section VI (Employer's Requirements). The method for their evaluation will be stipulated in Section III (Evaluation and Qualification Criteria).
14. Bid Prices and Discounts	14.1 The prices and discounts quoted by the Bidder in the Letter of Price Bid and in the Schedules shall conform to the requirements specified below.
	14.2 The Bidder shall submit a bid for the whole of the works described in ITB 1.1 by filling in price as Lumpsum price in Section VII (Priced Activity Schedule).
	14.3 The price to be quoted in the Letter of Price Bid shall be the total price of the Bid, excluding any discounts offered.

	14.4 Unconditional discounts, if any, and the methodology for their application shall be quoted in the Letter of Price Bid, in accordance with ITB 12.1.
	14.5 If so indicated in ITB 1.3, bids are invited for individual Contracts or for any combination of Contracts (packages). Bidders wishing to offer any price reduction for the award of more than one Contract shall specify in their bid the price reductions applicable to each package, or alternatively, to individual Contracts within the package. Price reductions or discounts shall be submitted in accordance with ITB 14.4, provided the Bids for all Contracts are submitted and opened at the same time.
	14.6 The price quoted by the Bidder shall be fixed which means that the price is not subjet to adjustment.
	14.7 The bidder is subject to local taxes such as VAT, social charges or income taxes on nonresident international personnel, and also duties, fees, levies on amounts payable by the employer under the Contract. All duties, taxes, and other levies payable by the Contractor under the Contract, or for any other cause, as of the date 30 days prior to the deadline for submission of bids, shall be included in the rates and prices and the total bid price submitted by the Bidder.
15. Currency of Bid and Payment	15.1 The prices shall be quoted by the bidder entirely in Nepali currency; if not **otherwise specified in the BDS**
16. Documents Comprising the Technical Proposal	16.1 The Bidder shall furnish a Technical Proposal including a statement of work methods, equipment, personnel, schedule and any other information as stipulated in Section IV (Bidding Forms), in sufficient detail to demonstrate the adequacy of the Bidders' proposal to meet the work requirements and the completion time.
17. Documents Establishing the Qualifications of the Bidder	17.1 To establish its qualifications to perform the Contract in accordance with Section III (Evaluation and Qualification Criteria) the Bidder shall provide the information requested in the corresponding information sheets included in Section IV (Bidding Forms).
18. Period of Validity of Bids	18.1 Bids shall remain valid for the period **specified in the BDS** after the bid submission deadline date prescribed by the Employer. A bid valid for a shorter period shall be rejected by the Employer as nonresponsive.
	18.2 In exceptional circumstances, prior to the expiration of the bid validity period, the Employer may request Bidders to extend the period of validity of their Bids. The request and the responses shall be made in writing. If a bid security is requested in accordance with ITB 19, it shall also be extended 30 days beyond the deadline of the extended validity period. A Bidder may refuse the

	request without forfeiting its bid security. A Bidder granting the request shall not be required or permitted to modify its Bid and to include any additional conditions against the provisions specified in Bid Documents.
19. Bid Security	19.1 The Bidder shall furnish as part of its bid, in original form, a bid security as **specified in the BDS**. In case of e-submission of bid, the Bidder shall upload scanned copy of Bid security letter at the time of electronic submission of the bid. The Bidder accepts that the scanned copy of the Bid security shall, for all purposes, be equal to the original. The details of original Bid Security and the scanned copy submitted with e-bid should be the same otherwise the bid shall be non-responsive.
	19.2 The bid security shall be, at the Bidder's option, in any of the following forms: (a) an unconditional bank guarantee from Commercial Bank or Financial Institution eligible to issue Bank Guarantee as per prevailing Law or; (b) a cash deposit voucher in the Employer's Account as **specified in BDS**. In the case of a bank guarantee, the bid security shall be submitted either using the Bid Security Form included in Section IV (Bidding Forms) or in another Form acceptable to the employer. The form must include the complete name of the Bidder. The bid security shall be valid for minimum thirty (30) days beyond the original validity period of the bid, or beyond any period of extension if requested under ITB 18.2.
	19.3 The bid security issued by any foreign Bank outside Nepal must be counter guaranteed by Commercial Bank or Financial Institution eligible to issue Bank Guarantee as per prevailing Law in Nepal.
	19.4 Any bid not accompanied by an enforceable and substantially compliant bid security shall be rejected by the Employer as nonresponsive. In case of e- Submission, if the scanned copy of an acceptable Bid Security letter is not uploaded with the electronic Bid then Bid shall be rejected.
	19.5 The bid security of unsuccessful Bidders shall be returned within three days, once the successful Bidder's furnishing of the required performance security and signing of the Contract Agreement pursuant to ITB 40.1 and 41.1
	19.6 The bid security shall be forfeited if: (a) a Bidder requests for withdrawal or modification of its bid, except as provided in ITB 18.2: (i) during the period of bid validity specified by the Bidder on the Letter of Technical Bid and Price Bid, in case of electronic submission; (ii) from the period twenty-four hours prior to bid submission deadline up to the period of bid validity specified by the Bidder on the Letter of Technical Bid and Price Bid, in case of hard copy

	submission. (b)a Bidder changes the prices or substance of the bid while providing information pursuant to clause 27.1; (c) a Bidder involves in fraud and corruption pursuant to clause 3.1; (d) the successful Bidder fails to: (i) furnish a performance security in accordance with ITB 40.1; (ii) sign the Contract in accordance with ITB 41.1; or (iii) accept the correction of arithmetical errors pursuant to clause 33.1
	19.7 The Bid Security of a Joint Venture shall be in the name of the Joint Venture that submits the bid. If the Joint Venture has not been legally constituted at the time of bidding, the Bid Security shall be in the names of all future partners as named in the letter of intent mentioned in ITB 4.1.
20. Format and Signing of Bid	20.1 The Bidder shall prepare the Technical Bid and the Price Bid comprising the Bid as described in ITB 11 Alternative bids, if permitted in accordance with ITB 13, shall be prepared as **"ALTERNATIVE".** The Bidder shall submit his bid electronically in PDF or web forms files as specified in ITB Clause 21.1(a).
	20.2 The bid shall be attached with the **signed authorization letter by an authorized person or persons duly authorized to sign on behalf of the Bidder**. This authorization shall consist of a written confirmation as **specified in the BDS** and shall be attached to the bid. The name and position held by each person signing the authorization must be typed or printed below the signature.
	20.3 Any amendments such as interlineations, erasures, or overwriting shall be valid only if they are signed or initialed by the person signing the bid.
D. Submission and Opening of Bids	
21. Submission of Bid	21.1 Bid submission procedure (a) **Bidders submitting the Bids shall follow the electronic bid submission procedure specified in this clause.** i. The bidder is required to register in the e-GP system https://www.bolpatra.gov.np/egp following the procedure specified in e-GP guideline. ii. Interested bidders may either purchase the bidding document from the Employer's office as specified in the Invitation for Bid (IFB) or bidders may download the IFB and bidding document from e-GP system. iii. The registered bidders need to maintain their profile data each time required during preparation of bids. iv. In order to submit their bids the cost of the bidding document can be deposited as specified in IFB. In addition, electronic

	scanned copy (.pdf format) of the bank deposit voucher/cash receipt should also be submitted along with the technical bid. v. The bidder can prepare their technical and price bids using data and documents maintained in bidder's profile and forms/format provided in bidding document by Employer. The bidder may submit bids as a single entity or as a joint venture. The bidder submitting bid in joint venture shall have to upload joint venture agreement along with partner(s) Bolpatra ID provided during bidder's registration. vi. Bidders (all partners in case of JV) should update their profile data and documents required during preparation and submission of their technical bids. vii. In case of bid submission in JV, the consent of the partners shall be obtained through the confirmation link sent to the registered email address and the partners shall have to acknowledge their confirmation. viii. After providing all the details and documents, two separate bid response documents i.e technical bids and price bids will be generated from the system. Bidders are advised to download and verify the response documents prior to bid submission. ix. For verifying the authentic user, the system will send one time password (OTP) in the registered e-mail address of the bidder. System will validate the OTP and allow bidder to submit their bid. x. Electronically submitted bids can be modified and/or withdrawn through system. The bidder may modify their bids multiple times online within bid submission date and time specified in e-GP system. Once a Bid is withdrawn, bidder won't be able to submit another bid response for the same bid. **xi. The Bidder / Bid shall meet the following requirements and conditions for e-submission of bids;** aa) The e-submitted bids must be readable through open standards interfaces. Unreadable and or partially submitted bid files shall be considered incomplete and rejected for further bid evaluation. bb) In addition to electronically submitted PDF files/web forms, the Bidder shall be required to submit original bid security letter/ documents and clarifications as specified in ITB Clause 27. If a bidder does not submit the original Bid security letter and requested documents and or clarifications within the specified time limit then the bid shall not be considered for further evaluation. cc) If major discrepancy is found between the electronically submitted PDF bid files and the documents/ clarifications provided by the Bidder as per ITB Clause 27, then the bid shall not be considered for further evaluation. dd) The facility for submission of bid electronically through e-submission is to promote transparency, non-discrimination, equality of access, and open competition in the bidding process.

The Bidders are fully responsible to use the e- submission facility properly in e-GP portal of PPMO- http://www.bolpatra.gov.np as per specified procedures and in no case the Employer shall be held liable for Bidder's inability to use this facility.

ee) When a bidder submits electronic bid through the PPMO e-GP portal, it is assumed that the bidder has prepared the bid by studying and examining the complete set of the Bidding documents including specifications, drawings and conditions of contract.

ff) Bidders who submit electronic bid should deposit the bidding document fee as specified in IFB and upload the scan copy (in pdf format) of the deposit voucher at the time of bid submission. The deposited amount shall be verified by the Employer during the bid evaluation process. The submitted Bid shall be non-responsive and shall not be evaluated if the cost for bidding document is not deposited as specified in the IFB.

The required forms and documents shall be part of technical bids.

No.	Document	Requirement	Remarks
1.	Letter of Technical Bid	Mandatory	PDF
2.	Bid Security/Bank Guarantee	Mandatory	PDF
3.	Company registration Certificate	Mandatory	PDF
4.	VAT registration Certificate	Mandatory for domestic bidders	PDF
5.	Business Registration Certificate	Mandatory	PDF
6.	Tax Clearance Certificate/Tax return submission evidence/evidence of time extension	Mandatory (for domestic bidders)	PDF
7.	Power of Attorney of Bid signatory	Mandatory	PDF
8.	Bank Voucher for cost of bid document	Mandatory	PDF
9.	Joint venture agreement	Mandatory in case of JV Bids Only	PDF

10.	Qualification Documents	Mandatory	Using profile data (financial details, contract details etc.) and Technical Proposal
11.	Additional documents; specified in ITB 11.2 (h)	If applicable	PDF

The required forms and documents shall be part of price bids.

No.	Document	Requirement	Remarks
1.	Letter of Price Bid	Mandatory	PDF
2.	Completed Activity Schedule (ACS)	Mandatory	Online Forms
3.	Additional Documents; specified in ITB 11.3 (d)	If applicable	PDF

Note: a) Bidders (all partners in case of JV) should verify/update their profile documents as appropriate for the specific bid before submitting their bid electronically.

22. Deadline for Submission of Bids	22.1 Bids must be submitted electronically no later than the date and time indicated **in the BDS**. The standard time for e-submission is Nepal Standard Time as set out in the server. The e-procurement system will accept the e-submission of bid from the date of publishing of notice and will automatically not allow the e-submission of bid after the deadline for submission of bid.
	22.2 The Employer may, at its discretion, extend the deadline for the submission of bids by amending the Bidding Document in accordance with ITB 8, in which case all rights and obligations of the Employer and Bidders previously subject to the deadline shall thereafter be subject to the deadline as extended.
23. Late Bids	23.1 The e-procurement system will automatically not allow the e-submission of bid after the deadline for submission of bid..
24. Withdrawal, and Modification of Bids	24.1 A Bidder may withdraw, or modify its bid- Technical or Price - after it has been submitted by e-submission. Once a Bid is withdrawn, bidder shall not be able to submit another bid for this bidding process. Procedures for withdrawal or modification of submitted bids are as follows:

	ii) . a) Bidder may submit modification or withdrawal prior to the deadline prescribed for submission of bids through e-GP system by using the forms and instructions provided by the system.
	24.2 Bids requested to be withdrawn in accordance with ITB 24.1 shall not be opened.
	24.3 The following provisions apply for withdrawal or modification of the Bids: (i) No bids shall be withdrawn or modified in the interval between deadline for submission of bids and the expiration of the period of bid validity specified by the Bidder on the Letter of Technical Bid and Price Bid or any extension thereof.
	24.4 Request for withdrawal or modifications through different medium shall not be considered.
25. Bid Opening	25.1 The Employer shall open the Technical Bids in public at the address, on the date and time **specified in the BDS** in the presence of Bidders` designated representatives who choose to attend.
	25.2 The Employer shall download the e-submitted Technical Bid. The e-GP system allows the Employer to download the e-submitted technical bid only after bid opening date and time after login simultaneously by at least two members of the Bid Opening Committee.
	25.3 Electronic Bids shall be opened one by one and read out. The e-submitted technical bids must be readable through open standards interfaces. Unreadable and or partially submitted bid files shall be considered incomplete.
	25.4 Only Technical Bids read out and recorded at bid opening shall be considered for evaluation. No bid shall be rejected at opening of Technical Bids.
	25.5 The Employer shall prepare a record of the opening of Technical Bids that shall include, as a minimum: the name of the Bidder and whether there is a withdrawal, or modification; and the presence or absence of a bid security. The Bidders' representatives who are present shall be requested to sign the record. The omission of a Bidder's signature on the record shall not invalidate the contents and effect of the record.
	25.6 At the end of the evaluation of the Technical Bids, the Employer will invite bidders who have submitted substantially responsive Technical Bids and who have been determined as being qualified for award to attend the opening of the Price Bids. The date, time, and location of the opening of Price Bids will be advised in writing by the Employer. Bidders shall be given at least 7 days notice for the opening of Price Bids.

	25.7 The Employer will notify Bidders in writing who have been rejected on the grounds of their Technical Bids being substantially nonresponsive to the requirements of the Bidding Document.
	25.8 The Employer shall conduct the opening of Price Bids of all Bidders who submitted substantially responsive Technical Bids, in the presence of Bidders` representatives who choose to attend at the address, on the date, and time specified by the Employer. The Bidder's representatives who are present shall be requested to sign a register evidencing their attendance.
	25.9 All envelopes containing Price Bids shall be opened one at a time and the following read out and recorded: (a) the name of the Bidder; (b) whether there is a modification; (c) the Bid Prices, including any discounts and alternative offers; and (d) any other details as the Employer may consider appropriate. Only Price Bids, discounts, modifications, and alternative offers read out and recorded during the opening of Price Bids shall be considered for evaluation. No Bid shall be rejected at the opening of Price Bids.
	25.10 The Employer shall prepare a record of the opening of Price Bids that shall include, as a minimum, the name of the Bidder, the Bid Price (per lot if applicable), any discounts, modifications and alternative offers. The Bidders' representatives who are present shall be requested to sign the record. The omission of a Bidder's signature on the record shall not invalidate the contents and effect of the record.
E. Evaluation and Comparison of Bids	
26. Confidentiality	26.1 Information relating to the examination, evaluation, comparison, and post-qualification of bids and recommendation of Contract award, shall not be disclosed to Bidders or any other persons not officially concerned with such process until information on Contract award is communicated to all Bidders.
	26.2 Any attempt by a Bidder to influence the Employer in the evaluation of the bids or Contract award decisions may result in the rejection of its bid.
	26.3 Notwithstanding ITB 26.2, from the time of bid opening to the time of Contract award, if any Bidder wishes to contact the Employer on any matter related to the bidding process, it may do so in writing.
27. Clarification of Bids	27.1 To assist in the examination, evaluation, and comparison of the Technical and Price Bids, the Employer may, at its discretion, ask any Bidder for a clarification of its Bid. Any clarification submitted by a Bidder that is not in response to a request by the Employer shall

	not be considered. The Employer's request for clarification and the response shall be in writing. No change in the substance of the Technical Bid or prices in the Price Bid shall be sought, offered, or permitted, except to confirm the correction of arithmetic errors discovered by the Employer in the evaluation of the Price Bids, in accordance with ITB 33. Upon notification from the employer, the bidder shall also submit the original of documents comprising the Technical and Price Bid as per ITB 11.2 and ITB 11.3 for verification of submitted documents for acceptance of the e-submitted bid.
	27.2 If a Bidder does not provide clarifications of its Bid by the date and time set in the Employer's request for clarification, its Bid may be rejected.
28. Deviations, Reservations, and Omissions	28.1 During the evaluation of bids, the following definitions apply: (a) "Deviation" is a departure from the requirements specified in the Bidding Document; (b) "Reservation" is the setting of limiting conditions or withholding from complete acceptance of the requirements specified in the Bidding Document; and (c) "Omission" is the failure to submit part or all of the information or documentation required in the Bidding Document.
29. Examination of Technical Bid	29.1 The Employer shall examine the Technical Bid to confirm that all documents and technical documentation requested in ITB 11.2 have been provided, and to determine the completeness of each document submitted.
	29.2 The Employer shall confirm that the following documents and information have been provided in the Technical Bid. If any of these documents or information is missing, the offer shall be rejected. (a) Letter of Technical Bid; (b) written confirmation of authorization to commit the Bidder; (c) Bid Security; and (d) Technical Proposal in accordance with ITB 16
30. Determination of Responsiveness of Technical Bid	30.1 The Employer's determination of a Bid's responsiveness is to be based on the contents of the bid itself, as defined in ITB11.2.
	30.2 A substantially responsive Technical Bid is one that meets the requirements of the Bidding Document without material deviation, reservation, or omission. A material deviation, reservation, or omission is one that, (a) if accepted, would: (i) affect in any substantial way the scope, quality, or performance of the Works specified in the Contract; or (ii) limit in any substantial way, inconsistent with the

	Bidding Document, the Employer's rights or the Bidder's obligations under the proposed Contract; or (b) if rectified, would unfairly affect the competitive position of other Bidders presenting substantially responsive bids.
	30.3 The Employer shall examine the technical aspects of the Bid submitted in accordance with ITB 16, Technical Proposal, in particular, to confirm that all requirements of Section VI (Works Requirements) have been met without any material deviation, reservation or omission.
	30.4 If a bid is not substantially responsive to the requirements of the Bidding Document, it shall be rejected by the Employer and may not subsequently be made responsive by correction of the material deviation, reservation, or omission.
	30.5 The Employer evaluates the bid on the basis of the information in the electronically submitted bid files. If the Bidder cannot substantiate or provide evidence to establish the information provided in e-submitted bid through documents/ clarifications as per ITB Clause 27.1, the bid shall not be considered for further evaluation. 30.6 Bidder shall be Non- Responsiveness, if the Bid Document Fee is not deposited to the stated bank account or paid to the employer's office. In case of JV, bidder must deposit or pay the bid document fee in the name of JV or all JV Partners. 30.7 In Case, a corruption case is being filed to Court against the Natural Person or Board of Director of the firm/institution /company or any partner of JV, such Natural Person or Board of Director of the firm/institution /company or any partner of JV such bidder's bid shall be excluded from the evaluation, if public entity receives instruction from Government of Nepal.
31. Nonconformities Errors, and Omissions	31.1 Provided that a bid is substantially responsive, the Employer may waive any non-conformities in the bid that do not constitute a material deviation, reservation, or omission.
	31.2 Provided that a Technical Bid is substantially responsive, the Employer may request that the Bidder submit the necessary information or documentation, within a reasonable period of time, to rectify nonmaterial nonconformities in the Technical Bid related to documentation requirements. Requesting information or documentation on such nonconformities shall not be related to any aspect of the Price Bid. Failure of the Bidder to comply with the request may result in the rejection of its bid.
	31.3 Provided that a Technical Bid is substantially responsive, the Employer shall rectify quantifiable nonmaterial nonconformities related to the Bid Price. To this effect, the Bid Price shall be adjusted, for comparison purposes only, to reflect the price of a missing or non-conforming item or component. The adjustment shall be made using the methods indicated in Section III (Evaluation and

	Qualification Criteria).
	31.4 If the monetary value of such non-conformities is found to be more than fifteen percent of the Bid Price of the bidder pursuant to ITB **31.3**, such bid shall be considered nonresponsive and shall not be involved in evaluation.
32 Qualification of the Bidder	32.1 The Employer shall determine to its satisfaction during the evaluation of Technical Bids whether Bidders meet the qualifying criteria specified in Section III (Evaluation and Qualification Criteria).
	32.2 The determination shall be based upon an examination of the documentary evidence of the Bidder's qualifications submitted by the Bidder, pursuant to ITB 17.1.
	32.3 An affirmative determination shall be a prerequisite for the opening and evaluation of a Bidder's Price Bid. A negative determination shall result into the disqualification of the Bid, in which event the Employer shall return the unopened Price Bid to the Bidder.
33. Correction of Arithmetical Errors	33.1 During the evaluation of Price Bids, the Employer shall correct arithmetical errors on the following basis: (a) If there is a discrepancy between the bid price in the Summary of Activity Schedule and the bid amount in item(c) of the Letter of Price Bid, the bid price in the Summary of Activity Schedule will prevail and the bid amount in item(c) of the Letter of Price Bid will be corrected. (b) If there is a discrepancy between words and figures, the amount in words shall prevail, unless the amount expressed in words is related to an arithmetic error, in which case the amount in figures shall prevail subject to (a).
	33.2 If the Bidder that submitted the lowest evaluated bid does not accept the correction of errors, its bid shall be disqualified and its bid security shall be forfeited.
34 Subcontractors	34.1 The Employer shall permit subcontracting for certain specialized works as indicated in Section III The sub-contractor shall meet the qualifications criteria as indicated in section III. Sub-contractors' qualification and experience will not be considered for evaluation of the Bidder. The Bidder on its own (without taking into account the qualification and experience of the sub-contractor) should meet the qualification criteria. If the qualification and experience shall not meet the qualifications criteria as indicated in section III, the proposed subcontractor shall be rejected but the responsibility to perform the scope of work shall be of the bidder itself. Bidders may propose subcontracting up to the percentage of total value of contracts or the volume of works as **specified in the BDS.**

35. Evaluation of Price Bids	35.1 The Employer shall evaluate Price Bid of each bid for which the Technical Bid has been determined to be substantially responsive. The Employer shall use the criteria and methodologies listed in this Clause. No other evaluation criteria or methodologies shall be permitted.
	35.2 To evaluate a Price Bid, the Employer shall consider the following: (a) the bid price, excluding Value Added Tax , Provisional Sums, and the provision, if any, for contingencies in the Summary Priced Activity Schedule **,** but including Day work items, where priced competitively; (b) price adjustment for correction of arithmetic errors in accordance with ITB 33.1; (c) price adjustment due to discounts offered in accordance with ITB 14.4; (d) adjustment for nonconformities in accordance with ITB 31.3; (e) application of all the evaluation factors indicated in Section III (Evaluation and Qualification Criteria); (f) the currency (ies) of the bid shall be converted into a single currency as specified in the **BDS.** (g) If applicable, bid price adjustment for a domestic preference as specified in the BDS
	35.3 The estimated effect of the price adjustment provisions of the Conditions of Contract, applied over the period of execution of the Contract, shall not be taken into account in bid evaluation.
	35.4 If this Bidding Document allows Bidders to quote separate prices for different Contracts, and to award multiple Contracts to a single Bidder, the methodology to determine the lowest evaluated price of the Contract combinations, including any discounts offered in the Letter of Price Bid, is specified in Section III (Evaluation and Qualification Criteria).
	35.5 If the bid, which results in the lowest Evaluated Bid Price **extremely low** in the opinion of the Employer, the Employer may require the Bidder to produce detailed price analysis for any or all activities of the Priced Activity Schedule, to demonstrate the internal consistency of the price with the construction methods and schedule proposed. After evaluation of the price analysis, taking into consideration the schedule of estimated Contract payments, the Employer may require that the amount of the performance security be increased at the expense of the Bidder as **mentioned in BDS** to protect the Employer against financial loss in the event of default of the successful Bidder under the Contract **or may consider the bid as non-responsive**.

	35.6 The total amount for the contract must be priced as Lumpsum. 35.7 The Employer evaluates the bid on the basis of the information in the electronically submitted bid files. If the Bidder cannot substantiate or provide evidence to establish the information provided in e-submitted bid through documents/ clarifications as per ITB Clause 27.1, the bid shall not be considered for further evaluation. 35.8 In Case, a corruption case is being filed to Court against the Natural Person or Board of Director of the firm/institution /company or any partner of JV, such Natural Person or Board of Director of the firm/institution /company or any partner of JV such bidder's bid shall be excluded from the evaluation, if public entity receives instruction from Government of Nepal.
36. Comparison of Bids	36.1 The Employer shall compare all substantially responsive bids in accordance with ITB 35.2 to determine the lowest evaluated bid.
37. Employer's Right to Accept Any Bid, and to Reject Any or All Bids	37.1 The Employer reserves the right to accept or reject any bid, and to annul the bidding process and reject all Bids at any time prior to contract award, without thereby incurring any liability to Bidders. In case of annulment, all Bids submitted and specifically, bid securities, shall be promptly returned to the Bidders.
F. Award of Contract	
38. Award Criteria	38.1 The Employer shall award the Contract to the Bidder whose offer has been determined to be the lowest evaluated bid as per ITB 35.2 and is substantially responsive to the Bidding Document, provided further that the Bidder is determined to be qualified to perform the Contract satisfactorily.
39. Letter of Intent to Award the Contract/Notification of Award	39.1 The Employer shall notify the concerned Bidder whose bid has been selected in accordance with ITB 38.1 within seven days of the selection of the bid, in writing that the Employer has intention to accept its bid and the information regarding the name, address and amount of selected bidder shall be given to all other bidders who submitted the bid.
	39.2 If no bidder submits an application pursuant to ITB 42 within a period of seven days of the notice provided under ITB 39.1, the Employer shall, accept the bid selected in accordance with ITB 38.1 and Letter of Acceptance shall be communicated to the selected bidder prior to the expiration of period of Bid validity, to furnish the performance security and sign the contract within fifteen days.
	39.3 At the same time, the Employer shall affix a public notice on the result of the award on its notice board and may make arrangements to post the notice into its website, if it has; and if it does not have, into the website of the Public Procurement Monitoring Office, identifying the bid and lot numbers and the following information: (i) name of each Bidder who submitted a Bid; (ii) bid prices as read out at Bid Opening; (iii) name and

	evaluated prices of each Bid; (iv) name of bidders whose bids were rejected and the reasons for their rejection; and (v) name of the winning Bidder, and the Price it offered, as well as the duration and summary scope of the Contract awarded. 39.4 In Case, a corruption case is being filed to Court against the Natural Person or Board of Director of the firm/institution /company or any partner of JV, such Natural Person or Board of Director of the firm/institution /company or any partner of JV such bidder's bid shall be rejected, if public entity receives instruction from Government of Nepal.
40. Performance Security and Line of Credit	40.1 Within Fifteen (15) days of the receipt of Letter of Acceptance from the Employer, the successful Bidder shall furnish the performance security in accordance with the Conditions of Contract, subject to ITB 35.5, as specified below from Commercial Bank or Financial Institution eligible to issue Bank Guarantee as per prevailing Law using Sample Form for the Performance Security included in Section X (Contract Forms), or another form acceptable to the Employer. The performance security issued by any foreign Bank outside Nepal must be counter guaranteed by an Commercial Bank or Financial Institution eligible to issue Bank Guarantee as per prevailing Law in Nepal. i) If bid price of the bidder selected for acceptance is up to 15 (fifteen) percent below the approved cost estimate (including Provisional Sum amount) the performance security amount shall be 5 (five) percent of the bid price. ii) For the bid price of the bidder selected for acceptance is more than 15 (fifteen) percent below of the cost estimate (including Provisional Sum amount), the performance security amount shall be determined as follows: **Performance Security Amount = [(0.85 x Cost Estimate –Bid Price) x 0.5] + 5% of Bid Price.** The Bid Price and Cost Estimate shall be exclusive of Value Added Tax. Within Fifteen (15) days of the receipt of Letter of Acceptance from the Employer, the successful Bidder shall furnish the Letter of Commitment for Bank's Undertaking for Line of Credit of the amount as specified in the BDS, using Sample Form for the Line of Credit included in Section X (Contract Forms) at the time of contract agreement.
	40.2 Failure of the successful Bidder to submit the above-mentioned Performance Security and Line of Credit or to sign the Contract Agreement shall constitute sufficient grounds for the annulment of the award and forfeiture of the bid security. In that event the Employer may award the Contract to the next lowest evaluated Bidder whose offer is substantially responsive and is determined by the Employer to be qualified to perform the Contract satisfactorily. The process shall be repeated according to ITB 39.
41 Signing of Contract	41.1 The Employer and the successful Bidder shall sign the Contract Agreement within the period as stated ITB 40.1.
	41.2 At the same time, the Employer shall affix a public notice on the result of the award on its notice board and make arrangement for causing such notice to be affixed on the notice board also of the ***District***

	Coordination Committee, District Administration Office, Provincial Treasury and Controller Office and District Treasury and Controller Office or publish in Employer's Web Site or PPMO Website. The Employer may make arrangements to post the notice into its website, if it has; and if it does not have, into the website of the Public Procurement Monitoring Office, identifying the bid and lot numbers and the following information: (i) the result of evaluation of bid; (ii) date of publication of notice inviting bids; (iii) name of newspaper; (iv) reference number of notice; (v) item of procurement; (vi) name and address of bidder making contract and (viii) contract price
	41.3 Within thirty (30) days from the date of issuance of notification pursuant to ITB 39.1 unsuccessful bidders may request in writing to the Employer for a debriefing seeking explanations on the grounds on which their bids were not selected. The Employer shall promptly respond in writing to any unsuccessful Bidder who, requests for debriefing.
	41.4 If the bidder whose bid has been accepted fails to sign the contract as stated ITB 41.1, the Public Procurement Monitoring Office shall blacklist the bidder on recommendation of the Public Entity.
42. Complaint and Review	42.1 If a Bidder is dissatisfied with the Procurement proceedings or thedecision made by the Employer in opening of the price bid or the intention to award the Contract, it may file an application to the Chief of the Public Entity within Seven (7) days of providing the notice under ITB 25.8 and ITB 39.1 by the Public Entity, for review of the proceedings stating the factual and legal grounds.
	42.2 Late application filed after the deadline pursuant to ITB 42.1 shall not be processed.
	42.3 The chief of Public Entity shall, within five (5) days after receiving the application, give its decision with reasons, in writing pursuant to ITB 42.1: (a) whether to suspend the procurement proceeding and indicate the procedure to be adopted for further proceedings; or (b) to reject the application. The decision of the chief of Public Entity shall be final for the Bid amount up to the value as stated in 42.4.
	42.4 If the Bidder is not satisfied with the decision of the Public Entity in accordance with ITB 42.3, is not given within five (5) days of receipt of application pursuant to ITB 42.1, it can, within seven (7) days of receipt of such decision, file an application to the Review Committee of the GoN, stating the reason of its disagreement on the decision of the chief of Public Entity and furnishing the relevant documents, provided that its Bid amount is equal or more than Rupees Twenty Million (NRs. 20,000,000). The application may be sent by hand, by post, by courier, or by electronic media at the risk of the Bidder itself.
	42.5 Late application filed after the deadline pursuant to ITB 42.4 shall not be processed.
	42.6 Within three (3) days of the receipt of application from the Bidder, pursuant to ITB 42.4, the Review Committee shall

	notify the concerning Public Entity to furnish its procurement proceedings, pursuant to ITB 42.3.
	42.7 Within three (3) days of receipt of the notification pursuant to ITB 42.6, the Public Entity shall furnish the copy of the related documents to the Review Committee.
	42.8 The Review Committee, after inquiring from the Bidder and the Public Entity, if needed, shall give its decision within one (1) month of the receipt of the application filed by the Bidder, pursuant to ITB 42.4.
	42.9 The Bidder, filing application pursuant to ITB 42.4, shall have to furnish a cash amount or Bank guarantee from Commercial Bank or Financial Institution eligible to issue Bank Guarantee as per prevailing Law equivalent to one percent (1%) of its quoted Bid amount with the validity period of at least ninety (90) days from the date of the filing of application pursuant to ITB 42.4.
	42.10 If the claim made by the Bidder pursuant to ITB 42.4 is justified, the Review Committee shall have to return the security deposit to the applicant, pursuant to ITB 42.9, within seven (7) days of such decision made. 42.11 If the claim made by the Bidder pursuant to ITB 42.4 is rejected by the Review Committee, the security deposit submitted by the Bidder pursuant to ITB 42.9 shall be forfeited.

Section II: Bid Data Sheet

A. General	
ITB 1.1	The number of the Invitation for Bids is: ***IFB-2077-78-10*** ***The Bid is invited as ICB***
ITB 1.1	The Employer is***: Department of Roads, Quality, Research and Development Center, Chakupat, Lalitpur***
ITB 1.1	The number and identification of lots comprising this bidding process is: ***DOR_QRDC/EPC/ICB/STP/077/78-05***
ITB 1.3	***Multiple Contract is Not Applicable***
ITB 2.1	The name of the Project is ***Planning, Design, Engineering, Procurement, Construction, Commissioning and Five Years of Service Operation & Maintenance of One Double Lane Standard Highway Tunnel, Rockshed Structure, Rock Fall Mitigation and Road Works on Engineering Procurement Construction (EPC) basis all complete*** The DP is ***Not Applicable*** The implementing agency is ***Quality Research and Development Center, Chakupat*** GoN Funded or DP Funded: ***GoN Funded***
ITB 3.3 (d)	***For DP Funded: Not Applicable*** ***(For GoN funded delete this row)***
ITB 4.1 (a)	For GoN Funded: Maximum number of partners in a joint venture shall be: **3 (three)**
ITB 4.4	*For DP:* ***Not Applicable***
B. Bidding Document	
ITB 7.1	For clarification purposes only, the Employer's address is: ***Attention: Director, Quality Research and Development Center*** ***Address: Chakupat, Lalitpur*** ***Telephone: +977-01-5260505/+977-01-5260696*** ***Facsimile number: Not Applicable*** ***Electronic mail address: dorqrdc@gmail.com***
ITB 7.4	A Pre-Bid meeting ***shall be*** held. Pre-Bid Meeting will Take place at the following date, time and place: ***Date: 13th June 2021*** ***Time: 13:00 Hours GMT*** ***Place: Quality Research and Development Center, Chakupat***

	A site visit ***shall not be*** organized by the Employer.
ITB 7.5	Time for request: Requests for clarification should be received by the Employer no later than **10 days** prior to the deadline for submission of bids.
C. Preparation of Bids	
ITB 10.1	The language of the bid is: **English.** All correspondence exchange shall be in **English** language. Language for translation of supporting documents and printed literature is ***English.***
ITB 11.2 (h)	The Bidder shall submit with its Technical Bid the following additional documents: ***None***
ITB 11.3 (b)	In accordance with ITB 12 and ITB 14, the following schedules shall be submitted with the bid, including the Schedule of Prices: ***None***
11.3 (d)	The Bidder shall submit with its Price Bid the following additional documents: ***Detail Breakdown for the percentage of proposed Foreign Currency Component.*** ***The contractor shall submit details of work/quantities with anticipated cost to carry out under each sub section.***
ITB 13.1	Alternative bids ***shall not be*** permitted.
ITB 13.2	Alternative times for completion ***shall not be*** permitted.
ITB 13.4	Alternative technical solutions shall be permitted for the following parts of the Works: ***Not Applicable***
ITB 14.6	The prices quoted by the Bidder ***shall not be*** subject to adjustment during the performance of the Contract.
ITB 15.1	If the currency of the Bid and payment is other than Nepalese currency: The currency applicable shall be ***United States Dollar*** The maximum ratio of Nepali Currency to Foreign Currency with respect to the evaluated bid price shall not be more than **70:30** a) Bidders shall indicate the portion of the bid price that corresponds to expenditures incurred in Nepalese currency in the Schedule of Payment Currencies included in Section IV (Bidding Forms). b) Bidders expecting to incur expenditures in other currencies for inputs to the Works supplied from outside the Employer's country and wishing to be paid accordingly may indicate up to three convertible foreign currencies included in daily publication of Nepal Rastra Bank foreign currency exchange rate in the Schedule of Payment Currencies included in Section IV (Bidding Forms). c) The rates of exchange to be used by the bidder for currency conversion during bid preparation shall be the selling rates for similar transactions prevailing on the date 30 days prior to the deadline for submission of bids published by Nepal Rastra Bank. Bidders should note that for the purpose of payments, the exchange rates confirmed by Nepal Rastra Bank as the selling rates prevailing 30 days prior to the deadline for submission of bids shall apply for the duration of the Contract so that no currency exchange risk is borne by the bidder.

	d) Foreign currency requirements indicated by the bidders in the Schedule of Payment Currencies shall include but not limited to the specific requirements for • expatriate staff and labor employed directly on the Works; • social, insurance, medical and other charges relating to such expatriate staff and labor, and foreign travel expenses; • imported materials, both temporary and permanent, including fuels, oil and lubricants required for the Works; • depreciation and usage of imported Plant and Contractor's Equipment, including spare parts, required for the Works; • foreign insurance and freight charges for imported materials, Plant and Contractor's Equipment, including spare parts; and • overhead expenses, fees, profit, and financial charges arising outside the Employer's country in connection with the Works. e) Bidders may be required by the Employer to clarify their foreign currency requirements, and to substantiate that the amounts included in the prices and shown in the Schedule of Payment Currencies are reasonable and responsive to (b) above, in which case a detailed breakdown of its foreign currency requirements shall be provided by the Bidder. f) Bidders should note that during the progress of the Works, the foreign currency requirements of the outstanding balance of the Contract Price may be adjusted by agreement between the Employer and the Contractor in order to reflect any changes in foreign currency requirements for the Contract, in accordance with General Condition of Contract 58. Any such adjustment shall be affected by comparing the percentages quoted in the bid with the amounts already used in the Works and the Contractor's future needs for imported items.
ITB 18.1	The bid validity period shall be: ***One Hundred Twenty Days [120 days]***
ITB 19.1	The Bidder shall furnish a bid security, from Commercial Bank or Financial Institution eligible to issue Bank Guarantee as per prevailing Law with a minimum of ***NRs. 207.00 Million***, which shall be valid for 30 days beyond the validity period of the bid.
ITB 19.2 (b)	***Office Name: Quality Research and Development Center, Chakupat*** ***Bank Name: Nepal Bank Limited*** ***Bank Address: Gabahal, Lalitpur Account*** ***Number: 00101000000001001001*** ***Office Code: 337013406***
ITB 20.1	In addition to the original of the bid, the number of copy/ies is/are: ***Not Applicable***
ITB 20.2	The written confirmation of authorization to sign on behalf of the Bidder shall indicate: (a) The name and description of the documentation required to demonstrate the authority of the signatory to sign the Bid such as a Power of Attorney; and

	(b) In the case of Bids submitted by an existing or intended JV, an undertaking signed by all parties (i) stating that all parties shall be jointly and severally liable, and (ii) nominating a Representative who shall have the authority to conduct all business for and on behalf of any and all the parties of the JV during the bidding process and, in the event the JV is awarded the Contract, during contract execution.
D. Submission and Opening of Bids	
ITB 21.1	Bidders shall submit their bids electronically.
ITB 22.1	***The deadline for bid submission is:*** ***Date: 7th July 2021*** ***Time: 12:00 Hours GMT***
ITB 25.1	***The Technical Bid opening shall take place at:*** ***Address: Quality Research and Development Center, Chakupat*** ***Date: 7th July 2021*** ***Time: 13:00 Hours GMT***
E. Evaluation and Comparison of Bids	
ITB 34.1	a) Contractor's proposed subcontracting: Maximum percentage of subcontracting permitted is: **25% of the total contract amount.** b) Sub-contractors' qualification and experience will not be considered for evaluation of the Bidder. The Bidder on its own (without taking into account the qualification and experience of the sub-contractor) should meet the qualification criteria.
ITB 35.2(f)	Nepali Currency
ITB 35.2(g)	Domestic Preference shall apply for domestic bidders. In comparing domestic bids with foreign bids, a Domestic preference shall be granted to eligible domestic contractors, as defined below, in accordance with the following provisions. (a) For application of domestic preference, all responsive bids shall first be classified into the following two categories: (i) Category I: Bids offered by domestic contractors (domestic bidder firms, intuitions, or company either in single or in joint venture (all partners)); and (ii) Category II: Bids offered by International firms, intuitions or company or collaboration with domestic firms, intuitions, company (b) The lowest evaluated bid of each category shall then be determined by comparing all evaluated bids in each category among themselves. (c) Such lowest evaluated bids shall next be compared with each other and if, as a result of this comparison, a bid from Category I is found to be the lowest, it shall be selected for the award of contract. (d) If, however, as a result of the comparison under (c) above, the lowest bid is found to be from Category II, it shall be further compared with the lowest evaluated bid from Category I. For the purpose of this, further comparison only an upward adjustment (domestic preference) shall be made to the lowest evaluated bid price of Category II by adding an amount equal to Five (5%) of the bid price. If, after such comparison, the Category I bid is determined to be

	the lowest, it shall be selected for the award of contract; if not, the lowest evaluated bid from Category II shall be selected.
ITB 35.5	The amount of the performance security be increased by **Eight (8)** percent of the quoted bid price.
ITB 40.1	Letter of Commitment for Bank's Undertaking for Line of Credit shall be of **NRs.** ***377.00 Million.***
ITB 41.4	For DP Funded: Not Applicable ***[For GoN funded delete this row]***

Section III: Evaluation and Qualification Criteria[1]

This Section contains all the criteria that the Employer shall use to evaluate bids and qualify Bidders by post-qualification exercise. GoN/DP requires bidders to be qualified by meeting predefined, precise minimum requirements. The method sets pass-fail criteria, which, if not met by the bidder, results in disqualification. In accordance with ITB 32 and ITB 35, no other methods, criteria and factors shall be used. The Bidder shall provide all the information requested in the forms included in Section IV (Bidding Forms).

1. Evaluation

In addition to the criteria listed in ITB 35.2 (a) - (e) the following criteria shall apply:

Note:
Use the evaluation criteria listed below as appropriate and required for the project.

1.1 Adequacy of Technical Proposal

Evaluation of the Bidder's Technical Proposal will include an assessment of the Bidder's technical capacity, to mobilize key equipment and personnel for the contract consistent with its proposal regarding work methods, scheduling, and material sourcing in sufficient detail and fully in accordance with the requirements stipulated in Section VI (Works Requirements).

1.2 Multiple Contracts

Multiple Contracts, if permitted under ITB 35.4, will be evaluated as follows:

Award Criteria for Multiple Contracts [ITB 35.4:

Bidders have the option to Bid for any one or more Contracts. Bids will be evaluated taking into account discounts offered, if any, for combined contracts. The contract(s) will be awarded to the Bidder or Bidders offering the lowest evaluated cost to the Employer for combined contracts, subject to the selected Bidder(s) meeting the required qualification criteria for combination of multiple contracts as the case may be.

Qualification Criteria for Multiple Contracts:

The criteria for qualification shall be the sum of the minimum requirements for respective individual contracts as specified under items 2.3.2, 2.3.3, and 2.4.2b.

With respect to the **Contracts of Similar Size and Nature** under item 2.4.2(a). of

Section III, the evaluation shall be done as below:

N is the minimum number of contracts as per Note (2) of 2.4.2 Specific Construction Experience

V is the minimum value of a single contract as per Note (3) of 2.4.2 Specific Construction Experience

i. Minimum requirements for combined contract(s) shall be the aggregate requirements for each contract for which the bidder has submitted bids as follows, and N1,N2,N3, etc. shall be different contracts:

Contract 1: N1 contracts, each of minimum value V1;

Contract 2: N2 contracts, each of minimum value V2;

Contract 3: N3 contracts, each of minimum value V3;

----etc.

and

ii. Total number of contracts is equal or less than N1 + N2 + N3 +--but the total value of all such contracts is equal or more than N1 x V1 + N2 x V2 + N3 x V3 +---.

iii. 1.3 In Case, other than Multiple Contracts

Bidders have the option to Bid for any one or more Contracts. The contracts will be awarded to the Bidder or Bidders offering the lowest evaluated cost to the Employer, subject to the selected Bidder(s) meeting the required qualification which shall be the sum of the minimum requirements for respective individual contracts as specified under items Required Bid Capacity as per 2.3.3. Under this case, Contract shall be awarded based on Least Cost Combination to the Employer.

1.4 Completion Time

An alternative Completion Time, if permitted under ITB 13.2, will be evaluated as follows:

Not Applicable

1.5 Alternative Technical Solutions

Alternative technical solutions, if permitted under ITB 13.4, will be evaluated as follows:

Not Applicable

1.6 Quantifiable Nonconformities and Omissions

Subject to ITB 14.2 and ITB 35.2, the evaluated cost of quantifiable nonconformities including omissions, is determined as follows:

["Pursuant to ITB 31.3, the cost of all quantifiable nonmaterial nonconformities shall be evaluated, but excluding omission of prices in the BoQ.The Employer will make its own assessment of the cost of any nonmaterial nonconformities and omissions for the purpose of ensuring fair comparison of bids."]

2. Qualification

2.1 Eligibility

Criteria		Compliance Requirements			Documents
Requirement	Single Entity	Joint Venture			Submission Requirements
		All Partners Combined	Each Partner	One Partner	
2.1.1 Nationality					
Nationality in accordance with ITB sub-clause 4.2	must meet requirement	must meet requirement	must meet requirement	not applicable	Letter of Technical Bid Forms ELI –1; ELI –2 with attachments
2.1.2 Conflict of Interest					
No conflicts of interest in accordance with ITB Sub-Clause 4.3.	must meet requirement	existing or intended JV must meet requirement	must meet requirement	not applicable	Letter of Technical Bid
2.1.3 Government/DP Eligibility					
Not having been declared ineligible by government/DP, as described in ITB Sub-Clause 4.4.	must meet requirement	must meet requirement	must meet requirement	not applicable	Letter of Technical Bid
2.1.4 Government-owned Entity					
Bidder required to meet conditions of ITB Sub-Clause 4.5.	must meet requirement	existing or intended JV must meet requirement	must meet requirement	not applicable	Forms ELI - 1, ELI - 2, with attachments
2.1.5 UN Eligibility					
Not having been	must meet	existing or	must meet	not	Letter of

declared ineligible based on a United Nations resolution or Employer's country law, as described in ITB Sub-Clause 4.8.	requirement	intended JV must meet requirement	requirement	applicable	Technical Bid
2.1.6 Other Eligibility					
Firm Registration Certificate	must meet requirement	not applicable	must meet requirement	not applicable	Document attachment
Business Registration Certificate	must meet requirement	not applicable	must meet requirement	not applicable	Document attachment
VAT and PAN Registration certificate ***(only for domestic bidders)***	must meet requirement	not applicable	must meet requirement	not applicable	Document attachment
Tax Clearance Certificate/Tax return submission evidence/evidence of time extension for the **F/Y 2076/77** (***Only for domestic bidders)***	must meet requirement	not applicable	must meet requirement	not applicable	Document attachment
Additional requirements ***[Insert if any]***	…….	……	……	……	……

2.2 Pending Litigation

Criteria		**Compliance Requirements**			**Documents**
Requirement	**Single Entity**	**Joint Venture**			**Submission Requirements**
		All Partners Combined	**Each Partner**	**One Partner**	
2.2.1 Pending Litigation					
All pending litigation shall be treated as resolved against the Bidder and so shall in total not represent more than Fifty	must meet requirement by itself or as partner to past or existing JV	not applicable	must meet requirement by itself or as partner to past or existing JV	not applicable	Form LIT - 1

[50] percent of the Bidder's net worth.					

2.3 Financial Situation

Criteria		Compliance Requirements			Documents
Requirement	**Single Entity**	**Joint Venture**			**Submission Requirements**
		All Partners Combined	**Each Partner**	**One Partner**	
2.3.1 Historical Financial Performance					
Submission of audited balance sheets and income statements, for the last ***Five [5]*** years to demonstrate the current soundness of the Bidder's financial position. As a minimum, a Bidder's net worth calculated as the difference between total assets and total liabilities should be positive.	must meet requirement	not applicable	must meet requirement	not applicable	Form FIN - 1 with attachments

Note:

(1) The financial information provided by a Bidder should be reviewed in its entirety to allow a truly informed judgment, and the pass-fail decision on the financial position of the Bidder should be given on this basis. Balance sheet of the past three to five years period which shall be decided according to the nature of the work.

2.3.2 Average Annual Construction Turnover					
Minimum average annual construction turnover of ***NRs 2264.00 Million*** calculated as total certified payments received for construction contracts in progress or completed, within best three years out of last ten fiscal years.	must meet requirement	must meet requirement	must meet 25% of the requirement	must meet 40% of the requirement	Form FIN -2

Only the net amount shall be calculated after deducting the amount for VAT and such amount shall be adjusted to present value by applying wholesale price index of Nepal Rastra Bank.

2.3.3 Required Bid Capacity					
The bidding capacity of the bidder should be equal to or more than the ***NRs. 7500.00 Million***	must meet requirement	must meet requirement	must meet 25% of the requirement	must meet 40% of the requirement	Form FIN -3,4

2.4 Experience

Criteria		Compliance Requirements			Documents
Requirement	**Single Entity**	**Joint Venture**			**Submission Requirement**
		All Partners Combined	**Each Partner**	**One Partner**	
2.4.1 General Construction Experience					
Experience under construction contracts in the role of contractor, subcontractor, or management contractor for at least the last ***Five [5]*** years prior to the applications submission deadline.	must meet requirement	not applicable	must meet requirement	not applicable	Form EXP - 1

2.4.2 Specific Construction Experience					
(a) Contracts of Similar Size and Nature					
Participation as Prime contractor, management contractor, or subcontractor, in at least one EPC/Turnkey/DB Contract within the last ten (10) years, with a value of at least ***NRs 3019.00 Million*** that includes Planning, Design, Engineering, Procurement and Construction, Commissioning and at least two years of Service Operation and Maintenance of double lane Road Tunnel (minimum 3m of one lane each) of length not less than 1.0 km that consist of i)	must meet requirement	not applicable	not applicable	must meet requirement	Form EXP – 2(a)

emergency cross passage, ii) tunnel ventilation iii) electrification and lightening, (iv Installation of Monitoring and Emergency Facilities that have been successfully or are substantially completed and that are similar to the proposed works. The similarity shall be based on the physical size, complexity, methods, technology or other characteristics as described in Section VI, Works Requirements. To substantiate the above qualification, the Applicant shall produce certificate of the above activities from the Client to demonstrate that it has completed the works within the agreed time frame as per the Agreement made. The Applicant shall be able to produce the Agreement Copy indicating Contract period, the Taking Over Certificate and the Certificate after completion of service works. The Applicant shall also submit GIS/GPS location with UTM coordinates of the completed project and photographs to supplement his achievements.					
(ii) Participation as Prime contractor, management contractor, or subcontractor, Contract within the last ten (10) years, with a value of at least ***NRs 1887.00 Million*** that have been	not applicable	not applicable	must meet requirement	not applicable	Form EXP – 2(a)

successfully or are substantially completed.					

Only the net amount shall be calculated after deducting the amount for VAT and such amount shall be adjusted to present value by applying wholesale price index of Nepal Rastra Bank.

(b) Construction Experience in Key Activities					
For the above or other contracts executed during the period stipulated in 2.4.2(a) above, a minimum construction experience in the following key activities:	must meet all requirements	must meet all requirements	not applicable	not applicable	Form EXP - 2(b)
Tunnel Lining Concrete Works of 17,000.00 cum					
Tunnel Excavation 100,000.00 cum					
Rock Shed Construction of 200 m or Slope Protection Works (Rock Netting, Rock Barriers etc.) with minimum area 15,000 sqm					

2.5 Understanding about the project and proposed design

Understanding about the project					
Submission of concept paper highlighting detail about understanding of the project from planning to completion stage including surveying, geotechnical investigation, environmental and social safeguard study, designing, procuring, constructing and operation and maintenance	must meet requirement	must meet requirement	not applicable	not applicable	Form EXP – 2(B)
Proposed design					
Submission of design methodology and concept design including design finalization procedure, assurance about design	must meet requirement	must meet requirement	not applicable	not applicable	Form EXP – 2(C)

and relevant codes					

2.6 Personnel

The Bidder must demonstrate that it has the personnel for the key positions that meet the following requirements:

SN.	Position	Required No.	Academic Qualification *[When position demands]*	Total Work Experience [Years]	Experience in Similar Works [years]
Engineering					
1.	Tunnel Design Engineer	1	Master's degree in Tunnel Engineering/Mining/Rock Mechanics	10	Experience of least 5 tunnel design projects
2.	Tunnel Facility Designer	2	Master's degree in Tunnel Engineering or related	10	Experience of least 5 tunnel design projects
3.	Hydrologist	1	Master's Degree in Hydrology/Water Resource/Hydropower Engineering or related field.	10	Experience in at least two road tunnel projects
4	Structural Engineer	1	Preferably Master's degree in Structural Engineering or related	10	Experience in at least two road tunnel projects
5	Geotechnical Engineer	1	Master's Degree in Geotech Engineering	10	Experience in at least two road tunnel projects and one rock fall projection project.
6	Geologist	1	Master's Degree in Geology/Rock Mechanics/Mining Engineering	10	Ten years of experience in the related field and shall have successfully completed design at least one Two road tunnel projects and one rock-fall protection project.
7	Rock-fall hazard expert	1	Bachelor's in Geotechnical/Civil Engineering or BSc in Geology	12	10 years of specific experience
8	Environmental expert	1	BSc in environmental engineering/science	12	10 years of specific

					experience
9	Exploitation and Safety Equipment Lead Engineer	1	Bachelor's in Electrical Engineering.	12	10 years of specific experience
10	Mechanical Lead Engineer	1	Bachelor's in Mechanical or Civil Engineering.	12	10 years of specific experience
Procurement					
1.	**None**				
Construction					
1	Project Manager	1	Bachelor's Degree in Civil Engineering	15	In-house staff with at least Ten years of experience in the related field as a Project Manager and shall have successfully completed at least one Tunnel Road Project on EPC basis.
2	Tunnel Works Manager (Supervision)	1	Preferably Master's or Bachelor's Degree in Tunnel Engineering/ Civil Engineering or relevant degree	10	In-house staff with at least Five years of experience in the related field and shall have successfully completed at least one road tunnel project.
3	Exploitation and Safety Equipment Works Manager	1	Preferably Master's or Bachelor's Degree in Electrical Engineering or Mechanical Engineering	10	Five years of experience in construction of Exploitation and Safety Equipment for road tunnels.
4	Pavement Engineer (Supervision)	1	Preferably Master's or Bachelor's Degree in Highway Engineering/ Pavement Engineering/Civil Engineering	10	Five years of experience in the related field and shall have successfully completed at least one road project.
5	Geotechnical Engineer	1	Preferably Master's or Bachelor's Degree in Engineering Geology / Geotechnical Engineering /Rock Mechanics / Rock Engineering/ Civil	10	Five years of experience in the related field and shall have successfully completed at least

			Engineering		one road tunnel project.
6	Quality Control Engineer	1	Bachelor's Degree in Civil Engineering	10	Five years of experience in the related field and shall have successfully completed at least one road tunnel project.
7	Health & Safety Manager	1	Bachelor's or Master's Degree in Health Science	10	Five years of experience in the related field and shall have successfully completed at least one road tunnel project.
8	Environment Protection Manager	1	Preferably Masters or Bachelor's Degree in Civil Engineering/ Environmental Engineering/ Environment Science	10	Five years of experience in the related field and shall have successfully completed at least one road tunnel project.
9	Site Geologist		Master's Degree in Geology/Rock Mechanics/Mining Engineering	10	Ten years of experience in the related field and shall have successfully completed at least one road tunnel project and one rockfall protection project.

In case the bidder proposes to consider Personnel that may be spared from committed/ongoing contracts for evaluation, the bidder shall provide details of personnel which will be spared from such committed/ongoing contracts based on the physical progress at the date of bid submission.

The Bidder shall provide details of the proposed personnel and their experience records in the relevant Information Forms included in Section IV (Bidding Forms).

The bidder may propose same person for the equivalent positions required to serve for engineering, procurement and construction phases if the person meets the criteria as above for all phases.

2.7 Equipment

The Bidder must demonstrate that it has the key equipment listed hereafter:

No.	Equipment Type and Characteristics	Min. Number Requirement
1	Multifunction Rotary Drilling Rig – Revolving Speed ≥ 10 m/h	1
2	High pressure double fluid grouting pump	2
3	Electric Air Compression Station – 40 to 60 cum/min	2
4	Axial Flow Fan	2
5	Three Arm Jumbo Drill	2
6	Pneumatic Rock Drill	4
7	Multifunction Deck – separable	1
8	Shotcreting/Concrete Delivery pump – 60 cum/hr Shotcreting/Concrete Deliver pump – 10 cum/hr	2 2
9	Two Stage Stone Crusher Plant (production > 60 cum/hr) with complete screening sets, Conveyors and sand pumps, set	1
10	Concrete Mixing Station (Automatic Batching Plant) min. production Capacity of 60 cum/hr	1
11	Robotic arm with radio remote control	2

In case the Bidder proposes to consider Equipment that may be spared from committed/ongoing contracts for evaluation, the Bidder shall provide details of Equipment which will be spared from committed / ongoing contracts clearly demonstrating the availability of such equipment with respect to the physical progress of the ongoing contracts on the date of bid submission.

In case of Equipment to be leased/hired the same procedure as mentioned above shall apply.

The Bidder shall provide further details of proposed items of equipment using the relevant Form in Section IV (Bidding Forms)

2.8 Subcontractors

The experience and financial capacity of the sub-contractors shall not be added to those of the Bidder for purposes of qualification of the Bidder.

The sub-contractors proposed shall be fully qualified for their work proposed, and meet the following criteria:

2.7 (a) Nature of Works that can be sub contracted:

1. Terminal Building Construction Works
2. Mechanical and Electrical Setup

Note: Employer should specify the nature of work, if sub-contracting is permitted.

2.7 (b) Qualification Criteria

The proposed sub-contractor shall meet the following requirements:

1) Completion of 80% of the quantity of the work being sub contracted

2) Average Annual Construction Turnover for the work being sub contracted should be at least 1.5 * V/T where V is the proposed value of sub contract and T is time in year. For contract duration of up to 1 year, T shall be "1".

3) Financial Resources**:** The sub contract must demonstrate that it has the financial resources to meet its current contract commitment plus three months' requirements for the sub contracted work.

Section IV: Bidding Forms

This Section contains the forms which are to be completed by the Bidder and submitted as part of its Bid.

Letter of Technical Bid

The Bidder must accomplish the Letter of Bid in its letterhead clearly showing the Bidder's complete name and address.

Date: .....

Name of the contract: .....

Invitation for Bid No.: .....

To:……
…….....

We, the undersigned, declare that:

(a) We have examined and have no reservations to the Bidding Documents, including Addenda issued in accordance with Instructions to Bidders (ITB) Clause 8.

(b) We offer to execute in conformity with the Bidding Documents the following Works:

(c) Our Bid consisting of the Technical Bid and the Price Bid shall be valid for a period of ***[insert validity period as specified in ITB 18.1 of the BDS]*** days from the date fixed for the bid submission deadline in accordance with the Bidding Documents, and it shall remain binding upon us and may be accepted at any time before the expiration of that period.

(d) Our firm, including any subcontractors or suppliers for any part of the Contract, have nationalities from eligible countries in accordance with ITB 4.2and meet the requirements of ITB 3.4,& 3.5

(e) We are not participating, as a Bidder or as a subcontractor, in more than one Bid in this bidding process in accordance with ITB 4.3(e), other than alternative offers submitted in accordance with ITB 13.

(f) Our firm, its affiliates or subsidiaries, including any Subcontractors or Suppliers for any part of the contract, has not been declared ineligible by DP, under the Employer's country laws or official regulations or by an act of compliance with a decision of the United Nations Security Council;

(g) We are not a government owned entity/We are a government owned entity but meet the requirements of ITB 4.5;[1]

(h) We declare that, we including any subcontractors or suppliers for any part of the contract do not have any conflict of interest in accordance with ITB 4.3 and we have not been punished for an offense relating to the concerned profession or business.

(i) We declarethat we are solely responsible for the authenticity of the documents submitted by us.The document and information submitted by us are true and correct. If any document/information given is found to be concealed at a later date, we shall accept any legal actions by the Employer.

(j) We agree to permit the Employer/DP or its representative to inspect our accounts and records and other documents relating to the bid submission and to have them audited by auditors appointed by the Employer.

(k) If our Bid is accepted, we commit to mobilizing key equipment and personnel in accordance with the requirements set forth in Section III (Evaluation and Qualification Criteria) and our technical proposal, or as otherwise agreed with the Employer.

(l) We are committed to submit the Letter of Commitment for Bank's Undertaking for Line of Credit of ……..Millions at the time of contract agreement, if the bid is awarded to us.

Name: .....

In the capacity of .....

Signed ……...

Duly authorized to sign the Bid for and on behalf of ……

Date ……....

Letter of Price Bid

The Bidder must accomplish the Letter of Bid in its letterhead clearly showing the Bidder's complete name and address.

Date: ….....

Name of the contract: ….....

Invitation for Bid No.: ….....

To:…….
……..

We, the undersigned, declare that:

(a) We have examined and have no reservations to the Bidding Documents, including Addenda issued in accordance with Instructions to Bidders (ITB) Clause 8;
(b) We offer to execute in conformity with the Bidding Documents the following Works:
(c) The total price of our Bid, excluding any discounts offered in item (d) below is: NRs/USD. ……..; or when left blank is the Bid Price indicated in the Activity Schedule.
(d) The discounts offered and the methodology for their application are:……..
(e) Our bid shall be valid for a period of ***[insert validity period as specified in ITB 18.1]*** days from the date fixed for the bid submission deadline in accordance with the Bidding Documents, and it shall remain binding upon us and may be accepted at any time before the expiration of that period;
(f) If our bid is accepted, we commit to obtain a performance security in accordance with the Bidding Document;
(g) We have paid, or will pay the following commissions, gratuities, or fees with respect to the bidding process or execution of the Contract:[2]

Name of Recipient	Address	Reason	Amount
.....	.....	.....	.....
.....	.....	.....	.....

(h) We understand that this bid, *together with your written acceptance thereof i*ncluded **i**n your notification of award, shall constitute a binding contract between us, until a formal contract is prepared and executed;
(i) We understand that you are not bound to accept the lowest evaluated bid or any other bid that you may receive; and
(j) We declare that we are solely responsible for the authenticity of the documents submitted by us.
(k) We agree to permit the Employer/DP or its representative to inspect our accounts and records and other documents relating to the bid submission and to have them audited by auditors appointed by the Employer.

Name: ….....
In the capacity of ….....
Signed ……
Duly authorized to sign the Bid for and on behalf of ……
Date …….

[2] If none has been paid or is to be paid, indicate "None".

Table A. Summary of Payment Currencies

(Applicable / Not Applicable)

Table: Alternative A

For ……..[insert name of Section of the Works]

Name of payment currency	**A** **Amount of currency**	**B** **Rate of exchange** **(local currency per unit of foreign)**	**C** **Local currency equivalent** **C = A x B**	**D** **Percentage of Total Bid Price (TBP)** **100xC** **TBP**
Local currency **_____**		**1.00**		
Foreign currency #1 **_____**				
Foreign currency #2 **_____**				
Foreign currency # **_____**				
Total Bid Price				**100.00**
Provisional sums expressed in local currency	[To be entered by the Employer]		[To be entered by the Employer]	
TOTAL BID PRICE (including provisional sum)				

Table: Alternative B

To be used only with Alternative B Prices directly quoted in the currencies of payment. *(Clause ITB 15.1)*

Summary of currencies of the bid for _____*[insert name of Section of the Works]*

Name of currency	*Amounts payable*
Local currency: _____	
Foreign currency #1: _____	
Foreign currency #2: _____	
Foreign currency #3: _____	
Provisional sums expressed in local currency _____	[To be entered by the Employer]

Bid Security

Bank Guarantee

Bank's Name, and Address of Issuing Branch or Office

(On Letter head of the Commercial bank or any Financial Institution eligible to issue Bank Guarantee as per prevailing Law)

Beneficiary: …..... **name and address of Employer** ……

Date: ……Bid Security No.: …..

We have been informed that. ……. ***[insert name of the Bidder]*** (hereinafter called "the Bidder")intends to submit its bid (hereinafter called "the Bid") to you for the execution of ……***name of Contract*** . …… under Invitation for Bids No. …… ("the IFB").
Furthermore, we understand that, according to your conditions, bids must be supported by a bid guarantee.

At the request of the Bidder, we……. . ***name of Bank*** …….. hereby irrevocably undertake to pay you any sum or sums not exceeding in total an amount of . . ……***amount in figures*** ……. ***(. ……..amount in words ……..)*** upon receipt by us of your first demand in writing accompanied by a written statement stating that the Bidder is in breach of its obligation(s) under the bid conditions, because the Bidder:

(a) has withdrawn or modifies its Bid:
   i) during the period of bid validity specified by the Bidder on the Letter of Technical and Price Bid, in case of electronic submission
   (ii) from the period twenty-four hours prior to bid submission deadline up to the period of bid validity specified by the Bidder on the Letter of Technical Bid and Price Bid, in case of hard copy submission; or

(b) does not accept the correction of errors in accordance with the Instructions to Bidders
   (hereinafter "the ITB"); or

(c) changes the prices or substance of the bid while providing information pursuant to clause 27.1 of ITB; or

(d) having been notified of the acceptance of its Bid by the Employer during the period of bid validity, (i) fails or refuses to execute the Contract Agreement, or (ii) fails or refuses to furnish the performance security, in accordance with the ITB.

(e) is involved in fraud and corruption in accordance with the ITB

This guarantee will remain in force up to and including the date ……***number***……days after the deadline for submission of Bids as such deadline is stated in the instructions to Bidders or as it may be extended by the Employer, notice of which extension(s) to the Bank is hereby waived. Any demand in respect of this guarantee should reach the Bank not letter than the above date.

This Bank guarantee shall not be withdrawn or released merely upon return of the original guarantee by the Bidder unless notified by you for the release of the guarantee.

This guarantee is subject to the Uniform Rules for Demand Guarantees, ICC Publication No. 758.

. . .Bank's seal and authorized signature(s) . . .

Note:
The bid security of ……..……. has been counter guaranteed by the Bank ……..……..…… on.……. (Applicable for Bid Security of Foreign Banks).

Technical Proposal Format

Personnel

Equipment

Site Organization

Method Statement

Mobilization Schedule

Construction Schedule

Others

Format for Understanding about the project

Knowledge about project area

Knowledge about planning stage

Approach towards surveying and types of surveys to be done,

Approach for geotechnical investigation and reporting details

Types of environmental and social safeguard study to be done including the way such studies shall be conducted, Environmental Protection Plan

Approach for designing

Procurement detailing including subcontracting

Construction stage detailing (approach, quality assurance and control mechanism)

Health Safety Plan

Finalization of construction & modality of handover

Mechanism for operation and maintenance

Proposed Design format

Design methodology

Concept design

Design finalization procedure

Assurance about design

Relevant codes for design

Personnel

Form PER – 1: Proposed Personnel

Bidders should provide the names of suitably qualified personnel to meet the specified requirements for each of the positions listed in Section III (Evaluation and Qualification Criteria). The data on their experience should be supplied using the Form below for each candidate.

No.	Name	Position*	Academic Qualification	Total Work Experience [Years]	Experience in Similar Works [years]
1.					
2.					
3.					
4.					
5.					

* As listed in Section III (Evaluation and Qualification Criteria).

Form PER – 2: Resume of Proposed Personnel

The Bidder shall provide all the information requested below. Fields with asterisk (*) shall be used for evaluation.

Position*		
Personal Information	Name	Date of Birth
	Professional qualifications	
Present employment	Name of employer	
	Address of employer	
	Telephone	Contact (manager/personnel officer)
	Fax	E-mail
	Job title	Years with present employer

Summarize professional experience over the last twenty years in reverse chronological order. Indicate particular technical and managerial experience relevant to the project.

From*	**To***	**Company, Project, Position and Relevant Technical and Management Experience***

Note:

In case of e-submission the Resume of Proposed Personnel shall be submitted on notification by the Employer as per ITB 27.

Equipment

The Bidder shall provide adequate information to demonstrate clearly that it has the capability to meet the requirements for the key equipment listed in Section III (Evaluation and Qualification Criteria). A separate Form shall be prepared for each item of equipment listed, or for alternative equipment proposed by the Bidder. The Bidder shall provide all the information requested below, to the extent possible. Fields with asterisk (*) shall be used for evaluation.

(i) For the equipment under Bidder's ownership

No.	Equipment Type and Characteristics	Total Nos. of Equipment under Bidder's Ownership	No. of Equipment engaged/proposed for ongoing/committed contracts	Nos. of Equipment proposed for this contract
1.				
2.				
3.				
4.				
5.				

(ii) For the Equipment to be leased/hired

No.	Equipment Type and Characteristics	Total Nos. of Equipment under the ownership of lease/hire provider	No. of Equipment engaged/committed for other works	Nos. of Equipment proposed to be leased/hired for this contract
1.				
2.				
3.				
4.				
5.				

Type of Equipment*		
Equipment Information	Name of manufacturer	Model and power rating
	Capacity*	Year of manufacture
Current Status	Current location	
	Details of current commitments	
Source	Indicate source of the equipment 🗀 Owned 🗀 Rented 🗀 Leased 🗀 Specially manufactured	

The following information shall be provided only for equipment not owned by the Bidder.

Owner	Name of owner	
	Address of owner	
	Telephone	Contact name and title
	Fax	email
Agreements	Details of rental / lease / manufacture agreements specific to the project	

The Bidder shall be solely responsible for the data provided. However, this shall not limit the right of Employer to verify the authenticity of submitted information.

Note:
In case of e-submission the "Agreements" shall be submitted on notification by the Employer as per ITB 27.1

Site Organization

The bidder shall show here in an Organogram format the organization of his site personnel showing clearly designated duties and responsibilities and the chain of command throughout the structure. Included in the chart shall be the names of respective personnel.

Mobilization Schedule

The bidder shall provide here a general description of the arrangements and methods which he proposes to adopt for the detailed site investigation, design and execution of the works which shall include but not be limited to:

(a) Mobilization period including periods required for establishing the Contractor's offices, workshops etc. and the facilities requires for the Engineer and his staff if applicable.
(b) Mobilization procedure for the detailed site investigation and design works.

Sources of Contractor's equipment and mobilization periods for items of plant.

Construction Schedule

The bidder shall provide here his proposed schedule for engineering, procurement and construction of the Works within the Prescribed Time for Completion. The schedule shall be presented in the form of a **bar chart showing main construction activities matching with the Milestones** prescribed by the employer. The proposed schedule shall include the establishment of contractor's site camp and offices, mobilization of manpower and equipment, detailed site survey and soil investigation, detailed design including approval of construction drawings, submission of construction plan and other requires documents, procurement work, execution of major work activities, testing and commissioning, as built drawings and submission of close out report.

Bidder's Information and Qualification Format

(Without Prequalification)

Bidder's Qualification

To establish its qualifications to perform the contract in accordance with Section III (Evaluation and Qualification Criteria) the Bidder shall provide the information requested in the corresponding Information Sheets included hereunder.

Form ELI – 1: Bidder's Information Sheet

Bidder's Information	
Bidder's legal name	
In case of JV, legal name of each partner	
Bidder's country of constitution	
Bidder's year of constitution	
Bidder's legal address in country of constitution	
Bidder's authorized representative (name, address, telephone numbers, fax numbers, e-mail address)	
Name of Owner **Name of Managing Director** **Name of Board of Director**	
Attached are copies of the following original documents.	
1. In case of single entity, articles of incorporation or constitution of the legal entity named above, in accordance with ITB 4.1 and 4.2. 2. Authorization to represent the firm or JV named in above, in accordance with ITB 20.2. 3. In case of JV, letter of intent to form JV or JV agreement, in accordance with ITB 4.1. 4. In case of a government-owned entity, any additional documents not covered under 1 above required to comply with ITB 4.5.	

Signature of Bidder

Form ELI - 2: JV Information Sheet

Each member of a JV must fill in this form

JV / Specialist Subcontractor Information	
Bidder's legal name	
JV Partner's or Subcontractor's legal name	
JV Partner's or Subcontractor's country of constitution	
JV Partner's or Subcontractor's year of constitution	
JV Partner's or Subcontractor's legal address in country of constitution	
JV Partner's or Subcontractor's authorized representative information (name, address, telephone numbers, fax numbers, e-mail address)	
Attached are copies of the following original documents.	
1. articles of incorporation or constitution of the legal entity named above, in accordance with ITB 4.1 and 4.2. 2. Authorization to represent the firm named above, in accordance with ITB 20.2. 3. In the case of government-owned entity, documents establishing legal and financial autonomy and compliance with commercial law, in accordance with ITB 4.5.	

Signature of Bidder

Form LIT - 1: Pending Litigation

Each member of a JV must fill in this form

Pending Litigation			
☐ No pending litigation in accordance with Criteria 2.2 of Section III (Evaluation and Qualification Criteria) ☐ Pending litigation in accordance with Criteria 2.2 of Section III (Evaluation and Qualification Criteria)			
Year	**Matter in Dispute**	**Value of Pending Claim in NRS**	**Value of Pending Claim as a Percentage on Net Worth**

Signature of Bidder

Form FIN - 1: Financial Situation

Each Bidder or member of a JV must fill in this form

Financial Data for Previous 3 Years [in NRS

Information from Balance Sheet

Years	Year 1 :	Year 2 :	Year 3 :
Total Assets(TA)			
Total Liabilities(TL)			
Net Worth(NW) =TA-TL			
Current Assets(CA)			
Current Liabilities(CL)			
Working Capital = CA – CL			

Information from Income Statement

Years	Year 1 :	Year 2 :	Year 3 :
Total Revenues			
Profit Before Tax			
Profit After Tax			

- Attached are copies of financial statements (balance sheets including all related notes, and income statements) for the last three or above years, as indicated above, complying with the following conditions.
- All such documents reflect the financial situation of the Bidder or partner to a JV, and not sister or parent companies.
- Historic financial statements must be audited by a certified auditor.
- Historic financial statements must be complete, including all notes to the financial statements.
- Historic financial statements must correspond to accounting periods already completed and audited (no statements for partial periods shall be requested or accepted).

Note:

In case of e-submission the attachments should not be uploaded but shall be submitted on notification by the Employer as per ITB 27.1

Signature of Bidder

Form FIN - 2: Average Annual Construction Turnover

Each Bidder or member of a JV must fill in this form

The information supplied should be the Annual Turnover of the Bidder or each member of a JV in terms of the amounts billed to clients for each year for work in progress or completed to NRs/USD at the end of the period reported.

Annual Turnover Data for the Last 10 Years (Construction only)			
Year	Amount Currency	Present Value Conversion Factor for Works in NRs/USD.	Present Value of Annual Turnover

- **Average Annual Construction Turnover (Best three years within the last 10 years) = NRs/USD…….**

Signature of Bidder

Note :

In Case of Currency other than NRs., Present Value Conversion Factor is taken as Unity for all year in count; only multiplied by Exchange Rate (Date of Bid Invitation), established by the Nepal Rastya Bank.

Form FIN - 3: Bid Capacity

Each Bidder or member of a JV must fill in this form

Bid Capacity = [(7 x A) – B]

A = Average Annual Turnover of best three years out of last ten fiscal years.

B = Annual Value of the existing commitments and works (ongoing) to be completed, calculated from **FIN-4.**

SN	Name of Bidder	Pan No.	A, in Million	B, in Million	Bid Capacity, in Million
1					
2					
3					

Total Bid Capacity :

Signature of Bidder

Form FIN-4: Current Contract Commitments / Works in Progress

Bidders and each partner to a JV should provide information on their current commitments on all contracts that have been awarded, or for which a letter of intent or acceptance has been received, or for contracts approaching completion, but for which an unqualified, full completion certificate has yet to be issued.

Current Contract Commitments (For Calculation of B with reference of FIN-3)									
No.	**Name of Contract**	**Name of the Contractor/s**	**Employer's Contact Address, Tel, Fax**	**Contract Share in % (a)**	**Contract Amount in Millions (b)**	**Contract Date(yyyy-mm) (c)**	**Initial or Revised Contract Duration (months) (d)**	**Value of outstanding works [In Millions,NRS]# (e)**	**Estimated Time in Month to Complete the outstanding works (f) = (c) + (d) – Date of Invitation of Bid (f)**
1									
2									
3									
4									

Signature of Bidder

 # The Outstanding Works means Contract Price (excluding Vat) minus Work Evaluated by Employer till the reference date.Bidder shall have to submit the relevant documentary evidence to substantiate the facts/figures. Note 1: "B" shall be calculated as : $B = \sum \left[\frac{(e) \times (a)}{(f)} \right] x12$ **, If (f) is less than 12, then value of (f) shall be taken as 12.**

Note 2: If Initial or Revised Contract Date is run out with respect to Date of Invitation of Bid, the Estimated Time in Month to Complete the outstanding works shall be taken equal to 12 months.

Form EXP - 1: General Construction Experience

Each Bidder or member of a JV must fill in this form.

General Construction Experience				
Starting Month Year	**Ending Month Year**	**Year**	**Contract Identification and Name and Address of Employer Brief Description of the Works Executed by the Bidder**	**Role of Bidder**

Form EXP - 2(a): Specific Construction Experience

Fill up one (1) form per contract.

Contract of Similar Size and Nature			
Contract No…… of…..	**Contract Identification**		
Award Date		**Completion Date**	
Role in Contract	🗀 **Contractor**	🗀 **Management Contractor**	🗀 **Subcontractor**
Total Contract Amount	🗀 **NRS ……..**		
If Partner in a JV or subcontractor, specify participation of total contract amount	**Percent of Total**	**Amount**	
Employer's Name **Address** **Telephone/Fax** **Number** **E-mail**			
Description of the similarity in accordance with Criteria 2.4.2 (a) of Section III			
Note : ***The Employer should insert here contract size, complexity, methods, technology, or other characteristics as described in Section VI - Employer's Requirement (ERQ) against which the bidder demonstrates similarity in the box on the right-hand-side.***			

Form EXP - 2(b): Specific Construction Experience in Key Activities

Fill up one (1) form per contract.

Contract with Similar Key Activities			
Contract No…… of……..	**Contract Identification**		
Award Date		**Completion Date**	
Role in Contract	🗀 **Contractor**	🗀 **Management Contractor**	🗀 **Subcontractor**
Total Contract Amount	🗀 **NRS ……..**		
If Partner in a JV or subcontractor, specify participation of total contract amount	**Percent of Total**	**Amount**	
Employer's Name **Address** **Telephone/Fax** **Number** **E-mail**			
Description of the similarity in accordance with Criteria 2.4.2 (b) of Section III			
Note : *The Employer should insert here production rate(s) for the key activity (activities) subject contract against which the bidder demonstrates in the box on the right-hand-side production rates achieved by him on previous contracts.*			

Section V - Eligible Countries

[This section contains the list of eligible countries. Select one option, either GoN Funded or DP Funded.]

- ❑ For GoN funded*:*

  For the purpose of ITB 4.2: "**all Countries"**; and

  For the purpose of Country of Origin ITB 5.1 and GCC 79.2: **"all Countries"**

- ❑ For DP funded: [**attach list as per their list of eligible countries]**

Part II : REQUIREMENTS

Section VI Employer's Requirement (ERQ)

Section VII Activity Schedule (ACS)

Section VI - Employer's Requirement (ERQ)

Contents

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I. Project Summary

Siddhababa Tunnel Project is put forwarded by Government of Nepal, Ministry of Physical Infrastructure and Transport, Department of Roads (DOR) to reduce the loss of human capital and ensuing socio-economic losses from the casualties occurring from massive scale rock-falls and landslides at the infamous *Siddhababa* stretch of Siddhartha Highway in Nepal as described in this document. To achieve this goal, the project not only aims to construct a two-lane by-pass road tunnel (approximate length of 1126 m) for serving majority of vehicles from chainage 29+100.00 to 30+050, it also aims to rehabilitate the existing road and construct a rock-shed structure over this road to prevent the residual vehicles and pedestrians plying through the improved road from rock-falls and landslides. In addition, the project has conceived the construction of rock-net structures and rock-bolts along the approach roads and other required areas to minimize the frequency, risk and hazard of rock-fall events. Including the approach roads to the tunnel (and pavement with rock-shed structure) the project area lies between chainage 28+200.00 to 30+600.00 of Siddhartha Highway, Nepal. This project is fully funded by the Government of Nepal.

To materialize the project goal, DOR is procuring this contract on Engineering, Procurement and Construction model so as to free the employer from major risks of the project itself. Having this planned at one hand, DOR has also made a provision of hands-on trainings and technology transfer to engineering professionals—from DOR staffs and engineering college students—selected by DOR in tunneling and rock-fall prevention and slope stability techniques by involvement as trainees in all stages of this project right from the beginning phase. In addition to these trainings at survey, design and construction stage, the employer shall also deploy additional dedicated team of trainees for operation and maintenance phase. The successful bidder (or the contractor thereafter) shall conduct such trainings in all phase of the project.

Employer's Requirement presented herein is prepared based on the Detailed Project Report of the project prepared by Swiss Agency for Development Cooperation (SDC) as a part of collaboration between Swiss Government and Government of Nepal. Though provided as a part of the bidding document, the bidders shall be fully aware that this document is not a complete and final document in terms of design parameters such as soil and rock-type classification and topography. It shall be the scope of works and full responsibility of a successful bidder (or the contractor thereafter) for surveying, soil-investigation and rock-mass classification, and detailed design of the project as per the requirement of Employer as described herein and elsewhere in the bidding document. The bidders shall estimate their risks associated with this project based on site situation and the conditions of contract presented in this bidding document. If anything found unclear and misrepresentative, the bidders must notify the employer and ask for clarification before bidding during the bidding process as defined in Instructions to Bidders.

II. Scope of the Project.

The works under the contract mainly include Planning, Design, Engineering, Procurement, and Construction, Commissioning and Five Years of Service Operation & Maintenance of One Double Lane Standard Highway Tunnel, Rock-shed Structure on the existing road, Rock-fall Mitigation and Road Rehabilitation Works on Engineering Procurement and Construction (EPC) basis all complete for the project area as shown in Fig. 1 below.

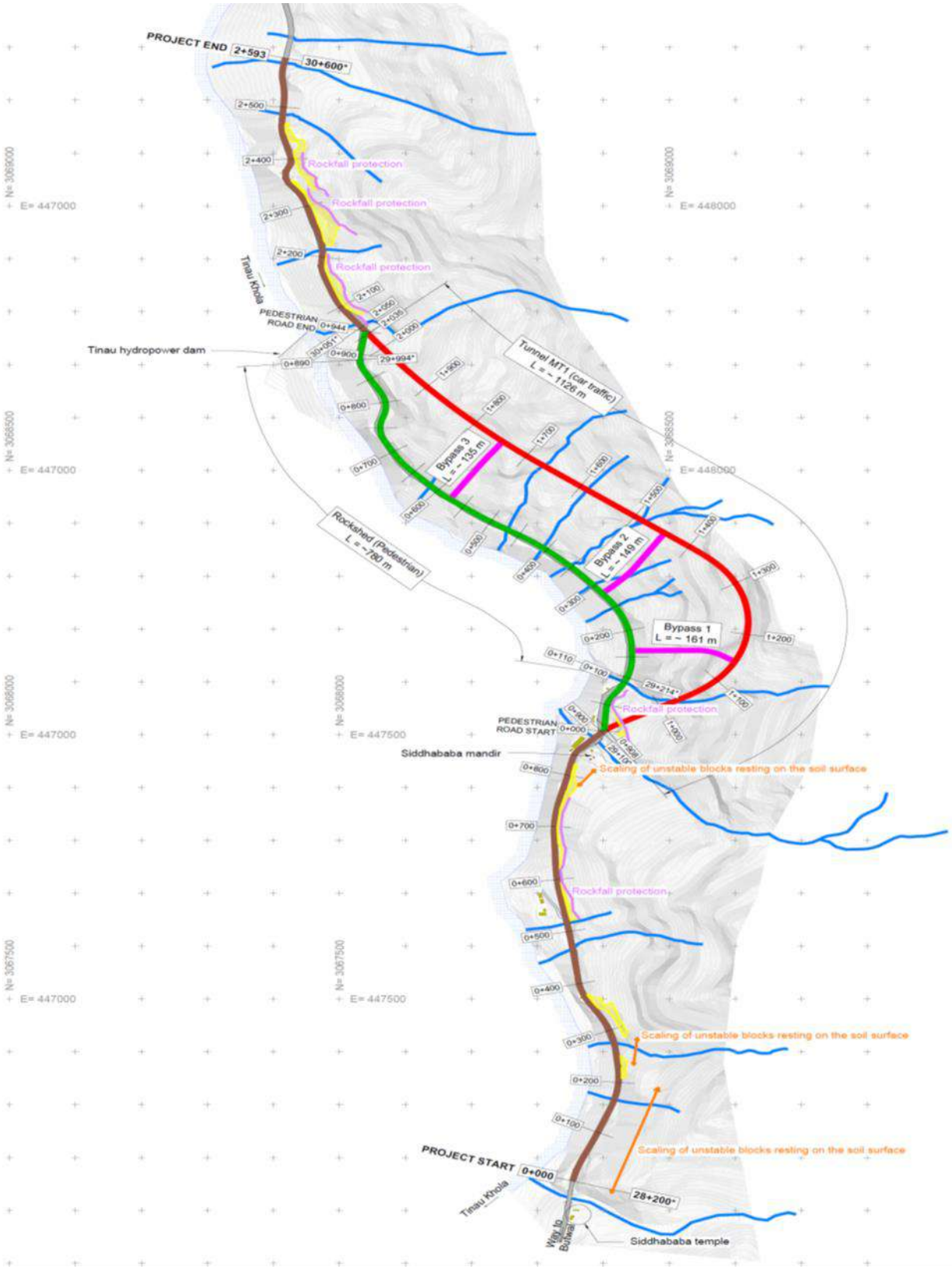

Fig. 1: General Plan View of the Project Area

The project aims at avoiding any risk related to rock-fall and slope instability throughout the high-hazard road-stretches for vehicular traffic and, at the same time, finding an attractive solution also for pedestrians and cycles. To achieve this target, this project foresees to construct a new two-lane tunnel for vehicular traffic only (one lane for each direction), along the whole high-hazard road-stretch, departing from the existing road near the Siddha Baba Mandir and reconnecting to the road near the hydropower plant, for a total length of about eleven hundred twenty-six (1126) meters. Bicycles and pedestrian traffic in addition to some vehicles that won't be allowed to pass through the tunnel shall keep on using the existing road alignment having the rehabilitated pavement surface protected along the whole high-hazard section by a rock-shed structure (with internal dimensions of five meter width and five meter height; this shall also be suitable to cater ambulance (or other emergency vehicles) in case of emergency situations.

The general plan view of the project area is shown in Fig.6. In detail, the road design foresees both the rehabilitation of the existing road, from Chainage 28+200.00 to 29+100.00 (called Main Road 1 (MR1)) and from Chainage 30+050.00 to 30+600.00, (called Main Road 2 (MR2)) and the reconfiguration of the existing road alignment to connect the new tunnel road, approximately eleven hundred twenty-six (1126) meter long, by deviating from the old alignment towards East at around the Chainage 29+100.00 and towards West at around the Chainage 30+050. In between these starting and end points of the proposed tunnel, the existing road (780 meter length) shall be provided with a rock-shed structure to protect the vehicular and pedestrian traffic that will be catered by this road; moreover, the existing pavement inside the proposed rock-shed shall be replaced with suitably designed asphalt- concrete pavement.

The newly proposed tunnel is expected to extend between Chainage 0+908.46 (south portal) and 2+034.521[1] (north portal) as measured with reference to the start point of this project; the position of the tunnel portals as shown has been chosen considering a suitable site to minimize necessary excavation, hence entering the mountain almost perpendicularly to the slope, as well as to avoid the whole high-hazard stretch. The U-shape of the tunnel horizontal alignment is chosen in order to reach as soon as possible a sufficient depth (tunnel overburden) to minimize the tunnel excavation in low overburden areas, where weaker and altered rock can be foreseen, as well as larger water ingress than usual is expected.

In addition to the newly proposed tunnel, the pre-existing alignment between Chainage 29+100 and 30+050 shall be converted into an improved road , also comprising of two emergency aprons for reversal of traffic direction in case of tunnel closure during emergency. Moreover, each apron could be used as a heliport in case of emergency. On this road, the construction of

[1] *Please note that the general absolute chainage referred to the existing Siddhartha Highway has to be abandoned for this project due to the new alignment of the tunnel road. (Refer attached Fig. 1).*

a covered road with a rock-shed has been foreseen from the Chainage around 29+214 to 29+994.

The rock-shed structure shall be connected to the emergency escape routes of the tunnel. According to tunnel safety measures (SIA 197-2[2]), three pedestrian by-passes are foreseen along the tunnel at Chainage 1+145.00, 1+445.00 and CH. 1+745.00, with a spacing of three hundred (300) meters, so that, in case of emergency, the tunnel users can evacuate in the shortest possible time from the danger zone, leading directly to a safe space within the by-pass tunnel itself, and from there to the rock-shed along the existing road.

The employer assumes that this solution provides a minimal residual risk with regards to rock-fall in the existing road, as the vehicular traffic diverted into the tunnel is completely independent from rock-fall events along the high-hazard stretches and pedestrians and the remaining volume of vehicular traffic are protected by the rock-shed structure. The tunnel allows to mitigate the risk of a traffic blockage not only in case of rock-fall events, but also for unexpected debris flow, landslides or flooding due to high level of rainfall. Moreover, the proposed tunnel provides maximum safety for pedestrian traffic, as their route is separated from the vehicular traffic in the tunnel.

Wire-mesh and rock-net shall be placed on adjacent medium-hazard and low-hazard sections, in addition to shotcreting for rock-wall stabilization and local scaling of unstable rock blocks.

During construction no complete closure of the route is allowed; hence, tunneling works shall be accomplished keeping in services the existing route. Whereas works along the existing road shall be performed keeping always at least one lane in service (alternate traffic) and, for rock-shed construction, deviating the traffic in the newly realized tunnel.

III. Project Site Description

The Siddhartha Highway (H10) is a 181 Km road that connects the Terai region in southern Nepal to the mountain region in the north. It starts from the Nepal-India Border, near Siddharthanagar, and end in Pokhara, within the Kaski district, acting as a lifeline for the western Region of the country. The Siddababa Section, currently under investigation, is a stretch of the Siddhartha highway, about 2.4 km long and extending from Ch. 28+200 and Ch. 30+600, in the Siwalik Hills. The road is located in the Palpa District of Nepal, within the Western Development Region, close to the town of Butwal.

[2] *SIA 197-2 Design of Tunnels; Road Tunnels*

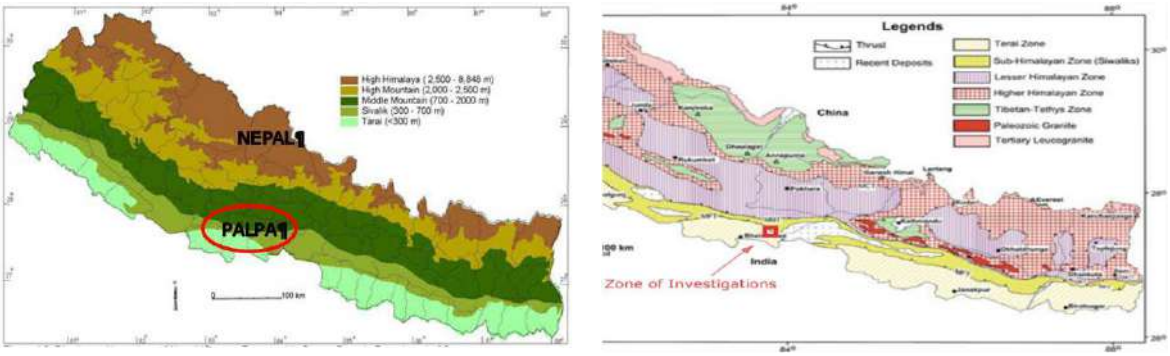

Fig.2: Nepal Physiography and Palpa District location (Source: Survey branch, Department of Survey) geological map of Nepal with project area (Dahal et al. 2008)

The Siddababa Section of this highway is particularly prone to rockfall events that caused the loss of many lives during time, due to, above all, weak geology and unfavorable inclination of rock bed with respect to the road alignment. Last rockfall events just occurred on September the 30th when a landslide triggered by rainfall obstructed the Siddababa Section, leaving hundreds of passengers stranded along the road for hours.

Every year during monsoon and dry season along the Siddhartha Highway between the Chainage of 28+200 and the Chainage of 30+600, rock falls and mud flow, as well as dry landslide problems, can be seen along the road alignment. More than twenty people have died and traffic is stopped for a long time, damage also occurs to the vehicles as well as to the road alignment every year. However, the government has planned to solve the problem of rock falls and mud flow hazards.

Fig. 3 : Rockfall events recorded during time along Siddababa highway (Gyawali et al. 2015)

The road runs between the Tinau River deep valley and the hillside slopes; area of dense vegetation alternate to steepest eroded slopes, interested by significantly higher risks of rockfall and debris flow events.

Fig. 4 : Rockfall events recorded during time along Siddababa highway (Gyawali et al. 2015)

Fig. 5 : Photographic Report – Road General Layout-Steeper and Eroded Slopes

Extended parts of the road are poorly paved, without significant ancillary systems and hydraulic structures to deal with crossing streams, causing additional risks to passengers, especially during strong rainfall and monsoon period.

Fig. 6: Nepal Physiography and Palpa District Location (Source: Survey Branch, Department of Survey)

IV. Project Components and its specific requirements

1.1 Major Features of the Project

The main features of the projects can be summarized as:

1.1.1 Road Improvements:

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

- Total road length = 2593 m (main road) + 944 m (existing road in between the proposed tunnel portals) = 3537 m; mostly two-lane road (Refer attached Fig. 1).

1.1.2 Environmental Protection Measures: Hydraulic Regimentation Measures

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

Concrete culverts of different dimensions and geometry are foreseen along the road alignment: embedded concrete pipes (internal dimension: at least from 1200mm) and rectangular section culverts (at least from 2000mm x 2000mm) are expected to be provided along the main road, while open channel with inner section 1500mm x 1500mm is expected to be placed on the top of the rock-shed structure. Two double-channel rectangular culverts are assumed to be required in the most critical area near the north and the south tunnel portal.

1.1.3 Environmental Protection Measures: Mitigation Measures for Rock-Fall (Medium and Low Risk Areas)

It is related to the three different types of measures foreseen as follows:

- Rock-net with Design Energy approximately between 3000 KJ and 5000 KJ

- Local installation of adherence wire-mesh with bolts on stable outcrops upon the road, where only superficial debris and small blocks are expected, and local stabilisation systems by shotcrete with additional rock bolts, in more fractured areas.
- Local removal of single unstable blocks that cannot be withstood by the rock-net or that are resting on thick clay layers within an outcrop that could otherwise get unstable because of gradual washout of clay during monsoon season.

1.1.4 Road Tunnel and Rock-Shed for Rock-fall (High-Risk Areas)

It is related to the construction of the road tunnel and the three emergency escape routes foreseen along its alignment with a maximum distance lower than required 300 m. The tunnel cross-section shall be in accordance to European and Swiss tunnel guidelines, in order to house a carriageway width of 7.5 m, sideways on both side with minimum width of 1.0 m and all necessary hydraulic systems and operational and safety equipment. The operational traffic space considered for design shall include not only the necessary space for passing vehicles and trucks (height up to 4.75 m), but also standard space for signaling, upon the carriageway and on both sides, and for safety margins defined in the guidelines mentioned in the Employer's Requirement.

Additionally, the tunnel shall also provide two utility ducts of clear dimensions 1.2 m width and 0.7 m depth at appropriate location of cross-section. This shall be utilized to house water supply pipelines and other utility that should be relocated.

Tunnel design shall also include all the equipment and systems needed for the structure to be operational, as per the requirement set out in Employers Requirement such as:

- -Tunnel Works:
- Total Tunnel length (main tunnel) = 1126 m, Typical section = 110 m^2
- By-pass tunnel (3 Numbers) = 431 m (By-pass 1 = 155 m, By-pass 2 = 145 m, By-pass 3 = 131 m)
- Two technical Buildings; at northern and southern portal
- Required permanent infrastructure (physical and electro-mechanical all complete) for energy supply in the tunnel including the energy supply for five years of operation stage.
    i. Medium voltage power supply from the national grid to south portal.
    ii. Low-voltage power supply of all tunnel plants from medium-voltage cells, including UPS power supply
- Lighting, including sensors.
- Ventilation, including sensors.

- Signage
- Surveillance system(video-surveillance, fire detection)
- Control system communication network, radio system, emergency telephone system
- Cabling system (earthing, fibre-optic cabling, copper cablings)
- Auxiliary systems (electrical and heating/air-conditioning systems in buildings, telephone systems, gates, doors, double floors, pumping stations)
- Control room
- Rock-shed structure for rock-fall high-risk areas including all works related to the construction of the cast-in-situ concrete structure characterized by a reinforced concrete slab covered with a cushion layer. Main characteristics of the rock shed are:

    i. Inner dimensions: Breadth x Height = 5.0 m x 5.0 m, with a length of about L = 780 m;
    ii. Cushion material, made of Lecca 0-30 (or similar) with an approximate cushion-depth of at least two (2) meter on the top slab of the shed, to protect the structure from falling rocks;
    iii. Appropriately chosen roof grade to provide drainage of the cushion material and allow falling rocks rolling over the rock-shed roof.

    Note: **The dimensions mentioned above supersedes the dimensions mentioned in any other documents**.

1.1.5 Relocation of Utilities

Existing water-supply pipelines shall be relocated into the utility ducts that shall be provided in the tunnel; additionally, electricity lines shall be appropriately relocated as per standards of Department of Roads and Nepal Electricity Authority. Any other utilities existing in the project area that will be in conflict with project activities shall also be appropriately relocated.

While relocating the utilities, the existing reusable property (for example the existing water-supply pipelines) shall be safely removed to minimize the damages. These properties shall be handed over to the employer.

1.1.6 Tunnel Operation and Maintenance

The basic prerequisite for tunnel operation and Maintenance are listed as;

- In this project the use of Swiss and European standards and directives has to be assumed concerning the characteristics of the tunnel facilities in relation to safety and operation.

- For electrical installations of buildings, as for low voltage electrical distribution, a generic solution has to be defined; in the execution phase, the Contractor will have to consider the application of the Nepalese regulations, where present, in this specific field.

- The installations are designed to be serviced at least once a year by specialized personnel. The correct maintenance frequency however depends on the characteristics of the individual plant and shall be defined by the contractor.

- The systems designed shall ensure automatic routines to guarantee the safety of the tunnel users. Nevertheless, the project assumes that the gallery is monitored and managed continuously (7 days a week, 24 hours a day) by at least two operators in the control room in the technical building at the south portal of the tunnel. In fact, in case of an emergency event such as a fire in the tunnel, only trained operators present on site, can ensure adequate treatment of emergencies. It has been assumed that these operators will interface with the rescue services, such as the police, firefighters and rescuers, for the operational management of the events.

- The project assumes that a regulation (tunnel safety documentation) will be provided by the Contractor that specifies the minimum operating conditions of the plants under which the tunnel can remain open and therefore, consequently, in correspondence with which plant faults the tunnel must be closed. Operation of the tunnel in the absence of adequate operating conditions of the plants (e.g. lack of ventilation, lack of fire detection, lack of electricity supply, and similar) exposes users to risk, can facilitate the occurrence of accidents and prevents the possibility of saving users.

- A general principle regarding all the elements forming the exploitation and safety systems is that they must be installed in cabinets or enclosures that allow protection against rain, dust, humidity, solar radiation, aggressive atmosphere, etc. Exceptions to this principle are the elements which, due to the function they perform, must be in direct contact with the field (traffic signs, sensors, cables, lamps, etc.).

- It is the task of the Contractor to define the functioning (algorithms) of the ventilation in the normal case (sanitary ventilation) and in the event of a fire (operation of the system in the various fire scenarios in the tunnel). The definition of these algorithms is essential for the safety of tunnel users in the event of a fire.

- Once the ventilation system has been defined and installed, the Contractor must provide for real operational tests, even simulating the event of a fire, involving the emergency services such as fire brigades, police, rescuers, etc.

- The closure of the tunnel in case of danger (accident, fire) is a critical event and must be informed in such a way that it is well understood by road users.

- In Nepal Road Standard 2070, there is no indication of the transition times for traffic lights (changeover to red, stop of the traffic-flow). Therefore, appropriate transition time shall be suggested by the contractor. It is imperative for the implementation phase that the contractor checks again with the competent authorities what the image transitions (switching from off/green to red and vice versa) of the traffic lights should be in order for the tunnel closure event to be clearly and unmistakably understood by road users.

- In this project, a sixty-month warranty operation and maintenance period must be assumed. As far as the exploitation end safety equipment are concerned, regular maintenance must be ensured at least annually, aimed both at repairing faults and preventing future potential problems. It should be noted that for some faults (power supply, ventilation, SCADA, etc.) it may be necessary to carry out immediate maintenance or in any case within a few hours, to allow the continuation of the tunnel operation. To this end it must be trained by specialized personnel, who must guarantee their availability continuously (i.e. seven days a week, twenty-four hours a day).

V. Design Criteria and Design Restrictions

Please refer Technical Requirements And Technical Specifications for Design Criteria And Design Restrictions.

VI. Reference Specification and Codes for Design

Please refer Technical Requirements And Technical Specifications for Reference Specification and Codes for Design

VII. Requirement of Design Reports

Please refer Technical Requirements And Technical Specifications for Requirement of Design Reports

VIII. List of Drawings

Please refer attached Drawings in Annex H.

IX. Design and drawing approval from employers

The employer shall approve design and drawing after checking and recommendations from the Employers representative/ consultants.

X. Specification of Works

Please refer Technical Requirements And Technical Specifications for Specification Of Works.

XI. Major Construction Output including milestone

The major construction output including milestone has been set as follows.

S.N	Description of Milestones	Time for Completion
1	Mobilization, Preliminary and Submission of Detail Design of Tunnel including Ventilation and Lighting, Pedestrian Rock Shed, Road Improvement Works with all ancillary Structures.	9 months from the date of commencement
2	Completion of the Tunnel Civil Works	30 months from the date of commencement
3	Completion of Tunnel Exploitation and Safety Equipment Works, Ventilation Works	42 months from the date of commencement
4	Completion of Rock Shed, Completion of Road Works, Retaining wall, Rock Fall barriers, Slope Projection Works all Complete and Demobilization	60 months from the date of commencement.

XII. Warranty, Operation and maintenance period and modality.

Please refer Technical Requirements And Technical Specifications for Warranty, Operation And Maintenance Period And Modality.

XIII. List of Tests during Construction Stage and/on Completion and Governing Codes/References

Please refer Technical Requirements And Technical Specifications for List of Tests During Construction Stage And/On Completion And Governing Codes/Refereces.

XIV. List of Tests after Completion and Governing Codes/References

Please refer Technical Requirements And Technical Specifications for List of Tests After Completion And Governing Codes/Refereces.

XV. List of Tests during Operation and Maintenance

The contractor shall submit the list of tests and operation and maintenance in accordance with the approved design, Operation and Maintenance manual.

Section VII - Activity Schedule (ACS)

Contract ID :

IFB No. :

1.1 The bid price for the contract is NRS …… ……. (in Figures) ……..
……..(in Words). [*To be fulfilled by the bidder as Lumpsum*]
[It is assigned for different activities as follows.]

S. No.	DESCRIPTION OF ACTIVITY	PERCENTAGE OF BID PRICE
1		***% of the Contract Price
2		***% of the Contract Price
3		***% of the Contract Price
4		***% of the Contract Price
	Total bid price	100% of the contract price

1.2 Weightage of the bid price for different stages of the contract shall be as specified below.

SN OF ACTIVITY	DESCRIPTION OF ACTIVITY	WEIGHTAGE IN PERCENTAGE TO THE BID PRICE	STAGE FOR PAYMENT	PERCENTAGE WEIGHTAGE	PAYMENT PROCEDURE
1					

Note:

(a) For Table 1.1, The employer shall categorize the activity of the whole project depending on the nature of the project and assign the percentage of the bid price. The number of activities shall generally be 4-7.

(b) Based on the activities categorized in (a), the employer shall mention the detailed weightage of the bid price and percentage assigned to different stage to make acquittance to the bidder for payment.

(c) The employer shall prepare the Table 1.2 as elaborative as possible in line with the milestone mentioned in section VI Employers' requirements to facilitate the payment procedure according to the progress of the work as per the milestone and mention the tests needed before payment to assure the quality of the work according to the specification.The Employer shall make arrangements for quality control by conducting test and checking the measurement of the work completed by the contractor.

Section VII-Activity Schedule (ACS)

Contract ID : DOR_QRDC/EPC/ICB/STP/077/78-05

IFB No: IFB-2077-78-10

1.1 The bid price for the contract is NRS …… ……. (in Figures)
…….. ……..(in Words).

S.No.	Description of Activity	Employers Proposed Range	Bidder's Proposed percentage
F	Provision Sums (NRs.)	686,197,980.32	-
A	General Items	6 to 8	X1
B	Tunnel Construction Works	60 to 65	X2
C	Approach Road Rehabilitation and Slope ProtectionWorks	12 to 15	X3
D	Rock Shed Construction and Slope Protection Works	14 to 16	X4
E	Operation and Maintenance of Tunnel, Rock Shed and Approach Road	1 to 3	X5
	Total bid price without PS		100.00

Note: The values of Bidder's Proposed Percentage (X1 - X5) shall be filled by Contractor

Contract ID : DOR_QRDC/EPC/ICB/STP/077/78-05
IFB No: IFB-2077-78-10

1.2 Weightage of the bid price for different stages of the contract shall be as specified below.

	S.N OF ACITIVITY	DESCRIPTION OF ACITIVITY	WEIGHTAGE PECENTAGE TO THE BID PRICE	STAGE FOR PAYMENT	PERCENTAGE WEIGHTAGE	PAYMENT PROCEDURE
	A	**General Items**	**X1**			
	A.1	Insurance for the loss of damage to Works, Plants, Materials, Equipment's, Property and Personnel Injury or Death, Property Insurance of Completed works, expenses for all other necessary fees, bank commission fees etc. and as specified in Employer's Requirements (Technical Requirement and Technical Specification)		A.1.1 Submission of Insurance Policy and Proof of premium Payment for events under Contractors risk as per Condition of Contract Clause No. 23	10% of X1	30% upon submission of Insurance Policy and Evidence of Premium Payment
						20 % upon commencement of Tunnel Construction Works
				A.1.2 Submission of Property Insurance Policies and Proof of Premium Payment ofor the Completed Work as per Condition of Contract Clause No. 23		30% upon submission of Insurance Policy and Evidence of Premium Payment
						20 % upon Submission of Final Account
	A.2	Mobilization, Detail Engineering Survey & Analyzing Geological/ Geo-Physical/ Topographic Survey/Drone Survey/ Geo-mechanical survey /Hydrology and all other required investigations and Design of Tunnel, Approach Road, River Training and Slope protection Works and Preparation of Working Drawings and Other necessary documents including Preparing & Submitting the Environmental Impact Assessment of Siddababa Tunnel Project including the Environmental Management		A.2.1 Mobilization as per Employers Requirement	57% of X1	20% upon mobilization
				A.2.2 Completion of Detail Engineering Survey and Investigations		30 % upon submission and Completion of Detail Engineering Survey and Investigation Reports
				A.2.3 Submission and Approval of Detail Design and Drawings		20% upon submission and approval of Detail Design and Working Drawings
				A.2.4 Submission and approval of Scoping Document and Terms of Reference for EIA as per EPA 2053 and EPR 2054		5% upon approval of Scoping and TOR

Contract ID : DOR_QRDC/EPC/ICB/STP/077/78-05
IFB No: IFB-2077-78-10

1.2 Weightage of the bid price for different stages of the contract shall be as specified below.

	S.N OF ACITIVITY	DESCRIPTION OF ACITIVITY	WEIGHTAGE PECENTAGE TO THE BID PRICE	STAGE FOR PAYMENT	PERCENTAGE WEIGHTAGE	PAYMENT PROCEDURE
		Action plan all complete & get it approved from the concerned authority as per EPA 2053 & EPR 2054 and implementing and Demobilization as indicated as specified in Employer's Requirements (Technical Requirement and Technical Specification) and as instructed by the Engineer.		A.2.5 Approval of EIA for the Project		5% upon approval of EIA
				A.2.6 Demobilization as per Employers Requirement		20% upon commission and completion of Works.
	A.3	Erection of 11 Kv High Tension Transmission Line from Butwal Golpark to Palpa Siddhababa Mandir, South Portal all complete, Construction Power during Construction of Main Tunnel, By pass Tunnel, Rockshed, Approach Roads and Slope Stabilization Works as specided in Employers Requirement (Technical Requirement and Technical Specifcation) and as instructed by the Engineer		A.3.1 Erection of 11 Kv High Tension Transmission Line from Butwal Golpark to Palpa Siddhababa Mandir, South Portal all complete,	33% of X1	10% upon completion of the works
				A.3.2 Construction Power during Construction of Main Tunnel, By pass Tunnel, Rockshed, Approach Roads and Slope Stabilization Works as specided in Employers Requirement (Technical Requirement and Technical Specifcation) and as instructed by the Engineer		90 % Payment shall be made on pro rata basis of the achieved progress
		Total			100.00	
	B.	**Tunnel Construction Works**	**X2**			
		Construction and Quality Control of Portals (North Portal and South Portal) for main Tunnel and Bypass Tunnel including Control Terminal Buildings construction at South and North Portals all complete with HVAC(Heating,Ventilation and Air Conditioning) Plants, providing and		B.4.1 Excavation and Quality control of South Portal all complete including excavation as approved design and as instructed by engineer.		5% Payment shall be made on completion of each stage of a tunnel portal as per the weightage given in the approved design.
				B.4.2 Completion of Cut and Cover Works of South Portal		21% Payment shall be made on completion of each stage of a tunnel portal as per the weightage given in the approved design.

Contract ID : DOR_QRDC/EPC/ICB/STP/077/78-05
IFB No: IFB-2077-78-10

1.2 Weightage of the bid price for different stages of the contract shall be as specified below.

	S.N OF ACITIVITY	DESCRIPTION OF ACITIVITY	WEIGHTAGE PECENTAGE TO THE BID PRICE	STAGE FOR PAYMENT	PERCENTAGE WEIGHTAGE	PAYMENT PROCEDURE
	B.1	installing fire emergency and extinguishing system as per approved design and all complete as specified in Employer's Requirements (Technical Requirement and Technical Specification) and as instructed by the Engineer.		B.4.3 Completion of Final Landscaping Works of South Portal	9% of X2	6 % Payment shall be made on completion of each stage of a tunnel portal as per the weightage given in the approved design.
				B.4.4 Construction of Control Terminal Building at South Portal all complete with HVAC (Heating, Ventilation and Air Conditioning) Plant, Providing and installation of fire emergency and extinguishing system as per approved design all complete and as instructed by Engineer		23% Payment shall be made on completion of a control building all complete at south portal.
				B.4.5 Excavation and Quality Control of North Portal all complete including excavation as per approved design and as instructed by Engineer		4% Payment shall be made on completion of each stage of a tunnel portal as per the weightage given in the approved design.
				B.4.6 Completion of Cut and Cover Works of North Portal		16% Payment shall be made on completion of each stage of a tunnel portal as per the weightage given in the approved design.
				B.4.7 Completion of Final Landscaping Works of North Portal		5 % Payment shall be made on completion of each stage of a tunnel portal as per the weightage given in the approved design.
				B.4.8 Construction of Control Terminal Building at North Portal all complete with HVAC (Heating, Ventilation and Air Conditioning) Plant, Providing and installation of fire emergency and extinguishing system as per approved design all complete and as instructed by Engineer		20% Payment shall be made on completion of a North Portal all complete.

Contract ID : DOR_QRDC/EPC/ICB/STP/077/78-05
IFB No: IFB-2077-78-10

1.2 Weightage of the bid price for different stages of the contract shall be as specified below.

	S.N OF ACITIVITY	DESCRIPTION OF ACITIVITY	WEIGHTAGE PECENTAGE TO THE BID PRICE	STAGE FOR PAYMENT	PERCENTAGE WEIGHTAGE	PAYMENT PROCEDURE
	B.2	Construction and Quality Control of Main Tunnel of Siddababa Tunnel Project including Excavation, shotcrete for face stabilization, Fiber reinforced shotcrete, Self Drilling Anchor, Lining, Necessary Support System, Steel Fore poling, Granular filling etc. Including pavement works, signaling, water proofing and drainage construction as per approved design all complete as specified in Employer's Requirements and as instructed by Engineer (Technical Requirement and Technical Specification)		B.1.1 Main Tunnel Construction including excavation, shotcrete for face stablization, fiber reinforced concrete, self drilling achor, necessary support system, Steel Forepoling, Grannular Fillings and muck disposal as per Employer Requriment and as instructed by Engineer	80% of X2	60% Payment shall be made on pro rata basis with respect to the total linear length of the tunnel
				B.1.2 Tunnel Lining, Water Proofing and Drainage Construction all complete as per Employers Requirement and as instructed by Enginner		33% Payment shall be made on pro rata basis with respect to the total linear length of the tunnel
				B.1.3 Tunnel Pavement and Signalling Works		7% Payment shall be made on pro rata basis with respect to the total linear length of the tunnel
	B.3	Construction and Quality Control of By Pass Tunnel of Siddababa Tunnel Project including Excavation, shotcrete for face stabilization, Fiber reinforced shotcrete, Self Drilling Anchor, Lining, Necessary Support System, Steel Fore poling, Granular filling etc. Including pavement works, signaling,water proofing and drainage construction all complete as specified in Employer's Requirements (Technical Requirement and Technical Specification) and as instructed by the Engineer		B.2.1 Bypass Tunnel Construction including excavation, shotcrete for face stablization, fiber reinforced concrete, self drilling achor, necessary support system, Steel Forepoling, Grannular Fillings and muck disposal as per Employer Requriment and as instructed by Engineer	7% of X2	60% Payment shall be made on pro rata basis with respect to the total linear length of the tunnel
				B.2.2 Tunnel Lining, Water Proofing and Drainage Construction all complete as per Employers Requirement and as instructed by Enginner		33% Payment shall be made on pro rata basis with respect to the total linear length of the tunnel
				B.2.3 Tunnel Pavement and Signalling W		7% Payment shall be made on pro rata basis with respect to the total linear length of the tunnel

Contract ID : DOR_QRDC/EPC/ICB/STP/077/78-05
IFB No: IFB-2077-78-10

1.2 Weightage of the bid price for different stages of the contract shall be as specified below.

	S.N OF ACITIVITY	DESCRIPTION OF ACITIVITY	WEIGHTAGE PECENTAGE TO THE BID PRICE	STAGE FOR PAYMENT	PERCENTAGE WEIGHTAGE	PAYMENT PROCEDURE
	B.4	Supplying and Installing the Electro-Mechanical System by providing energy supply, lighting, ventillation, engress tunnel ventilation, signage, detection, communication & control system, tunnel fire detection system, videosurvilliance system, communication network, tunnel control system, radio diffusion in tunnel, emergency telephone system, cabling system including secondary installations, etc.. for main tunnel and Bypass tunnel as per approved design all complete as specified in Employer's Requirements (Technical Requirement and Technical Specification) and as instructed by the Engineer.		B.3.1 Supply of Electro Mechanical System	4% of X2	40% on Supply of the Electro Mechanical System as per the recommendation of the Enginner
						30% upon installation and successful operation of primary and secondary Electro Mechanical all Systems after successful testing.
				B.3.2 Installation and Successful Operation of primary and secondary Electro Mehcanical System		30 % at the end of Operation and Maintenance Period
		Total			100	
	C	**Approach Road Rehabilitation and Slope ProtectionWorks**	**X3**			

Contract ID : DOR_QRDC/EPC/ICB/STP/077/78-05
IFB No: IFB-2077-78-10

1.2 Weightage of the bid price for different stages of the contract shall be as specified below.

	S.N OF ACITIVITY	DESCRIPTION OF ACITIVITY	WEIGHTAGE PECENTAGE TO THE BID PRICE	STAGE FOR PAYMENT	PERCENTAGE WEIGHTAGE	PAYMENT PROCEDURE
	C1.	Construction and Quality Control of Road alignment of Approach Road South stretch from Ch 28+200 km to 29+104.55 km and North stretch from chainage Ch 30+050 km to 30+609 km, including Excavation, Embankment Filling, Side drain, Reinforced Concrete Wall, Pavement Works, Signaling, Culverts and minor bridges etc.. along the Siddhartha highway (NH47) as per approved design all complete as specified in Employer's Requirements and as instructed by Engineer(Technical Requirement and Technical Specification)		Construction and Quality Control of Road alignment of Approach Road South stretch from Ch 28+200 km to 29+104.55 km and North stretch from chainage Ch 30+050 km to 30+609 km, including Excavation, Embankment Filling, Side drain, Reinforced Concrete Wall, Pavement Works, Signaling, Culverts and minor bridges etc.. along the Siddhartha highway (NH47) as per approved design all complete as specified in Employer's Requirements and as instructed by Engineer(Technical Requirement and Technical Specification)	25% of X3	60% & 40% Payment shall be made on completion of South Approach Road and North Approach Road respectively all complete..
	C2.	Construction and Quality Control of Rockfall Protection Measures (Rock Nets, Rock Fall Barriers, anchoring etc) and Scaling of unsuitable blocks resting on the soil surface as per approved design all complete as specified in Employer's Requirements (Technical Requirement and Technical Specification) and as instructed by Engineer		Construction and Quality Control of Rockfall Protection Measures (Rock Nets, Rock Fall Barriers, anchoring etc) and Scaling of unsuitable blocks resting on the soil surface as per approved design all complete as specified in Employer's Requirements (Technical Requirement and Technical Specification) and as instructed by Engineer	75% of X3	5% Payment shall be made on completion of scaling of unstable blocks resting on soil surface, 70% payment shall be made on the completion of Rocknet, on pro rata basis per square basis and 25% payment shall be made on completion of Rockfall barrier, on pro rata basis per square meter.
		Total			100	

Contract ID : DOR_QRDC/EPC/ICB/STP/077/78-05
IFB No: IFB-2077-78-10

1.2 Weightage of the bid price for different stages of the contract shall be as specified below.

	S.N OF ACITIVITY	DESCRIPTION OF ACITIVITY	WEIGHTAGE PECENTAGE TO THE BID PRICE	STAGE FOR PAYMENT	PERCENTAGE WEIGHTAGE	PAYMENT PROCEDURE
	D.	**Rock Shed Construction and Slope Protection Works**	**X4**			
	D.1	Construction and Quality Control of Pedestrian RockShed including rock excavation, hydraulic works (cross drainage and water management) of Siddhababa Tunnel Project, Pavement Works including bituminous Macadam, Penetration Macadam and Asphalt wearing course as per approved design and as specified in Employer's Requirements (Technical Requirement and Technical Specification) and as instructed by the Engineer		D.1.1 Construction and Quality Control of Pedestrian RockShed including rock excavation, hydraulic works (cross drainage and water management) as specified in Employers Requirement and as instructed by Engineer	84% of X4	87% Payment shall be made on pro rata basis with respect to the total linear length of the rock shed
				D.1.2 Construction and Quality Control of Pavement Works including Bituminous Macamdam, Penetration Macadam and Asphalt Wearing Course as specified in Employers Requirement and as instructed by Engineer		13% Payment shall be made on pro rata basis with respect to the total linear length of the rock shed
	D2.	Construction and Quality Control of Reinforced wall construction including anchoring, weep holes, Slope Protection Works as per approved design all complete and as specified in Employer's Requirements (Technical Requirement and Technical Specification) and as instructed by the Engineer		Construction and Quality Control of Reinforced wall construction including anchoring, weep holes, Slope Protection Works as per approved design all complete and as specified in Employer's Requirements (Technical Requirement and Technical Specification) and as instructed by the Engineer	16% of X4	100% Payment shall be made on completion of each stage of a tunnel portal as per the weightage given in the approved design.
		Total			100	
	E.	Operation and Maintenance of Tunnel, Rock Shed and Approach Road	**X5**			

Contract ID : DOR_QRDC/EPC/ICB/STP/077/78-05
IFB No: IFB-2077-78-10

1.2 Weightage of the bid price for different stages of the contract shall be as specified below.

	S.N OF ACITIVITY	DESCRIPTION OF ACITIVITY	WEIGHTAGE PECENTAGE TO THE BID PRICE	STAGE FOR PAYMENT	PERCENTAGE WEIGHTAGE	PAYMENT PROCEDURE
	E1.	Operation and Maintenance Cost of Siddhababa Tunnel Project for Five year of time period all complete as specified in Employer's Requirements and as instructed by Engineer (Technical Requirement and Technical Specification)		Operation and Maintenance Cost of Siddhababa Tunnel Project for Five year of time period all complete as specified in Employer's Requirements and as instructed by Engineer (Technical Requirement and Technical Specification)	49% of X5	100% Payment shall be made on monthly basis
	E2.	Technology Transfer (International and National Training) as specified in Employer's Requirements and as instructed by Engineer(Technical Requirement and Technical Specification)		E.2.1 Internatinal Training	51% of X5	30% upon completion of International Training as instructed by Engineer
				E.2.2 National Training		10 % for each Training for total number of training of 7(seven) upon completion of each session of National Training as instructed by Engineer.
		Total			100	

Section VIII: General Conditions of Contract

Quality Research and Development Center

Chakupat, Lalitpur

Planning, Design, Engineering, Procurement, Construction, Commissioning and Five Years of Service Operation & Maintenance of One Double Lane Standard Highway Tunnel, Rock shed Structure, Rock Fall Mitigation and Road Works of Siddababa Tunnel Project on Engineering Procurement Construction (EPC) basis all complete;

Contract No.: DOR_QRDC/EPC/ICB/STP/077/78-05

Table of Clauses

General Conditions of Contract	
Clause	**Details**
General	
1. Definitions	1.1 Boldface type is used to identify defined terms. a) **Accepted Contract Amount** means the amount accepted in the Letter of Acceptance for the execution and completion of the Works and the remedying of any defects. b) **Activity Schedule** is a schedule of the activities comprising the construction, installation, testing, and commissioning of the Works in a lump sum contract. It includes a lump sum price for each activity, which is used for valuations and for assessing the effects of Variations and Compensation Events. c) **Base Date** means the date 30 days prior to the latest date for submission of the Tender. d) **Compensation Events** are those defined in GCC 35.4 hereunder. e) **Completion Date** is the date of completion of the Works as certified by the Employer. f) **Contract** is the Contract between the Employer and the Contractor to design, execute, complete, and maintain the Works. It consists of the documents listed in GCC 2.3 below. g) **Contractor** is the party whose Bid to carry out the Works has been accepted by the Employer. h) **Contractor's Representative** means the person named by the Contractor in the Contract or appointed from time to time by the Contractor under Clause 12. [Contractor's Representative], who acts on behalf of the Contractor. i) **Contractor's Personnel** means the Contractor's Representative and all personnel whom the Contractor utilises on Site, who may include the staff, labour and other employees of the Contractor and of each Subcontractor; and any other personnel assisting the Contractor in the execution of the Works. j) **Contractor's Documents** means the calculations, computer programs and other software, drawings, manuals, models and other documents of a technical nature supplied by the Contractor under the Contract; k) **Contractor's Bid** is the completed bidding document submitted by the Contractor to the Employer. l) **Contract Price** is the Accepted Contract Amount stated in the Letter of Acceptance and thereafter as adjusted in accordance with the Contract. m) **Commencement Date** is given i**n the SCC**. It is the latest date when the Contractor shall commence execution of the

	Design and Works. It does not necessarily coincide with any of the Site Possession Dates. n) **Days** are calendar days; months are calendar-months. o) **Dayworks** are varied work inputs subject to payment on a time basis for the Contractor's employees and Equipment, in addition to payments for associated Materials and Plant. p) **Defect** is any part of the Works not completed in accordance with the Contract. q) **Defects Liability Certificate** is the certificate issued by Employer upon correction of defects by the Contractor. r) **Defects Liability Period** is the period calculated from the Completion Date where the Contractor remains responsible for remedying defects. s) **Drawings** include calculations and other information provided or approved by the Employer for the execution of the Contract. t) **Employer** is the party who employs the Contractor to carry out the Works, as **specified in the SCC**. u) **Employer's Representative** means the person named by the Employer in the Contract or appointed from time to time by the Employer under Clause 13. [The Employer's Representative], who acts on behalf of the Employer. v) **Employer's Personnel** means the Employer's Representative, the assistants referred to in Clause 13.5 and all other staff, labour and other employees of the Employer's Representative, and any other personnel notified to the Contractor, by the Employer or the Employer's Representative, as Employer's Personnel w) **Equipment** is the Contractor's machinery and vehicles brought temporarily to the Site to construct the Works. x) **Force Majeure** means an exceptional event or circumstance: which is beyond a Party's control; which such Party could not reasonably have provided against before entering into the Contract; which, having arisen, such Party could not reasonably have avoided or overcome; and, which is not substantially attributable to the other Party. y) **Initial Contract Price** is the Contract Price listed in the Employer's Letter of Acceptance. z) **Intended Completion Date** is the date on which it is intended that the Contractor shall complete the Works. The Intended Completion Date is **specified in the SCC**. The Intended Completion Date may be revised only by the Employer by issuing an extension of time or an acceleration order. aa) **Letter of Acceptance** means the formal acceptance by the Employer of the Bid and denotes the formation of the contract at the date of acceptance. bb) **Materials** are all supplies, including consumables, used by the

	Contractor for incorporation in the Works. cc) **Party** means the Employer or the Contractor, as the context requires. dd) **SCC** means Special Conditions of Contract ee) **Plant** is any integral part of the Works that shall have a mechanical, electrical, chemical, or biological function. ff) **Employer** is the person **named in the SCC** (or any other competent person appointed by the Employer and notified to the Contractor, to act in replacement of the Employer) who is responsible for supervising the execution of the Works and administering the Contract. gg) **Retention Money** means the aggregate of all monies retained by the Employer pursuant to GCC 60.1 hh) **Schedules** means the document(s) entitled schedules, completed by the Contractor and submitted with the Letter of Bids, as included in the Contract. Such document may include the Bill of Quantities, data, lists, and schedules of rates and/or prices. ii) **Site** means the places **specified in the SCC** where the Permanent Works are to be executed and to which Plant and Materials are to be delivered, and any other places as may be specified in the Contract as forming part of the Site. jj) **Site Investigation Reports** are those that were included in the bidding documents and are factual and interpretative reports about the surface and subsurface conditions at the Site. kk) **Specification** means the Specification of the Works included in the Contract and any modification or addition made or approved by the Employer. ll) **Subcontractor** is a person or corporate body who has a Contract with the Contractor to carry out a part of the work in the Contract, which includes work on the Site. mm) **Temporary Works** are works designed, constructed, installed, and removed by the Contractor that are needed for construction or installation of the Works. nn) **Tests on Completion** means the tests which are specified in the Contract or agreed by both Parties or instructed as a Variation, and which are carried out before the Works are taken over by the Employer. oo) **Tests after Completion** means the tests (if any) which are specified in the Contract which are carried out after the Works are taken over by the Employer. pp) **Variation** is an instruction given by the Employer which varies the Works qq) **Works** are what the Contract requires the Contractor to plan, conduct engineering study, design, construct, install, operate and maintain and finally turn over to the Employer, as **defined in the SCC**. rr) **Operation and Maintenance Period** is the period from the end

	of Defect Liability Period where the contractors remain responsible for operation and performance based maintenance of the works.
2. Interpretation	2.1 In the Contract, except where the context requires otherwise: (a) words indicating one gender include all genders; (b) words indicating the singular also include the plural and words indicating the plural also include the singular; (c)provisions including the word "agree", "agreed" or "agreement" require the agreement to be recorded in writing, and (d) "written" or "in writing" means hand-written, type-written, printed or electronically made, and resulting in a permanent record. The marginal words and other headings shall not be taken into consideration in the interpretation of these Conditions 2.2 If sectional completion, referred as milestone is **specified in the SCC**, references in the GCC to the Works, the Completion Date, and the Intended Completion Date apply to any Section of the Works (other than references to the Completion Date and Intended Completion Date for the whole of the Works). 2.3 The documents forming the Contract shall be interpreted in the following order of priority: (a) Contract Agreement, (b) Letter of Acceptance, (c) Letters of Technical Bid and Price Bid, (d) Special Conditions of Contract, (e) General Conditions of Contract, (f) Employer's Requirements, (g) Activity Schedules, and (h) Any other document **listed in the SCC** as forming part of the Contract. 2.4 If an ambiguity or discrepancy in the contract document is found, the priority shall be such as may be accorded by the governing law

3. Law and Language	3.1 The law governing the Contract is **stated in the SCC**. 3.2 Throughout the execution of the Contract, the Contractor shall comply with the import of goods and services prohibitions in the Employer's country when by an act of compliance with a decision of the United Nations Security Council taken under Chapter VII of the Charter of the United Nations, the Borrower's Country prohibits any import of goods from, or any payments to, a particular country, person, or entity. Where the borrower's country prohibits payments to a particular firm or for particular goods by such an act of compliance, that firm may be excluded 3.3.As between the Parties, the Employer shall retain the copyright and other Employer's intellectual property rights in the Employer's Requirements and other documents made by (or on behalf of) the Employer. The Contractor may, at his cost, copy, use, and obtain communication of these documents for the purposes of the Contract. They shall not, without the Employer's consent, be copied, used or communicated to a third party by the Contractor, except as necessary for the purposes of the Contract 3.4.The language for communications shall be that stated **in the SCC**. If no language is stated there, the language for communications shall be the language in which the Contract (or most of it) is written. If there are versions of any part of the Contract which are written in more than one language, the version which is in the ruling **language stated in the SCC** shall prevail.
4. Contract Agreement	4.1 The Contract shall come into full force and effect on the date stated in the Contract Agreement. 4.2 Without altering the basic nature or scope of work, the agreement may be revised upon mutual written consent as per prevailing Public Procurement Law 4.3 The Contractor shall design, execute and complete the Works in accordance with the Contract, and shall remedy any defects in the Works. When completed, the Works shall be fit for the purposes for which the Works are intended as defined in the Contract. 4.4 The Contractor shall provide the Plant and Contractor's Documents specified in the Contract, and all Contractor's Personnel, Goods, consumables and other things and services, whether of a temporary or permanent nature, required in and for this design, execution, completion and remedying of defects. 4.5 The Works shall include any work which is necessary to satisfy the Employer's Requirements, or is implied by the Contract, and all works which (although not mentioned in the Contract) are necessary for stability or for the completion, or safe and proper operation, of the Works. 4.6 Throughout the design and execution of the Works, and as long thereafter as is necessary to fulfil the Contractor's obligations, the Contractor shall provide all necessary superintendence to plan, arrange, direct, manage, inspect and test the work. Superintendence shall be given by a sufficient number of persons having adequate

	knowledge of the language for communications (defined in Clause 3. [Law and Language]) and of the operations to be carried out (including the methods and techniques required, the hazards likely to be encountered and methods of preventing accidents), for the satisfactory and safe execution of the Works. 4.7 The Contractor shall be responsible for the adequacy, stability and safety of all Site operations, of all methods of construction and of all the Works. 4.8 The Contractor shall, whenever required by the Employer, submit details of the arrangements and methods which the Contractor proposes to adopt for the execution of the Works. No significant alteration to these arrangements and methods shall be made without this having previously been notified to the Employer. **4.9** Except as otherwise stated in the Contract: (a) the Contractor shall be deemed to have obtained all necessary information as to risks, contingencies and other circumstances which may influence or affect the Works; (b)by signing the Contract, the Contractor accepts total responsibility for having foreseen all difficulties and costs of successfully completing the Works; and (c) the Contract Price shall **not be adjusted** to take account of any unforeseen difficulties or costs. 4.10 For the purposes of Clause 4.9, unforeseeable difficulties include physical conditions like man-made or natural physical conditions including sub-surface and hydrological conditions which the Contractor encounters at the Site during execution of the Works. 4.11 Subject to any mandatory requirements under the governing law of the Contract, termination of the Contract under any Clause of these Conditions shall require no action of whatsoever kind by either Party other than as stated in the Clause.
5. Use of Contractor's Documents	5.1 The Contractor shall retain the copyright and other intellectual Contractor's Documents property rights in the Contractor's Documents and other design documents made by (or on behalf of) the Contractor. The Contractor shall be deemed (by signing the Contract) to give to the Employer a non-terminable transferable non-exclusive royalty-free license to copy, use and communicate the Contractor's Documents, including making and using modifications of them. This license shall: (a) apply throughout the actual or intended working life (whichever is longer) of the relevant parts of the Works, (b) entitle any person in proper possession of the relevant part of the Works to copy, use and communicate the Contractor's Documents for the purposes of completing, operating, maintaining, altering, adjusting, repairing and demolishing the Works, and (c) in the case of Contractor's Documents which are in the form of computer programs and other software, permit their use on any computer on the Site and other places as envisaged

	by the Contract, including replacements of any computers supplied by the Contractor. 5.2 The Contractor's Documents and other design documents made by (or on behalf of) the Contractor, shall not, without the Contractor's consent, be used, copied or communicated to a third party by (or on behalf of) the Employer for purposes other than those permitted under this Clause.
6. Contractor's Use of Employer's Documents	6.1 The Employer shall retain the copyright and other Employer's intellectual property rights in the Employer's Requirements and other documents made by (or on behalf of) the Employer. The Contractor may, at his cost, copy, use, and obtain communication of these documents for the purposes of the Contract. They shall not, without the Employer's consent, be copied, used or communicated to a third party by the Contractor, except as necessary for the purposes of the Contract.
7. Assignment	7.1 Neither Party shall assign the whole or any part of the Contract or any benefit or interest in or under the Contract. However, either Party (a) may assign the whole or any part with the prior agreement of the other Party, at the sole discretion of such other Party; and (b) may, as security in favor of a commercial bank or financial institution, assign its right to any moneys due, or to become due, under the Contract.
8. Care and Supply of Documents	8.1 Each of the Contractor's Documents shall be in the custody and care of the Contractor, unless and until taken over by the Employer. Unless otherwise stated in the Contract, the Contractor shall supply to the Employer's Representative six copies of each of the Contractor's Documents. 8.2 The Contractor shall keep, on the Site, a copy of the Contract, publications named in the Specification, the Contractor's Documents (if any), the Drawings and Variations and other communications given under the Contract. The Employer's Personnel shall have the right of access to all these documents at all reasonable times. 8.3 If a Party becomes aware of an error or defect in a document which was prepared for use in executing the Works, the Party shall promptly give notice to the other Party of such error or defect.
9. Confidential Details	9.1 The Contractor's and the Employer's Personnel shall disclose all such confidential and other information as may be reasonably required in order to verify the Contractor's compliance with the Contract and allow its proper implementation. 9.2 Each of them shall treat the details of the Contract as private and confidential, except to the extent necessary to carry out their respective obligations under the Contract or to comply with applicable Laws. Each of them shall not publish or disclose any particulars of the Works prepared by the other Party without the previous agreement of the other Party. However, the Contractor

	shall be permitted to disclose any publicly available information, or information otherwise required to establish his qualifications to compete for other projects. 9.3 Notwithstanding the above, the Contractor may furnish to its Subcontractor(s) such documents, data and other information it receives from the Employer to the extent required for the Subcontractor(s) to perform its work under the Contract, in which event the Contractor shall obtain from such Subcontractor(s) an undertaking of confidentiality similar to that imposed on the Contractor under this Clause.
10. Compliance with Laws	10.1 The Contractor shall, in performing the Contract, comply with applicable Laws. Unless otherwise **stated in the SCC**: (a) the Employer shall have obtained (or shall obtain) the planning, zoning or similar permission for the Permanent Works, and any other permissions described in the Employer's Requirements as having been (or being) obtained by the Employer; and the Employer shall indemnify and hold the Contractor harmless against and from the consequences of any failure to do so; and (b) the Contractor shall give all notices, pay all taxes, duties and fees, and obtain all permits, licences and approvals, as required by the Laws in relation to the design, execution and completion of the Works and the remedying of any defects; and the Contractor shall indemnify and hold the Employer harmless against and from the consequences of any failure to do so. 10.2 The Employer shall (where he is in a position to do so) provide reasonable assistance to the Contractor at the request of the Contractor: (a) by obtaining copies of the Laws of Nepal which are relevant to the Contract but are not readily available, and (b) for the Contractor's applications for any permits, licences or approvals required by the Laws of Nepal: (i) which the Contractor is required to obtain under Clause 10.1, (ii) for the delivery of Goods, including clearance through customs, and (iii) for the export of Contractor's Equipment when it is removed from the Site.
11. Joint and Several Liability	11.1 If the Contractor is a joint venture of two or more entities , all such entities shall be jointly and severally liable to the Employer for the fulfillment of the provisions of the Contract, and shall designate one of such persons to act as a leader with authority to bind the joint venture. The composition or the constitution of the joint venture shall not be altered.
12. Contractor's Representative	12.1 The Contractor shall appoint the Contractor's Representative and shall give him all authority necessary to act on the Contractor's behalf under the Contract. 12.2 Unless the Contractor's Representative is named in the Contract, the Contractor shall, prior to the Commencement Date, submit to the Employer for consent the name and particulars of

	the person the Contractor proposes to appoint as Contractor's Representative. If consent is withheld or subsequently revoked, or if the appointed person fails to act as Contractor's Representative, the Contractor shall similarly submit the name and particulars of another suitable person for such appointment. 12.3 The Contractor shall not, without the prior consent of the Employer, revoke the appointment of the Contractor's Representative or appoint a replacement. The Contractor's Representative shall, on behalf of the Contractor, receive instructions under Clause 33. [Instructions, Inspection and Audits]. 12.4 The Contractor's Representative may delegate any powers, functions and authority to any competent person, and may at any time revoke the delegation. Any delegation or revocation shall not take effect until the Employer has received prior notice signed by the Contractor's Representative, naming the person and specifying the powers, functions and authority being delegated or revoked. 12.5 The Contractor's Representative and all these persons shall be fluent in the language for communications defined in Clause 3. [Law and Language] .
13. The Employer's Representative	13.1 The Employer may appoint an Employer's Representative to act on his behalf under the Contract. In this event, he shall give notice to the contractor of the name, address, duties and authority of the Employer's Representative. 13.2 The Employer's Representative shall carry out the duties assigned to him, and shall exercise the authority delegated to him, by the Employer. Unless and until the Employer notifies the Contractor otherwise, the Employer's Representative shall be deemed to have the full authority of the Employer under the Contract, except in respect of Clause 79 [Termination by Employer] , to amend the Contract and to relieve either Party of any duties, obligations or responsibilities under the Contract; and 13.3 Any approval, check, certificate, consent, examination, inspection, instruction, notice, proposal, request, test, or similar act by the Employer or Employer's Representative (including absence of disapproval) shall not relieve the Contractor from any responsibility he has under the Contract, including responsibility for errors, omissions, discrepancies and non-compliances. 13.4 If the Employer wishes to replace any person appointed as Employer's Representative, the Employer shall give the Contractor not less than 15 days' notice of the replacement's name, address, duties and authority, and of the date of appointment. 13.5 The Employer or the Employer's Representative may from time to time assign duties and delegate authority to assistants, and may also revoke such assignment or delegation, by giving a Notice to the Contractor of the name, assigned duties and delegated authority of the assistant. The assignment, delegation or revocation shall not take effect until this Notice has been received by the Contractor. 13.6 Assistants shall be suitably qualified persons, who are competent

	to carry out these duties and exercise this authority, and who are fluent in the language for communications defined in Clause 3. [Law and Language]
14. Delegation	14.1 All these persons, including the Employer's Representative and assistants, to whom duties have been assigned or authority has been delegated, shall only be authorized to issue instructions to the Contractor to the extent defined by the delegation. Any approval, check, certificate, consent, examination, Inspection, instruction, notice, proposal, request, test, or similar act by a delegated person, in accordance with the delegation, shall have the same effect as though the act had been an act of the Employer. However: (a) unless otherwise stated in the delegated person's communication relating to such act, it shall not relieve the Contractor from any responsibility he has under the Contract, including responsibility for errors, omissions, discrepancies and non-compliances; (b) any failure to disapprove any work, Plant or Materials shall not constitute approval, and shall therefore not prejudice the right of the Employer to reject the work, Plant or Materials; and (c) if the Contractor questions any determination or instruction of a delegated person, the Contractor may refer the matter to the Employer, who shall promptly confirm, reverse or vary the determination or instruction.
15. Communications	15.1 Communications between parties that are referred to in the Conditions shall be effective only when in writing. Wherever these Conditions provide for the giving or issuing of approvals, certificates, consents, determinations, notices and requests, these communications shall be: (a) in writing and delivered by hand (against receipt), sent by mail or courier, or transmitted using any of the agreed systems of electronic transmission as **stated in the SCC**; and (b) delivered, sent or transmitted to the address for the recipient's communications as stated in the Contract. However: (i) if the recipient gives notice of another address, communications shall thereafter be delivered accordingly; and (ii) if the recipient has not stated otherwise when requesting an approval or consent, it may be sent to the address from which the request was issued.
16. Subcontracting	16.1 The Contractor shall not subcontract the maximum % value of whole Works, **as stated in the SCC**. The Contractor shall be responsible for the acts or defaults of any Subcontractor, his agents or employees, as if they were the acts or defaults of the Contractor. The Sub contractor shall meet the qualification requirement **as specified in SCC**. Where specified in the SCC, the Contractor shall give the Employer not less than 30 days' notice of: (a) the intended appointment of the Subcontractor, with detailed

	particulars which shall include his relevant experience, (b) the intended commencement of the Subcontractor's work, and (c) the intended commencement of the Subcontractor's work on the Site. 16.2 In the event of approved subcontracting the Contractor shall ensure that Subcontractors do not further sub-let their contract. 16.3 The Contractor shall not terminate the engagement of a subcontractor without the prior written consent of the Employer. 16.4 The Contractor shall keep a log showing the following information on the Sub Contractors, suppliers and transporters engaged in the contract works: • Name and Address • Copy of Sub Contracting Agreement • Works and value contract • Commencement and completion dates • Copy of payment certificates
17. Other Contractors	17.1 The Contractor shall cooperate and share the Site with other contractors, public authorities, utilities, and the Employer between the dates given in the Schedule of Other Contractors, **as stated in the SCC**. The Contractor shall also provide facilities and services for them as described in the Schedule. The Employer may modify the Schedule of Other Contractors, and shall notify the Contractor of any such modification
18. Personnel and Equipment	18.1 The Contractor shall employ the key personnel and use the equipment identified in its Bid to carry out the Works, or other personnel and equipment approved by the Employer. The Employer shall approve any proposed replacement of key personnel and equipment only if their relevant qualifications or characteristics are substantially equal to or better than those proposed in the Bid. 18.2 The Employer may require the Contractor to remove (or cause to be removed) any person employed on the Site or Works, including the Contractor's Representative if applicable, who: (a) persists in any misconduct or lack of care, (b) carries out duties incompetently or negligently, (c) fails to conform with any provisions of the Contract, or (d) persists in any conduct which is prejudicial to safety, health, or the protection of the environment. If appropriate, the Contractor shall then appoint (or cause to be appointed) a suitable replacement person. 18.3 The Contractor shall be responsible for all Contractor's Equipment. When brought on to the Site, Contractor's Equipment shall be deemed to be exclusively intended for the execution of the Works. 18.4 The Contractor shall submit, to the Employer, details showing the number of each class of Contractor's Personnel and of each type of

	Contractor's Equipment on the Site. 18.5 Details shall be submitted each calendar month, in a form approved by the Employer, until the Contractor has completed all work. 18.6 The Contractor shall at all times take all reasonable precautions to prevent any unlawful, riotous or disorderly conduct by or amongst the Contractor's Personnel, and to preserve peace and protection of persons and property on and near the Site. 18.7 Each item of Plant and Materials shall, to the extent consistent with the Laws of Nepal, become the property of the Employer at whichever is the earlier of the following times, free from liens and other encumbrances: (a) when it is delivered to the Site; (b) when the Contractor is entitled to payment of the value of the Plant and Materials under Clause 44. [Delays Ordered by the Employer].
19.Indemnities	19.1 The Contractor shall indemnify and hold harmless the Employer, the Employer's Personnel, and their respective agents, against and from all claims, damages, losses and expenses (including legal fees and expenses) in respect of: (a) bodily injury, sickness, disease or death, of any person whatsoever arising out of or in the course of or by reason of the design, execution and completion of the Works and the remedying of any defects, unless attributable to any negligence, willful act or breach of the Contract by the Employer, the Employer's Personnel, or any of their respective agents, and (b) damage to or loss of any property, real or personal (other than the Works), to the extent that such damage or loss; arises out of or in the course of or by reason of the Contractor's design (if any) , execution and completion of the Works and the remedying of any defects, and is not attributable to any negligence, willful act or breach of the Contract by the Employer, the Employer's Personnel, their respective agents, or anyone directly or indirectly employed by any of them. 19.2 The Employer shall indemnify and hold harmless the Contractor, the Contractor's Personnel, and their respective agents, against and from all claims, damages, losses and expenses (including legal fees and expenses) in respect of (a) bodily injury, sickness, disease or death, which is attributable to any negligence, willful act or breach of the Contract by the Employer, the Employer's Personnel, or any of their respective agents, and (b) the matters for which liability may be excluded from insurance cover, as the Employer's right to have the Permanent Works executed on, over, under, in or through any land, and to occupy this land for the Permanent Works, damage which is an unavoidable result of the Contractor's obligations to execute the Works and remedy any defects, and a causes under Employer's Risks, except to the extent that cover is available at

	commercially reasonable terms. 19.3 Neither Party shall be liable to the other Party for loss of use of any Works, loss of profit, loss of any contract or for any indirect or consequential loss or damage which may be suffered by the other Party in connection with the Contract, other than under Clause 83.[Payment upon Termination] and Clause 19.1. This Clause shall not limit liability in any case of fraud, deliberate default or reckless misconduct by the defaulting Party. 19.4 The Contractor shall take full responsibility for the care of the items **listed in the SCC(if any)** , from the respective dates of use or occupation by the Contractor, up to the respective dates of hand-over or cessation of occupation (where hand-over or cessation of occupation may take place after the date stated in the Taking-Over Certificate for the Works). If any loss or damage happens to any of the above items while the Contractor is responsible for their care, arising from any cause whatsoever other than those for which the Employer is liable, the Contractor shall, at his own cost, rectify the loss or damage to the satisfaction of the Employer
20. Intellectual and Industrial Property Rights	20.1 In this Clause, "infringement" means an infringement (or alleged infringement) of any patent, registered design, copyright, trade mark, trade name, trade secret or other Rights intellectual or industrial property right relating to the Works; and "claim" means a claim (or proceedings pursuing a claim) alleging an infringement. 20.2 Whenever a Party does not give notice to the other Party of any claim within 30 days of receiving the claim, the first Party shall be deemed to have waived any right to indemnity under this Clause. 20.3 The Employer shall indemnify and hold the Contractor harmless against and from any claim alleging an infringement which is or was: (a) an unavoidable result of the Contractor's compliance with the Employer's Requirements, or (b) a result of any Works being used by the Employer: (i) for a purpose other than that indicated by, or reasonably to be inferred from, the Contract, or (ii) in conjunction with anything not supplied by the Contractor, unless such use was disclosed to the Contractor prior to the Base Date or is stated in the Contract. 20.4 The Contractor shall indemnify and hold the Employer harmless against and from any other claim which arises out of or in relation to (i) the Contractor's design, manufacture, construction or execution of the Works, (ii) the use of Contractor's Equipment, or (iii) the proper use of the Works. 20.5 If a Party is entitled to be indemnified under this Clause, the indemnifying Party may (at its cost) conduct negotiations for the settlement of the claim, and any litigation or arbitration

	which may arise from it. The other Party shall, at the request and cost of the indemnifying Party, assist in contesting the claim. This other Party (and its Personnel) shall not make any admission which might be prejudicial to the indemnifying Party, unless the indemnifying Party failed to take over the conduct of any negotiations, litigation or arbitration upon being requested to do so by such other Party.
21. Employer's Risks	21.1 From the Commencement Date until the Defects Liability Certificate has been issued, the following are Employer's risks: Occurrence of natural disaster such as earthquake, fire, *Excessive rainfall (atibrishti)*, flood and landslide in such a way that affects the component of the project adversely or the contractor cannot perform the work due to the notification from the Government of Nepal during the occurrence of any pandemic. 21.3 If and to the extent that any of the risks listed in Clause 21.1 above results in loss or damage to the Works, Goods or Contractor's Documents, the Contractor shall promptly give notice to the Employer and shall rectify this loss or damage to the extent required by the Employer. 21.4 If the Contractor suffers delay and/or incurs Cost from rectifying this loss or damage, the Contractor shall give a further notice to the Employer and shall be entitled subject to Clause 35. [Contractor's Claims] to: (a) an extension of time for any such delay, if completion is or will be delayed, under Clause 42 [Extension of Intended Completion Date],and (b) payment of any such Cost, which shall be added to the Contract Price. 21.5 After receiving this further notice, the Employer shall proceed in accordance with Sub Clause 32. [Determinations] to agree or determine these matters.
22. Contractor's Risks	22.1 From the Commencement Date until the Defects Liability Certificate has been issued, the risks of personal injury, death, and loss of or damage to property (including, without limitation, the **Design**, Works, Plant, Materials, and Equipment) and other contractor's obligations mentioned in the Contract, which are not Employer's risks are Contractor's risks. 22.2 If any loss or damage happens to the Design, Works, Goods or Contractor's Documents during the period when the Contractor is responsible for their care, from any cause not listed in Clause 21.1, the Contractor shall rectify the loss or damage at the Contractor's risk and cost, so that the Design, Works, Goods and Contractor's Documents conform with the Contract. 22.3 The contractor shall bear the risk for changes in the cost of materials, fuel or other prices due to variation in the currency exchange rate. 22.4 The contractor shall bear the risk of increases in the cost of labour and materials (the inflation risk). In case of those outside the specified time period (contract period or extended contract

	period where the time extension has been granted to the Contractor by the Employer), the Contractor may act as per Clause 35. [Contractor's Claims] 22.5 The contractor shall bear all the risk including geological, professional and technical risk during execution of the project in design, procurement, construction and operation and maintenance stage.
23. Insurance	23.1 The Contractor shall be responsible for effecting and maintaining the insurance specified in the relevant Clause. Each insurance shall be effected with insurers and in terms approved by the Employer. These terms shall be consistent with any terms agreed by both Parties before they signed the Contract Agreement. 23.2 The Contractor shall provide insurance in the joint names of the Employer and the Contractor from the Commencement Date to the end of the Defects Liability Period, in the amounts and deductibles per occurrence of not more than the amount **stated in the SCC** for the following events which are due to the Contractor's risks: (a) loss of or damage to the Works, Plant, and Materials; (b) loss of or damage to Equipment; (c) loss of or damage to property (except the Works, Plant, Materials, and Equipment) in connection with the Contract; and (d) Personal injury or death. (e) Liability for breach of professional duty Liability for breach of professional duty : To the extent that the Contractor is responsible for the design of part of the Permanent Works under the Contract, and consistent with the indemnities specified in Clause 19 [Indemnities]: (a) the Contractor shall effect and maintain professional indemnity insurance against liability arising out of any act, error or omission by the Contractor in carrying out the Contractor's design obligations in an amount not less than that **stated in the SCC** (if not stated, the amount agreed with the Employer); and (b) **if stated in the SCC**, such professional indemnity insurance shall also indemnify the Contractor against liability arising out of any act, error or omission by the Contractor in carrying out the Contractor's design obligations under the Contract that results in the Works (or Section or Part or major item of Plant, if any), when completed, not being fit for the purpose(s) for which they are intended under the Contract. The Contractor shall maintain this insurance for the period specified **in the SCC.** 23.3 The Contractor shall insure the Works, Plant, Materials and Contractor's Documents for not less than the full reinstatement cost including the costs of demolition, removal of debris and professional fees and profit. 23.4 The Contractor shall insure the Contractor's Equipment for not less than the full replacement value, including delivery to

	Site. For each item of Contractor's Equipment, the insurance shall be effective while it is being transported to the Site and until it is no longer required as Contractor's Equipment. 23.5 The Contractor shall insure against each Party's liability for any loss, damage, death or bodily injury which may occur to any physical property (except for Works and Contractor's Equipment) or to any person (except Contractor's Personnel), which may arise out of the Contractor's performance of the Contract and occurring before end of Defect Liability Period. 23.6 The Contractor shall effect and maintain insurance against liability for claims, damages, losses and expenses (including legal fees and expenses) arising from injury, sickness, disease or death of any person employed by the Contractor or any other of the Contractor's Personnel. The Employer shall also be indemnified under the policy of insurance, except that this insurance may exclude losses and claims to the extent that they arise from any act or neglect of the Employer or of the Employer's Personnel. The insurance shall be maintained in full force and effect during the whole time that these personnel are assisting in the execution of the Works. For a Subcontractor's employees, the insurance may be effected by the Subcontractor, but the Contractor shall be responsible for compliance with this Clause. 23.7 The contractor shall insure the engineering stage work such as survey, design and drawing in the form of professional liability insurance for not less than the cost assigned for the engineering stage, as a liability for breach of professional duty. 23.8 Policies, certificates and evidence of premium payment for insurance shall be delivered by the Contractor to the Employer for the Employer's approval before the Commencement Date. All such insurance shall provide for compensation to be payable in the proportions of **Nepali Rupees** required to rectify the loss or damage incurred. 23.9 If the Contractor does not provide any of the policies and certificates required, the Employer may affect the insurance which the Contractor should have provided and recover the premiums the Employer has paid from payments otherwise due to the Contractor or, if no payment is due, the payment of the premiums shall be a debt due. 23.10 The contractor shall keep the insurers informed of any relevant changes to the execution of the Works and ensure that insurance is maintained in accordance with this Clause. 23.11 Nothing in this Clause limits the obligations, liabilities or responsibilities of the Contractor, under the other terms of the Contract or otherwise. Any amounts not insured or not recovered from the insurers shall be borne by the Contractor in accordance with these obligations, liabilities or responsibilities. However, if the Contractor fails to effect and keep in force an insurance which is available and which it is required to effect and maintain under the Contract, and the Employer neither approves the omission nor effects insurance

	for the coverage relevant to this default, any moneys which should have been recoverable under this insurance shall be paid by the Contractor. 23.12 Alterations to the terms of insurance shall not be made without the approval of the Employer. 23.13 Both parties shall comply with any conditions of the insurance policies.
24. Site Data and Reports	24.1 The Contractor, in preparing the Bid, shall rely on conceptual design report or any such report referred to **in the SCC,** made available by the Employer, supplemented by any information available to the Contractor. The Contractor shall be responsible for verifying and interpreting all such data. The employer shall not bear the risk of the accuracy or discrepancy of the study report provided to the contractor. 24.2 To the extent which was practicable (taking account of cost and time), the Contractor shall be deemed to have obtained all necessary information as to risks, contingencies and other circumstances which may influence or affect the Tender or Works. To the same extent, the Contractor shall be deemed to have inspected and examined the Site, its surroundings, the above data and other available information, and to have been satisfied before submitting the Tender as to all relevant matters, including (without limitation): (a) the form and nature of the Site, including sub-surface conditions, (b) the hydrological and climatic conditions, (c) the extent and nature of the work and Goods necessary for the execution and completion of the Works and the remedying of any defects, (d) the Laws, procedures and labour practices of Nepal, and (e) the Contractor's requirements for access, accommodation, facilities, personnel, power, transport, water and other services
25. Contractor to Construct the Works	25.1 The Contractor shall construct and install the Works in accordance with the Employer's Requirements. 25.2 The Contractor shall set out the Works in relation to original points, lines and levels of reference specified in the Contract or notified by the Employer or Employer Representative. The Contractor shall be responsible for the correct positioning of all parts of the Works, and shall rectify any error in the positions, levels, dimensions or alignment of the Works. 25.3 The Employer shall not be responsible for the accuracy, sufficiency or completeness of the data provided.
26. Works to Be Completed within intended Completion Date	26.1 The Contractor may commence execution of the Works on the Commencement Date and shall carry out the Works in accordance with the Program submitted by the Contractor, as updated with the approval of the Employer, and complete them within the intended Completion Date abiding the fulfillment of

	the completion of the milestone of the project. 26.2 The Contractor shall confine his operations to the Site, and to any additional areas which may be obtained by the Contractor and agreed by the Employer as working areas. The Contractor shall take all necessary precautions to keep Contractor's Equipment and Contractor's Personnel within the Site and these additional areas, and to keep them off adjacent land. 26.3 During the execution of the Works, the Contractor shall keep the Site free from all unnecessary obstruction, and shall store or dispose of any Contractor's Equipment or surplus materials. The Contractor shall clear away and remove from the Site any wreckage, rubbish and Temporary Works which are no longer required. 26.4 Upon the issue of the Taking-Over Certificate for the Works, the Contractor shall clear away and remove all Contractors' Equipment, surplus material, wreckage, rubbish and Temporary Works. The Contractor shall leave the Site and the Works in a clean and safe condition. However, the Contractor may retain on Site, during the Defects Liability Period, such Goods as are required for the Contractor to fulfil obligations under the Contract.
27. Design by Contractor	27.1 The Contractor shall be deemed to have scrutinized, prior to bid submission, the Obligations the Employer's Requirements (including design criteria and calculations, if any). The Contractor shall carry out, and be responsible for the design of the Works and for the accuracy of such Employer's Requirements (including design criteria and calculations), except as stated in Clause 27.3. Design shall be prepared by qualified designers who (a) are engineers or other professionals, qualified, experienced and competent in the disciplines of the design for which they are responsible; (b) comply with the criteria (if any) stated in the Employer's Requirements; and (c) are qualified and entitled under applicable Laws to design the Works. 27.4 The Contractor's Documents shall comprise the technical documents specified in the Employer's Requirements, documents required to satisfy all regulatory approvals, and the documents described in the Clause 78. [Operating and Maintenance Manuals] . Unless otherwise stated in the Employer's Requirements, the Contractor's Documents shall be written in the language for communications defined in Clause 3. [Law and Language]]. 27.5 The Contractor shall prepare all Contractor's Documents, and shall also prepare any other documents necessary to instruct the Contractor's Personnel. 27.6 If the Employer's Requirements describe the Contractor's Documents which are to be submitted to the Employer for review, they shall be submitted accordingly, together with a notice as described below. In the following provisions of this Clause, (i) "**review period**" means the period required by the Employer for review, and (ii) "Contractor's Documents" exclude

	any documents which are not specified as being required to be submitted for review. 27.7 Unless otherwise stated in the Employer's Requirements, each review period shall not exceed 45 days, calculated from the date on which the Employer receives a Contractor's Document and the Contractor's notice. This notice shall state that the Contractor's Document is considered ready, both for review in accordance with this Clause and for use. The notice shall also state that the Contractor's Document complies with the Contract, or the extent to which it does not comply. 27.8 The Employer may, within the review period, give notice to the Contractor of approval or that a Contractor's Document fails (to the extent stated) to comply with the Contract. If a Contractor's Document so fails to comply, it shall be rectified, resubmitted and reviewed in accordance with this Clause, at the Contractor's cost. During underground work, if site condition differs the condition considered in design, the contractor shall revise the design as per new condition, submit to employer and shall get approval letter and shall start the work. 27.9 For each part of the Works, and except to the extent that the Parties otherwise agree: (a) execution of such part of the Works shall not commence prior to the expiry of the review periods for all the Contractor's Documents which are relevant to its design and execution; (b) execution of such part of the Works shall be in accordance with these Contractor's Documents, as submitted for review; and (c) if the Contractor wishes to modify any design or document which has previously been submitted for review, the Contractor shall immediately give notice to the Employer. Thereafter, the Contractor shall submit revised documents to the Employer in accordance with the above procedure. 27.10 No examination or lack of examination of whatsoever nature by the Employer, or Employer's Representatives or Employer Personnel of the Contractor's drawings, documents, calculations or details relating to the execution of the Works or otherwise nor any certification, comment, rejection or approval expressed by such persons in regard thereto, either with or without modification, shall in any respect relieve or absolve the Contractor from any obligations or liability under or in connection with the Contract. 27.11 The design, the Contractor's Documents, the execution and the completed Works shall comply with Nepal's technical standards, building, construction and environmental Laws, Laws applicable to the product being produced from the Works, and other standards specified in the Employer's Requirements, applicable to the Works, or defined by the applicable Laws. 27.12 All these Laws shall, in respect of the Works and each Section, be those prevailing when the Works are taken over by the

	Employer under Clause 76. [Taking Over of the Works]. References in the Contract to published standards shall be understood to be references to the edition applicable on the Base Date, unless stated otherwise. 27.13 If changed or new applicable standards come into force in Nepal after the Base Date, the Contractor shall give notice to the Employer and (if appropriate) submit proposals for compliance. In the event that: (a) the Employer determines that compliance is required, and (b) the proposals for compliance constitute a variation, then the Employer shall initiate a Variation in accordance with Clause 53 [Variations]. 27.14The Contractor shall carry out the training of Employer's Personnel in the operation and maintenance of the Works to the extent specified in the Employer's Requirements. If the Contract specifies training which is to be carried out before taking-over, the Works shall not be considered to be completed for the purposes of taking-over under Clause 76. [Taking Over of the Works] until this training has been completed. 27.15 If errors, omissions, ambiguities, inconsistencies, inadequacies or other defects are found in the Contractor's Documents, they and the Works shall be corrected at the Contractor's cost, notwithstanding any consent or approval under this Clause.
28. Safety, Security and Protection of the Environment	28.1 The Contractor shall: (a) comply with all applicable safety regulations, (b) take care for the safety of all persons entitled to be on the Site, (c) use reasonable efforts to keep the Site and Works clear of unnecessary obstruction so as to avoid danger to these persons, (d) provide fencing, lighting, guarding and watching of the Works until completion and taking over under Clause 76. [Taking Over of the Works], and (e) provide any Temporary Works (including roadways, footways, guards and fences) which may be necessary, because of the execution of the Works, for the use and protection of the public and of owners and occupiers of adjacent land 28.2 The Contractor shall not interfere unnecessarily or improperly with: (a) the convenience of the public, or (b) the access to and use and occupation of all roads and footpaths, irrespective of whether they are public or in the possession of the Employer or of others. 28.3 The Contractor shall indemnify and hold the Employer harmless against and from all damages, losses and expenses (including legal fees and expenses) resulting from any such unnecessary or improper interference. 28.4 Unless otherwise stated in the contract:

	(a) The Contractor shall be responsible for keeping unauthorized persons off the Site, and (b) authorized persons shall be limited to the Contractor's Personnel and the Employer's Personnel; and to any other personnel notified to the Contractor, by (or on behalf of) the Employer, as authorized personnel of the Employer's other contractors on the Site. 28.5 The Contractor shall take all reasonable steps to protect the environment (both on and off the Site) and to limit damage and nuisance to people and property resulting from pollution, noise and other results of his operations. The Contractor shall ensure that any cut or fill slopes are planted in grass or other plant cover as soon as possible to protect them from erosion. Any spoil or material removed from drains shall be disposed of to designated stable tipping areas as directed by the Employer. 28.6 The Contractor shall ensure that emissions, surface discharges and effluent from the Contractor's activities shall not exceed the values indicated in the Employer's Requirements, and shall not exceed the values prescribed by applicable Laws. 28.7 The Employer shall have the power to disallow any working practice or activity of the Contractor or direct that such practices or activities be modified should the Employer consider, on the advice of the relevant Government Departments, that the practices or activities will be harmful to wildlife. 28.8 The Contractor shall provide on the Site such lifesaving apparatus as may be appropriate and an adequate and easily accessible first aid outfit or such outfits as may be required by any government ordinance, factory act, etc., subsequently published and amended from time to time.
29. Discoveries	29.1 Anything of historical or fossils, coins, articles of value or antiquity, and structures or other interest or of significant value unexpectedly discovered on the Site ,shall be the property of the employer. The Contractor shall notify the Employer of such discoveries and carry out the Employer's instructions for dealing with them. 29.2 The Contractor shall take reasonable precautions to prevent Contractor's Personnel or other persons from removing or damaging any of these findings. 29.3 If the Contractor suffers delay and/or incurs Cost from complying with the instructions, the Contractor shall give a further notice to the Employer and shall be entitled subject to Clause 35. [Contractor's Claims] to: (a) an extension of time for any such delay, if completion is or will be delayed, under Clause 42 [Extension of Intended Completion Date] , and (b) payment of any such Cost, which shall be added to the Contract Price. 29.4 After receiving this further notice, the Employer shall proceed in accordance with Clause 32. [Determinations] to agree or determine

	these matters.
30. Possession of the Site and it's Access	30.1 The Employer shall give the Contractor right of access to, and possession of, all the Site parts of the Site within the time (or times) **stated in the SCC.** The right and possession may not be exclusive to the Contractor. If, under the Contract, the Employer is required to give (to the Contractor) possession of any foundation, structure, plant or means of access, the Employer shall do so in the time and manner stated in the Employer's Requirements. However, the Employer may withhold any such right or possession until the Performance Security has been received. If no such time is stated in the SCC, the Employer shall give the Contractor right of access to, and possession of, the Site with effect from the Commencement Date. 30.2 Until the Performance Certificate has been issued, the Contractor shall have the right of access to all parts of the Works and to records of the operation and performance of the Works, except as may be inconsistent with the Employer's reasonable security restrictions. 30.3 If right of access to, and possession of a part is not given by the date stated in the SCC, the Employer shall be deemed to have delayed the start of the relevant activities, and this shall be a Compensation Event. 30.4 The Contractor shall allow the Employer and any person authorized by the Employer access to the Site and to any place where work in connection with the Contract is being carried out or is intended to be carried out.
31. Access Route and Transport of Goods	31.1 The Contractor shall be deemed to have been satisfied as to the suitability and availability of access routes to the Site. The Contractor shall use reasonable efforts to prevent any road or bridge from being damaged by the Contractor's traffic or by the Contractor's Personnel. These efforts shall include the proper use of appropriate vehicles and routes. 31.2 Except as otherwise stated in these Conditions: (a) the Contractor shall (as between the Parties) be responsible for any maintenance which may be required for his use of access routes; (b) the Contractor shall provide all necessary signs or directions along access routes, and shall obtain any permission which may be required from the relevant authorities for his use of routes, signs and directions; (c) the Employer shall not be responsible for any claims which may arise from the use or otherwise of any access route, (d) the Employer does not guarantee the suitability or availability of particular access routes, and (e) Costs due to non-suitability or non-availability, for the use required by the Contractor, of access routes shall be borne by the Contractor. 31.3 Unless otherwise **stated in the SCC**:

	(a) the Contractor shall give the Employer not less than 21 days' notice of the date on which any Plant or a major item of other Goods will be delivered to the Site; (b) the Contractor shall be responsible for packing, loading, transporting, receiving, unloading, storing and protecting all Goods and other things required for the Works; and (c) the Contractor shall indemnify and hold the Employer harmless against and from all damages, losses and expenses (including legal fees and expenses) resulting from the transport of Goods, and shall negotiate and pay all claims arising from their transport.
32. Determinations	32.1 When carrying out his/her duties under this Clause, the Employer's Representative shall not be deemed to act for the Employer. Whenever these Conditions provide that the Employer shall proceed in accordance with this Clause 32. [Determination] to agree or determine any matter, the Employer shall consult with the Contractor in an endeavor to reach agreement. If agreement is not achieved, the Employer shall make a fair determination in accordance with the Contract, taking due regard of all relevant circumstances. 32.2 The Employer shall give notice to the Contractor of each agreement or determination, with supporting particulars. Each Party shall give effect to each agreement or determination, unless the Contractor gives notice, to the Employer, of his dissatisfaction with a determination within 15 days of receiving it. After then, parties shall proceed as per Clause 36. [Dispute Settlement] or Clause 37. [Dispute Settlement by Arbitration]
33. Instructions, Inspections and Audits	33.1 The Employer may issue to the Contractor instructions which may be necessary for the Contractor to perform his obligations under the Contract. The Contractor shall carry out all instructions of the Employer, or from the Employer's Representative or an assistant to whom the appropriate authority which comply with the applicable laws where the Site is located. 33.2 Each instruction shall be given in writing and shall state the obligations to which relates and the Clause (or other term of the Contract) in which the obligations are specified. If any such instruction constitutes a Variation, Clause 53 [Variations] shall apply. 33.3 The Contractor shall keep, and shall make all reasonable efforts to cause its Subcontractors and consultant [if any] to keep accurate and systematic accounts and records in respect of the Works in such form and details as will clearly identify relevant time changes and costs. 33.4 The Contractor shall permit the GoN/DP and/or persons appointed by the GoN/DP to inspect the Site and/or the accounts and records of the Contractor and its sub-contractors relating to the performance of the Contract, and to have such accounts and records audited by auditors appointed by the GoN/DP if required by the GoN/DP. The Contractor's attention is drawn to

	Clause 84.2 which provides, inter alia, that acts intended to materially impede the exercise of the GoN's/DP's inspection and audit rights provided for under this Clause constitute an obstructive practice subject to contract termination.
34. Employer's Claims	34.1 If the Employer considers himself to be entitled to any payment under any Clause of these Conditions or otherwise in connection with the Contract, and/or to any extension of the Defects Liability Period, he shall give notice and particulars to the Contractor. 34.2 The notice shall be given as soon as practicable after the Employer became aware of the event including the condition of non-compliance with the milestone or circumstances giving rise to the claim. A notice relating to any extension of the Defects Liability Period shall be given before the expiry of such period. 34.3 The particulars shall specify the Clause or other basis of the claim, and shall include substantiation of the amount and/or extension to which the Employer considers himself to be entitled in connection with the Contract. The Employer shall then proceed in accordance with Clause 32. [Determinations] to agree or determine (i) the amount (if any) which the Employer is entitled to be paid by the Contractor, and/or (ii) the extension (if any) of the Defects Liability Period in accordance with Clause 49.2. 34.4 The Employer may deduct this amount from any moneys due, or to become due, to the Contractor. The Employer shall only be entitled to set off against or make any deduction from an amount due to the Contractor, or to otherwise claim against the Contractor, in accordance with this Clause or with sub-paragraph (a) and/or (b) of Clause 55.6.
35.Contractor's Claims	35.1 If the Contractor considers himself to be entitled to any extension of the Time for Completion and/or any additional payment, under any Clause of these Conditions or otherwise in connection with the Contract, the Contractor shall give notice to the Employer of such Compensation Events or cause of additional payments, describing the event or circumstance giving rise to the claim. The notice shall be given as soon as practicable, and not later than 21 days after the Contractor became aware, or should have become aware, of the event or circumstance. 35.2 If the Contractor fails to give notice of a claim within such period of 21 days, the Time for Completion shall not be extended, the Contractor shall not be entitled to additional payment, and the Employer shall be discharged from all liability in connection with the claim. 35.3 The Contractor shall also submit any other notices which are required by the Contract, and supporting particulars for the claim, all as relevant to such event or circumstance. 35.4 The following shall be Compensation Events: (a) The Employer does not give access to a part of the Site by the Site Possession Date pursuant to GCC 30.1.

	(b) The Employer modifies the Schedule of Other Contractors in a way that affects the work of the Contractor under the Contract. (c) The Employer instructs the Contractor to uncover or to carry out additional tests upon work, which is then found to have no Defects. (d) The Employer unreasonably does not approve a subcontract to be let. (e) The Employer gives an instruction for dealing with an unforeseen condition, caused by the Employer, or additional work required for safety or other reasons. (f) Other contractors, public authorities, utilities, or the Employer does not work within the dates and other constraints stated in the Contract, and they cause delay or extra cost to the Contractor. (g) The advance payment is delayed. (h) The effects on the Contractor of any of the Employer's Risks. (i) The Employer unreasonably delays issuing a Certificate of Completion. 35.5 The Contractor shall not be entitled to compensation to the extent that the Employer's interests are adversely affected by the Contractor's not having given early warning or not having cooperated with the Employer. Also, all events (like monsoon rain, festivals, government holidays etc.), what shall sure to be occurred during the Contract Period; shall not be Compensation Event. If the contractor has not completed any activity as per the milestone, without having any compensation event, such activities shall be subjected to liquidated damages. 35.6 The Contractor shall keep such contemporary records as may be necessary to substantiate any claim, either on the Site or at another location acceptable to the Employer. Without admitting liability, the Employer may, after receiving any notice under this Clause, monitor the record-keeping and/or instruct the Contractor to keep further contemporary records. The Contractor shall permit the Employer to inspect all these records, and shall (if instructed) submit copies to the Employer. 35.7 Within 21 days after the Contractor became aware (or should have become aware) of the event or circumstance giving rise to the claim, or within such other period as may be proposed by the Contractor and approved by the Employer, the Contractor shall send to the Employer a fully detailed claim which includes full supporting particulars of the basis of the claim and of the extension of time and/or additional payment claimed. If the event or circumstance giving rise to the claim has a continuing effect: (a) this fully detailed claim shall be considered as interim; (b) the Contractor shall send further interim claims at monthly intervals, giving the accumulated delay and/or amount claimed, and such further particulars as the Employer may

	reasonably require; and (c) the Contractor shall send a final claim within 30 days after the end of the effects resulting from the event or circumstance, or within such other period as may be proposed by the Contractor and approved by the Employer. 35.8 Within 21 days after receiving a claim or any further particulars supporting a previous claim, or within such other period as may be proposed by the Employer and approved by the Contractor, the Employer shall respond with approval, or with disapproval and detailed comments. He may also request any necessary further particulars, but shall nevertheless give his response on the principles of the claim within such time. 35.9 Each interim payment shall include such amounts for any claim as have been reasonably substantiated as due under the relevant provision of the Contract. Unless and until the particulars supplied are sufficient to substantiate the whole of the claim, the Contractor shall only be entitled to payment for such part of the claim as he has been able to substantiate. 35.10 The Employer shall proceed in accordance with Clause 32. [Determinations] to agree or determine (i) the extension (if any) of the Time for Completion (before or after its expiry) in accordance with Clause 42 [Extension of Intended Completion Date], and/or (ii) the additional payment (if any) to which the Contractor is entitled under the Contract. 35.11 The requirements of this Clause are in addition to those of any other Clause which may apply to a claim. If the Contractor fails to comply with this or another Clause in relation to any claim, any extension of time and/or additional payment shall take account of the extent (if any) to which the failure has prevented or prejudiced proper investigation of the claim, unless the claim is excluded the Clause 35.2.
36. Dispute Settlement	36.1 The Employer and the Contractor shall attempt to settle amicably by direct negotiation any disagreement or dispute arising between them under or in connection with the Contract. 36.2 Any dispute between the Parties as to matters arising pursuant to this Contract which cannot be settled amicably within thirty (30) days after receipt by one Party of the other Party‘s request for such amicable settlement may be referred to Arbitration within 30 days after the expiration of amicable settlement period.
37. Dispute Settlement by Arbitration	37.1 Unless settled amicably, any dispute shall be finally settled by arbitration. The arbitration shall be conducted in accordance with the arbitration procedures at the place **given in the SCC**. The Arbitration Act, 2055 (1999) shall be the governing law for arbitration process. 37.2 The arbitrator(s) shall have full power to open up, review and revise any certificate, determination, instruction, and opinion or valuation of (or on behalf of) the Employer, relevant to the

	dispute.
Staff and Labor	
38. Staff, Labour and theirs facilities	38.1 The Contractor shall and make arrangements for the engagement of all staff and labour, local or otherwise, and for their payment, housing, feeding and transport. 38.2 The Contractor shall pay rates of wages, and observe conditions of labour, which are not lower than those established for the trade or industry where the work is carried out. 38.3 The Contractor shall not employ forced labor, which consists of any work or service, not voluntarily performed, that is exacted from an individual under threat of force or penalty. This covers any kind of involuntary or compulsory labor, such as indentured labor, bonded labor, or similar labor–contracting arrangements. 38.4 The Contractor shall not recruit, or attempt to recruit, staff and labour from amongst the Employer's Personnel. 38.5 The Contractor shall comply with all the relevant labour Laws applicable to the Contractor's Personnel, including Laws relating to their employment, health, safety, welfare, immigration and emigration, and shall allow them all their legal rights. 38.6 The Contractor shall require his employees to obey all applicable Laws, including those concerning safety at work. 38.7 The Contractor shall not permit any of the Contractor's Personnel to maintain any temporary or permanent living quarters within the structures forming part of the Permanent Works. 38.8 The Contractor shall at all times take all reasonable precautions to maintain the health and safety of the Contractor's Personnel. In collaboration with local health authorities, the Contractor shall ensure that medical staff, first aid facilities, sick bay and ambulance service are available at all times at the Site and at any accommodation for Contractor's and Employer's Personnel, and that suitable arrangements are made for all necessary welfare and hygiene requirements and for the prevention of epidemics. 38.9 The Contractor shall appoint an accident prevention officer at the Site, responsible for maintaining safety and protection against accidents. This person shall be qualified for this responsibility, and shall have the authority to issue instructions and take protective measures to prevent accidents. Throughout the execution of the Works, the Contractor shall provide whatever is required by this person to exercise this responsibility and authority. 38.10 The Contractor shall send, to the Employer, details of any accident as soon as practicable after its occurrence. The Contractor shall maintain records and make reports concerning health, safety and welfare of persons, and damage to property,

	as the Employer may reasonably require. 38.11 Except as otherwise stated in the Employer's Requirements, the Contractor shall provide and maintain all necessary accommodation and welfare facilities for the Contractor's Personnel. The Contractor shall also provide facilities for the Employer's Personnel as stated in the Employer's Requirements. 38.12 Key Personnel: If no Key Personnel are specified in the Employer's Requirements this Clause shall not apply. The Contractor shall appoint the natural persons named in the Bid to the positions of Key Personnel. If not so named, or if an appointed person fails to act in the relevant position of Key Personnel, the Contractor shall submit to the Employer for consent the name and particulars of another person the Contractor proposes to appoint to such position. If consent is withheld or subsequently revoked, the Contractor shall similarly submit the name and particulars of a suitable replacement for such position. If the Employer does not respond within 15 days after receiving any such submission, by giving a Notice stating an objection to the appointment of such person (or replacement) with reasons, the Employer shall be deemed to have given the Employer's consent. The Contractor shall not, without the Employer's prior consent, revoke the appointment of any of the Key Personnel or appoint a replacement (unless the person is unable to act as a result of death, illness, disability or resignation, in which case the appointment shall be deemed to have been revoked with immediate effect and the appointment of a replacement shall be treated as a temporary appointment until the Employer gives his/her consent to this replacement, or another replacement is appointed, under this Clause). All Key Personnel shall be based at the Site (or, where Works are being executed off the Site, at the location of the Works) for the whole time that the Works are being executed. If any of the Key Personnel is to be temporarily absent during execution of the Works, a suitable replacement shall be temporarily appointed, subject to the Employer's prior consent. All Key Personnel shall be fluent in the language for communications defined in Clause 3. [Law and Language]
39. Child Labor	39.1 The Contractor shall not employ any child to perform any work including work, that is economically exploitative, or is likely to be hazardous to, or to interfere with, the child's education, or to be harmful to the child's health or physical, mental, spiritual, moral, or social development. 'Child' means a child below the statutory minimum age specified under applicable national law. Where national laws have provisions for employment of minors, the Contractor shall follow those laws applicable to the Contractor. Children below the age of 18 years shall not be employed in dangerous work.

40. Non-discrimination and Equal Opportunity	40.1 The Contractor shall not make employment decisions on the basis of personal characteristics unrelated to inherent job requirements. The Contractor shall base the employment relationship on the principle of equal opportunity and fair treatment, and shall not discriminate with respect to aspects of the employment relationship, including recruitment and hiring, compensation (including wages and benefits), working conditions and terms of employment, access to training, promotion, termination of employment or retirement, and discipline. In countries where national law provides for non-discrimination in employment, the Contractor shall comply with national law. When national laws are silent on nondiscrimination in employment, the Contractor shall meet this Sub clause's requirements. Special measures of protection or assistance to remedy past discrimination or selection for a particular job based on the inherent requirements of the job shall not be deemed discrimination.
Time Control	
41. Program and Progress	41.1 Within the time **stated in the SCC**, after the date of the Letter of Acceptance, the Contractor shall submit to the Employer for approval a Program showing the general methods, arrangements, order, and timing for all the activities consistent with those in the Activity Schedule. 41.2 Unless otherwise stated in the Contract, each program shall include: (a) the order in which the Contractor intends to carry out the Works, including the anticipated timing of each major stage of the Works, (b) the periods for reviews for Contractor's Documents, (c) the sequence and timing of inspections and tests specified in the Contract, and (d) a supporting report which includes: (i) a general description of the methods which the Contractor intends to adopt for the execution of each major stage of the Works, and (ii) the approximate number of each class of Contractor's Personnel and of each type of Contractor's Equipment for each major stage. 41.3 Whenever the previous program is inconsistent with actual progress or with the Contractor's obligations, an update of the Program shall be done by the Contractor showing the actual progress achieved on each activity and the effect of the progress achieved on the timing of the remaining work, including any changes to the sequence of the activities. 41.4 The Contractor shall submit an updated Activity Schedule within 15 days of being instructed to by the Employer's Representative, for Approval. 41.5 The Employer approval of the Program shall not alter the

	Contractor's obligations. The Contractor may revise the Program and submit it to the Employer again at any time 41.6 The contractor shall have to keep daily log of all the activities in a format approved by the Employer. The daily log shall not constitute nor take the place of any notice required to be given by Contractor to Employer pursuant to the Contract Documents. The daily log shall document all activities at the Project site including, but not limited to, the following: (i.) Weather conditions showing the high and low temperatures during work hours, the amount of precipitation received on the Project site, and any other weather conditions which adversely affect the Work; (ii.) Soil conditions which adversely affect the Work; (iii.) The hours of operation by Contractor and subcontractor's personnel; (iv.) The number of Contractor and subcontractor's personnel present and working at the Project site, by subcontract and trade; (v.) All equipment present at the Project site, description of equipment use and designation of time equipment was used (specifically indicating any down time); (vi.) Description of Work being performed at the Project site; (vii.) Any unusual or special occurrences at the Project site; (viii.) Materials received at the Project site; and (ix.) A list of all visitors to the Project site. 41.7 Unless otherwise **stated in the SCC**, monthly progress reports shall be prepared by the Contractor and submitted to the Employer in six copies **or as stated in the SCC**. The first report shall cover the period up to the end of the first calendar month following the Commencement Date. Reports shall be submitted monthly thereafter, each within 7 days after the last day of the period to which it relates. Reporting shall continue until the Contractor has completed all work which is known to be outstanding at the completion date stated in the Taking-Over Certificate for the Works. Each report shall include: (a) charts and detailed descriptions of progress, including each stage of design, Contractor's Documents, procurement, manufacture, delivery to Site, construction, erection, testing, commissioning and trial operation; (b) photographs showing the status of manufacture and of progress on the Site; (c) for the manufacture of each main item of Plant and Materials, the name of the manufacturer, manufacture location, percentage progress, and the actual or expected dates of: (i) commencement of manufacture, (ii) Contractor's inspections,

	(iii) tests, and (iv) shipment and arrival at the Site; (d) the details described in Clause 18.4,18.5; (e) copies of quality assurance documents, test results and certificates of Materials; (f) list of Variations, notices given under Clause 34. [Employer's Claims] and notices given under Clause 35.[Contractor's Claims] ; (g) safety statistics, including details of any hazardous' incidents and activities relating to environmental aspects and public relations; and (h) comparisons of actual and planned progress, with details of any events or circumstances which may jeopardize the completion in accordance with the Contract, and the measures being (or to be) adopted to overcome delays.
42. Extension of the Intended Completion Date	42.1 The Contractor shall be entitled to an extension of the Time for Completion if natural disaster such as earthquake, fire, *Excessive rainfall (atibrishti)*, flood and landslide occurs and affects the component of the project adversely or the contractor cannot perform the work due to the notification from the Government of Nepal during the occurrence of any pandemic.
43. Acceleration	43.1 When the Employer wants the Contractor to finish before the Intended Completion Date, the Employer shall obtain priced proposals for achieving the necessary acceleration from the Contractor. If the Employer accepts these proposals, the Intended Completion Date shall be adjusted accordingly and confirmed by both the Employer and the Contractor. 43.2 If the Contractor's priced proposals for acceleration are accepted by the Employer, they are incorporated in the Contract Price and treated as a Variation.
44. Delays Ordered by the Employer	44.1 The Employer may instruct the Contractor to delay or to suspend progress of part or all of the Works at any time instruct the Contractor. During such delay or suspension, the Contractor shall protect, store and secure such part or the Works against any deterioration, loss or damage.
45. Management Meetings	45.1 Either the Employer or the Contractor may require the other to attend a management meeting. The business of a management meeting shall be to review the plans for remaining work and to deal with matters raised in accordance with the early warning procedure. 45.2 The Employer shall record the business of management meetings and provide copies of the record to those attending the meeting and to the Employer. The responsibility of the parties for actions to be taken shall be decided by the Employer either at the management meeting or after the management meeting and stated in writing to all who attended the meeting.

	45.3 The Employer shall set pre-determined frequency of such meetings, as **specified in the SCC**
46. Early Warning	46.1 The Contractor shall warn the Employer at the earliest opportunity of specific likely future events or circumstances that may adversely affect the quality of the work, increase the Contract Price, or delay the execution of the Works. The Employer may require the Contractor to provide an estimate of the expected effect of the future event or circumstance on the Contract Price and Completion Date. The estimate shall be provided by the Contractor as soon as reasonably possible. 46.2 The Contractor shall cooperate with the Employer in making and considering proposals for how the effect of such an event or circumstance can be avoided or reduced by anyone involved in the work and in carrying out any resulting instruction of the Employer.
Quality Control	
47. Quality Assurance	47.1 The Contractor shall institute a quality assurance system to demonstrate compliance with the requirements of the Contract. The system shall be in accordance with the details stated in the Contract. The Employer shall be entitled to audit any aspect of the system. 47.2 Details of all procedures and compliance documents shall be submitted to the Employer for information before each design and execution stage is commenced. When any document of a technical nature is issued to the Employer, evidence of the prior approval by the Contractor himself shall be apparent on the document itself. 47.3 Compliance with the quality assurance system shall not relieve the Contractor of any of his duties, obligations or responsibilities under the Contract. 47.4 The Contractor shall carry out the manufacture of Plant, the production and manufacture of Materials, and all other execution of the Works: (a) in the manner (if any) specified in the Contract, (b) in a proper workmanlike and careful manner, in accordance with recognized good practice, and (c) with properly equipped facilities and non-hazardous Materials, except as otherwise specified in the Contract. 47.5 The Contractor shall submit samples to the Employer, for review in accordance with the procedures for Contractor's Documents, as specified in the Contract and at the Contractor's cost. Each sample shall be labelled as to origin and intended use in the Works. 47.6 The Employer's Personnel shall at all reasonable times: (a) have full access to all parts of the Site and to all places from which natural Materials are being obtained, and (b) during production, manufacture and construction (at the Site and, to the extent specified in the Contract, elsewhere), be entitled to examine, inspect, measure and test the materials and workmanship, and to check the progress of manufacture of Plant

	and production and manufacture of Materials. 47.7 The Contractor shall give the Employer's Personnel full opportunity to carry out these activities, including providing access, facilities, permissions and safety equipment. No such activity shall relieve the Contractor from any obligation or responsibility. 47.8 In respect of the work which Employer's Personnel are entitled to examine, inspect, measure and/or test, the Contractor shall give notice to the Employer whenever any such work is ready and before it is covered up, put out of sight, or packaged for storage or transport. 47.9 The Employer shall then either carry out the examination, inspection, measurement or testing without unreasonable delay, or promptly give notice to the Contractor that the Employer does not require to do so. If the Contractor fails to give the notice, he shall, if and when required by the Employer, uncover the work and thereafter reinstate and make good, all at the Contractor's cost.
48. Tests	48.1 This Clause shall apply to all tests specified in the Contract, other than the Tests after Completion [as stated in SCC] 48.2 The Employer shall check the Contractor's work and notify the Contractor of any Defects that are found. Such checking shall not affect the Contractor's responsibilities. The Employer may instruct the Contractor to search for a Defect and to uncover and test any work that the Employer considers may have a Defect. 48.3 If the Employer instructs the Contractor to carry out a test not specified in the Employer's Requirements to check whether any work has a Defect and the test shows that it does, the Contractor shall pay for the test and any samples. If there is no Defect, the test shall be a Compensation Event. 48.4 The Contractor shall provide all apparatus, assistance, documents and other information, electricity, equipment, fuel, consumables, instruments, labour, materials, and suitably qualified and experienced staff, as are necessary to carry out the specified tests efficiently. 48.5 The Contractor shall agree, with the Employer, the time and place for the specified testing of any Plant, Materials and other parts of the Works. 48.6 The Employer shall give the Contractor not less than 24 hours' notice of the Employer's intention to attend the tests. If the Employer does not attend at the time and place agreed, the Contractor may proceed with the tests, unless otherwise instructed by the Employer, and the tests shall then be deemed to have been made in the Employer's presence. 48.7 If the Contractor suffers delay and/or incurs Cost from complying with these instructions or as a result of a delay for which the Employer is responsible, the Contractor shall give notice to the Employer and shall be entitled subject to Clause 35. [Contractor's Claims] to: (a) an extension of time for any such delay, if completion is or will be delayed, under Clause 42 [Extension of Intended

	Completion Date], and (b) payment of any such Cost, which shall be added to the Contract Price. After receiving this notice, the Employer shall proceed in accordance with Clause 32. [Determinations] to agree or determine these matters. 48.8 The Contractor shall promptly forward to the Employer duly certified reports of the tests. When the specified tests have been passed, the Employer shall, endorse the Contractor's test certificate, or issue a certificate to him, to that effect. If the Employer has not attended the tests, he shall be deemed to have accepted the readings as accurate.
49. Correction of Defects	49.1 If, as a result of an examination, inspection, measurement or testing, any Plant, Materials, design or workmanship is found to be defective or otherwise not in accordance with the Contract, the Employer may reject the Plant, Materials, design or workmanship by giving notice to the Contractor, with reasons ; before the end of the Defects Liability Period, which begins at Completion, and is defined **in the SCC**.The Contractor shall then promptly make good the defect and ensure that the rejected item complies with the Contract. 49.2 Every time notice of a Defect is given, the Contractor shall correct the notified Defect within the length of time specified by the Employer's notice. Otherwise, The Defects Liability Period shall be extended for as long as Defects remain to be corrected. 49.3 If the Employer requires this Plant, Materials, design or workmanship to be retested, the tests shall be repeated under the same terms and conditions. If the rejection and retesting cause the Employer to incur additional costs, the Contractor shall subject to Clause 34. [Employer's Claims] pay these costs to the Employer. 49.4 Notwithstanding any previous test or certification, the Employer may instruct the Contractor to: (a) remove from the Site and replace any Plant or Materials which is not in accordance with the Contract, (b) remove and re-execute any other work which is not in accordance with the Contract, and (c) execute any work which is urgently required for the safety of the Works, whether because of an accident, unforeseeable event or otherwise. 49.5 If the Contractor fails to comply with any such instruction, which complies with Clause 33. [Instructions, Inspection and Audits], the Employer shall be entitled to employ and pay other persons to carry out the work. Except to the extent that the Contractor would have been entitled to payment for the work, the Contractor shall subject to Clause 34. [Employer's Claims] pay to the Employer all costs arising from this failure. 49.6 If delivery and/or erection of Plant and/or Materials was

	suspended under Clause 44.2 or Clause 80.[Contractor's Entitlement to Suspend Work], the Contractor's obligations under this Clause shall not apply to any defects or damage occurring more than two years after the Defects Liability Period for the Plant and/or Materials would otherwise have expired. 49.7 If the work of remedying of any defect or damage may affect the performance of the Works, the Employer may require the repetition of any of the tests described in the Contract, including Tests on Completion and/or Tests after Completion [if applicable]. The requirement shall be made by notice within 30 days after the defect or damage is remedied. These tests shall be carried out in accordance with the terms applicable to the previous tests. 49.8 The Contractor shall, if required by the Employer, search for the cause of any defect, under the direction of the Employer. Unless the defect is to be remedied at the cost of the Contractor, the Cost of the search shall be agreed or determined in accordance with Clause 32.[Determinations] and shall be added to the Contract Price. 49.9 The contractor shall be liable to the project completed by him to the Latent Defect Liability period, if specified in the SCC.
50. Uncorrected Defects	50.1 If the Contractor has not corrected a Defect within the time specified in the Employer's notice, the Employer shall assess the cost of having the Defect corrected, and remedial work shall have to be executed at the risk and cost of the Contractor. The Employer may (at his option): (a) carry out the work himself or by others, in a reasonable manner and at the Contractor's risk and cost, and the Contractor shall subject to Clause 34.[Employer's Claims] pay to the Employer the costs reasonably incurred by the Employer in remedying the defect or damage; (b) agree or determine a reasonable reduction in the Contract Price in accordance with Clause 32.[Determinations]; or (c) if the defect or damage deprives the Employer of substantially the whole benefit of the Works or any major part of the Works, terminate the Contract as a whole, or in respect of such major part which cannot be put to the intended use. Without prejudice to any other rights, under the Contract or otherwise, the Employer shall then be entitled to recover all sums paid for the Works or for such part (as the case may be), plus financing costs and the cost of dismantling the same, clearing the Site and returning Plant and Materials to the Contractor. 50.2 If the defect or damage cannot be remedied expeditiously on the Site and the Employer gives consent, the Contractor may remove from the Site for the purposes of repair such items of Plant as are defective or damaged. This consent may require the Contractor to increase the amount of the Performance Security by the full replacement cost of these items, or to provide other appropriate security.

Cost Control	
51. Contract Price	51.1 The Contractor shall be deemed to have satisfied himself as to the Correctness and Sufficiency of the Contract Price. Unless otherwise stated in the Contract, the Contract Price covers all the Contractor's obligations under the Contract (including those under Provisional Sums, if any) and all things necessary for the proper design, execution and completion of the Works and the remedying of any defects. 51.2 The Contractor shall bear all costs and charges for special and/or temporary rights-of-way which he may require, including those for access to the Site. The Contractor shall also obtain, at his risk and cost, any additional facilities outside the Site which he may require for the purposes of the Works. 51.3 Each Provisional Sum shall only be used, in whole or in part, in accordance with the Employer's instructions, and the Contract Price shall be adjusted accordingly. The total sum paid to the Contractor shall include only such amounts, for the work, supplies or services to which the Provisional Sum relates, as the Employer shall have instructed. For each Provisional Sum, the Employer may instruct: (a) work to be executed (including Plant, Materials or services to be supplied) by the Contractor and valued under Clause 53. [Variations]; and/or (b) Plant, Materials or services to be purchased by the Contractor, for which there shall be added to the Contract Price less the original Provisional Sums: (i) the actual amounts paid (or due to be paid) by the Contractor, and (ii) a sum for overhead charges and profit, calculated as a percentage of these actual amounts by applying the relevant percentage rate (if any) stated in the Contract. 51.4 The Contractor shall, when required by the Employer, produce quotations, invoices, vouchers and accounts or receipts in substantiation. 51.5 In such lump sum contract, the Activity Schedule shall contain the priced activities for the Works to be performed by the Contractor. The Activity Schedule is used to monitor and control the performance of activities on which basis the Contractor will be paid. If payment for Materials on Site shall be made separately, the Contractor shall show delivery of Materials to the Site separately on the Activity Schedule. 51.6 Unless otherwise stated in the SCC: (a) payment for the Works shall be made on the basis of the lump sum Contract Price, subject to adjustments in accordance with the Contract; and (b) the Contractor shall pay all taxes, duties and fees required to be paid by him under the Contract, and the Contract Price shall

	not be adjusted for any of these costs, except otherwise as per the Clause 53.5
52. Changes in the Contract Price	52.1 The Activity Schedule shall be amended by the Contractor to accommodate changes of Program or method of working made at the Contractor's own discretion. Prices in the Activity Schedule shall not be altered when the Contractor makes such changes to the Activity Schedule.
53. Variations	53.1 No variation order shall be made unless and otherwise any addition or alteration to the work is made by the Employer. 53.2Variations may be initiated by the Employer at any time, with or with out request from the Contractor prior to issuing the Taking-Over Certificate for the Works. A Variation shall not comprise the omission of any work which is to be carried out by others. Each instruction to execute a Variation, with any requirements for the recording of Costs, shall be issued by the Employer to the Contractor, who shall acknowledge receipt. 53.3 The Contractor shall execute and be bound by each Variation, unless the Contractor promptly gives notice to the Employer stating (with supporting particulars) that (i) the Contractor cannot readily obtain the Goods required for the Variation, (ii) it will reduce the safety or suitability of the Works, or (iii) it will have an adverse impact on the achievement of the Performance Guarantees. Upon receiving this notice, the Employer shall cancel, confirm or vary the instruction 53.4 The Contractor may, at any time, submit to the Employer a written proposal which (in the Contractor's opinion) will, if adopted, (1) accelerate completion, (ii) reduce the cost to the Employer of executing, maintaining or operating the Works, (iii) improve the efficiency or value to the Employer of the completed Works, or (iv) otherwise be of benefit to the Employer. The proposal shall be prepared at the cost of the Contractor. The Employer shall, as soon as practicable after receiving such proposal, respond with approval, disapproval or comments. 53.5 Upon instructing or approving a Variation, the Employer shall proceed in accordance with Clause 32. [Determinations] to agree or determine adjustments to the Contract Price and the Schedule of Payments. These adjustments shall take account of the Contractor's submissions under Clause 53.3, if applicable. 53.6 Adjustments for Changes in Legislation :The Contract Price shall be adjusted to take account of any increase or decrease in Cost resulting from a change in the Laws of Nepal (including the introduction of new Laws and the repeal or modification of existing Laws) or in the judicial or official governmental interpretation of such Laws, made after the Base Date, which affect the Contractor in the performance of obligations under the Contract. If the Contractor suffers (or will suffer) delay and/or incurs (or will incur) additional Cost as a result of these changes in the Laws or in such interpretations, made after the Base Date, the Contractor shall give notice to the Employer and shall be

	entitled subject to Clause 35. [Contractor's Claims] to: (a) an extension of time for any such delay, if completion is or will be delayed, under Clause 42 [Extension of Intended Completion Date], and (b) payment of any such Cost, which shall be added to the Contract Price. After receiving this notice, the Employer shall proceed in accordance with Clause 32. [Determinations] to agree or determine these matters.
54. Cash Flow Forecasts	54.1 When the Program is updated, the Contractor shall provide the Employer with an updated cash flow forecast.
55. Interim Payment Certificate	55.1 The Contractor shall submit a Statement in six copies (**or as stated in the SCC**) to the Employer after the end of the period of payment **stated in the SCC** (if not stated, after the end of each month), in a form approved by the Employer, showing in detail the amounts to which the Contractor considers himself to be entitled, together with supporting documents which shall include the relevant report on progress in accordance with Clause 41. [Program and Progress]. 55.2 The Statement shall include the following items, as applicable, which shall be expressed in the various currencies in which the Contract Price is payable, in the sequence listed: (a) the estimated contract value of the Works executed and the Contractor's Documents produced up to the end of the month (including Variations but excluding items described in sub-paragraphs (b) to (f) below); (b) any amounts to be added and deducted for changes in legislation and changes in cost, in accordance with the Clause 53.5 and Clause 59. [Price Adjustments]; (c) any amount to be deducted for retention, calculated by applying the percentage of retention as per the Clause 60.[Retention] to the total of the above amounts, (d) any amounts to be added and deducted for the advance payment and repayments in accordance with Clause 63. [Advance Payment]; (e) any other additions or deductions which may have become due under the Contract or otherwise, including those under Clause 36.[Dispute Settlement],37.[Dispute Settlement by Arbitaration]; and (f) the deduction of amounts included in previous Statements. 55.3 The estimated contract value of the Works executed shall comprise the value of completed activities in the Activity Schedule and/or as methodology **stated in the SCC**. 55.4 Schedule of Payments : If the Contract includes a Schedule of Payments specifying the installments in which the Contract Price will be paid, then unless otherwise stated in this Schedule: (a) the installments quoted in the Schedule of Payments shall be

	the estimated contract values for the purposes of sub-paragraph (a) of Clause 55.2, subject to Clause 55.5; and (b) if these installments are not defined by reference to the actual progress achieved in executing the Works, and if actual progress is found to be less than that on which the Schedule of Payments was based, then the Employer may proceed in accordance with Clause 32. [Determinations] to agree or determine revised installments, which shall take account of the extent to which progress is less than that on which the installments were previously based. If the Contract does not include a Schedule of Payments, the Contractor shall submit non-binding estimates of the payments which he expects to become due during each quarterly period. The first estimate shall be submitted within 45 days after the Commencement Date. Revised estimates shall be submitted at quarterly intervals, until the Taking-Over Certificate has been issued for the Works. 55.5 If the Contractor is entitled, under the Contract, to an interim payment for Plant and Materials which are not yet on the Site, the Contractor shall nevertheless not be entitled to such payment unless: (a) the relevant Plant and Materials are in the Country and have been marked as the Employer's property in accordance with the Employer's instructions; or (b) the Contractor has delivered, to the Employer, evidence of insurance and a bank guarantee in a form and issued by an entity approved by the Employer in amounts and currencies equal to such payment. This guarantee may be in a similar form to the form referred to in Clause 63. [Advance Payment] and shall be valid until the Plant and Materials are properly stored on Site and protected against loss, damage or deterioration. 55.6 Payments due shall not be withheld, except that: (a) if anything supplied or work done by the Contractor is not in accordance with the Contract, the cost of rectification or replacement may be withheld until rectification or replacement has been completed; and/or (b) if the Contractor was or is failing to perform any work or obligation in accordance with the Contract, and had been so notified by the Employer, the value of this work or obligation may be withheld until the work or obligation has been performed. 55.7 The Employer may, by any payment, make any correction or modification that should properly be made to any amount previously considered due. Payment shall not be deemed to indicate the Employer's acceptance, approval, consent or satisfaction.
56. Payments	56.1 The Employer shall pay the Contractor the amounts certified by the Employer after assurance of the quality of the work as per the

	specification substantiated with the test report as enunciated in the Employers' requirement and in the activity schedule within 30 days of the date of each payment certificate. 56.2 If the Employer makes a late payment, the Contractor shall be paid interest as **indicated in the SCC** on the late payment in the next payment. Interest shall be calculated from the date by which the payment should have been made up to the date when the late payment is made. The Contractor shall be entitled to this payment without formal notice, and without prejudice to any other right or remedy. 56.3 If an amount certified is increased in a later certificate or as a result of an award by an Arbitrator, the Contractor shall be paid interest upon the delayed payment as set out in this clause. Interest shall be calculated from the date upon which the increased amount would have been certified in the absence of dispute. 56.3 Activities of the Works which are unpriced in the Activity Schedule, shall not be paid for by the Employer and shall be deemed covered by other activities prices in the Contract.
57. Tax	57.1 The Employer shall not adjust the Contract Price in case of change in taxes, duties, and other levies.
58. Currency	58.1 The currency of Contracts shall be Nepali Rupees.
59. Price Adjustment	59.1 The contract shall not be subjected to price adjustment in any case.
60. Retention	60.1 The Employer shall retain from each payment due to the Contractor the proportion **stated in the SCC** until the expiry of the Defect Liability Period 60.2 Upon the issue of a Defects Liability Certificate by the Employer, **in accordance with GCC 77.0**, half the total amount retained shall be repaid to the Contractor and half when the Contractor has submitted the evidence of submission of tax return to the concerned Internal Revenue Office.
61. Liquidated Damages	61.1 If contractor fails to complete the section of work as per the milestone, the Employer shall charge liquidated damage **as stated in the SCC**, but if the contractor completes the whole project within the intended project completion date, the employer shall pay back the amount equivalent to the previously charged liquidated damage to the contractor. 61.2 If the Contractor fails to complete the works on or before the last date of intended completion date (initial or extended contract period where the time extension has been granted to the Contractor by the Employer period), the Contractor shall subject to Clause 34. [Employer's Claims] pay delay damages to the Employer for this default. These delay damages shall be the sum **stated in the SCC**, which shall be paid for every day which shall elapse between the relevant Time for Completion and the date stated in the Taking-Over Certificate.

	61.3 The total amount of liquidated damages shall not exceed the amount **defined in the SCC**. The Employer may deduct liquidated damages from payments due to the Contractor. However, in such case, the Employer shall extend the Intended Completion Date, which shall be subjected to the Liquidated Damage. 61.4 These delay damages shall be the only damages due from the Contractor for such default, other than in the event of termination under Clause 79. [Termination by Employer] prior to completion of the Works. These damages shall not relieve the Contractor from his obligation to complete the Works, or, from any other duties, obligations or responsibilities which he may have under the Contract.
62. Bonus	62.1 The Contractor shall be paid a Bonus calculated at the rate per calendar day **stated in the SCC** for each day (less any days for which the Contractor is paid for acceleration) that the Completion is earlier than the Initial Intended Completion Date. The Employer shall certify that the Works are complete, although they may not be due to be complete. 62.2 The total amount of Bonus shall not exceed the amount **defined in the SCC**.
63. Advance Payment	63.1 The Employer shall make an advance payment in two equal installments, as an interest-free loan for mobilization and design, when the Contractor submits an unconditional bank guarantee from 'A' class commercial Bank or Financial Institution in a form acceptable to the Employer in amounts equal to the advance payment, in accordance with this Clause including the details **stated in the SCC**. 63.2 The Contractor is to use the advance payment only to pay for Design, Equipment, Plant, Materials, and mobilization expenses required specifically for execution of the Contract. The Contractor shall demonstrate that advance payment has been used in this way by supplying copies of invoices or other documents to the Employer. 63.3 The guarantee shall remain effective until the advance payment has been repaid, but the amount of the guarantee shall be progressively reduced by the amounts repaid by the Contractor. 63.4 The advance payment shall be amortized at the rate for repayments **as stated in SCC**, and it shall be calculated by dividing the total amount of the advance payment by the Contract Price stated in the Contract Agreement less Provisional Sums. 63.5 No account shall be taken of the advance payment or its repayment in assessing valuations of work done, Variations, price adjustments(if claimed under the contract), Compensation Events, Bonuses, or Liquidated Damages.
64. Securities	64.1 The Performance Security (including any additional performance securities {above 5% of contract price} required as per the Prevailing Public Procurement Act and Regulation) shall be

	provided to the Employer no later than the date specified in the Letter of Acceptance and shall be issued in an amount **specified in the SCC**, by a 'A' class commercial Bank or Financial Institution acceptable to the Employer, and denominated in Nepali Rupees. The Performance Security (other than additional performance securities) shall be valid until a date 30 days from the date of issue of the Defect Liability Certificate in the case of a bank guarantee. 64.2 Any additional performance securities {above 5% of contract price} as per Clause 64.1 shall be valid until a date 30 days from the date of Taking Over of the Works and shall be returned within 15 days from the Taking Over of the Works. 64.3 The performance security issued by any foreign Bank outside Nepal must be counter guaranteed by an 'A' class commercial Bank or Financial Institution in Nepal. 64.4 The Employer shall not make a claim under the Performance Security, except for amounts to which the Employer is entitled under the Contract in the event of: (a) failure by the Contractor to extend the validity of the Performance Security as instructed by Employer, in which event the Employer may claim the full amount of the Performance Security, (b) failure by the Contractor to pay the Employer an amount due, as either agreed by the Contractor or determined under Clause 34. [Employer's Claims] or Clause 36[Dispute Settlement] or Clause 37[Dispute Settlement by Arbitration] , within 45 days after this agreement or determination, (c) failure by the Contractor to remedy a default within 45 days after receiving the Employer's notice requiring the default to be remedied, or (d) circumstances which entitle the Employer to termination under Clause 79.[Termination by Employer], irrespective of whether notice of termination has been given. 64.5 The Employer shall indemnify and hold the Contractor harmless against and from all damages, losses and expenses (including legal fees and expenses) resulting from a claim under the Performance Security to the extent to which the Employer was not entitled to make the claim. 64.6 The Employer shall return the Performance Security (other than additional performance securities) to the Contractor within 21 days after the Contractor has become entitled to receive the Performance Certificate.
65. Day works	65.1 If applicable, the Day works rates in the Contractor's Bid shall be used for small additional amounts of work only when the Employer has given written instructions in advance for additional work to be paid for in that way. 65.2 For work of a minor or incidental nature, the Employer may instruct that a Variation shall be executed on a daywork basis.

	The work shall then be valued in accordance with the daywork schedule included in the Contract, and the following procedure shall apply. If a daywork schedule is not included in the Contract, this Clause shall not apply. 65.3 Before ordering Goods for the work, the Contractor shall submit quotations to the Employer. When applying for payment, the Contractor shall submit invoices, vouchers and accounts or receipts for any Goods. 65.4 Except for any items for which the daywork schedule specifies that payment is not due, the Contractor shall deliver each day to the Employer accurate statements in duplicate which shall include the following details of the resources used in executing the previous day's work: (a) the names, occupations and time of Contractor's Personnel, (b) the identification, type and time of Contractor's Equipment and Temporary Works, and (c) the quantities and types of Plant and Materials used. 65.5 One copy of each statement will, if correct, or when agreed, be signed by the Employer and returned to the Contractor. The Contractor shall then submit priced statements of these resources to the Employer, prior to their inclusion in the next Statement under Clause 55.[Interim Payment Certificates].
66. Cost of Repairs	66.1 Loss or damage to the Works or Materials to be incorporated in the Works between the Commencement Date and the end of the Defects Correction periods shall be remedied by the Contractor at the Contractor's cost if the loss or damage arises from the Contractor's acts or omissions.
Force Majeure	
67. Definition of Force Majeure	67.1 In this Clause, "Force Majeure" means an exceptional event or circumstance, natural disaster such as earthquake, fire, *Excessive rainfall (atibrishti)*, flood and landslide, if occurs and affects the component of the project adversely or the contractor cannot perform the work due to the notification from the Government of Nepal during the occurrence of any pandemic.
68. Notice of Force Majeure	68.1 If a Party is or will be prevented from performing its substantial obligations under the Contract by Force Majeure, then it shall give notice to the other Party of the event or circumstances constituting the Force Majeure and shall specify the obligations, the performance of which is or will be prevented. The notice shall be given within 15 days after the Party became aware, or should have become aware, of the relevant event or circumstance constituting Force Majeure. 68.2 The Party shall, having given notice, be excused performance of its obligations for so long as such Force Majeure prevents it from performing them. 68.3 Notwithstanding any other provision of this Clause, Force Majeure shall not apply to obligations of either Party to make

	payments to the other Party under the Contract.
69. Duty to Minimize Delay	69.1 Each Party shall at all times use all reasonable endeavors to minimize any delay in the performance of the Contract as a result of Force Majeure. 69.2 A Party shall give notice to the other Party when it ceases to be affected by the Force Majeure.
70. Consequences of Force Majeure	70.1 If the Contractor is prevented from performing its substantial obligations under the Contract by Force Majeure of which notice has been given under GCC 68, and suffers delay and/or incurs Cost by reason of such Force Majeure, the Contractor shall be entitled subject to GCC 37 to (a) an extension of time for any such delay, if completion is or will be delayed, under GCC42 ; and (b) if the event or circumstance is of the kind described in sub-paragraphs (a) to (d) of GCC 68.2 and, in the case of subparagraphs (b) to (d), occurs in Nepal, payment of any such Cost, including the costs of rectifying or replacing the Works and/or Goods damaged or destructed by Force Majeure, to the extent they are not indemnified through the insurance policy referred to in GCC 23. 70.2 After receiving this notice, the Employer shall proceed in accordance with GCC 32[Determinations] to agree or determine these matters.
71. Force Majeure Affecting Subcontractor	71.1 If any Subcontractor is entitled under any contract or agreement relating to the Works to relief from force majeure on terms additional to or broader than those specified in this Clause, such additional or broader force majeure events or circumstances shall not excuse the Contractor's nonperformance or entitle him to relief under this Clause.
72. Optional Termination, Payment and Release	72.1 If the execution of substantially all the Works in progress is prevented for a continuous period of 90 days by reason of Force Majeure of which notice has been given under GCC 68, or for multiple periods which total more than 150 days due to the same notified Force Majeure, then either Party may give to the other Party a notice of termination of the Contract. In this event, the termination shall take effect 7 days after the notice is given, and the Contractor shall proceed in accordance with GCC 79.5. 72.2 Upon such termination, the Employer shall determine the value of the work done and issue a Payment Certificate, which shall include (a) the amounts payable for any work carried out for which a price is stated in the Contract; (b) the Cost of Plant and Materials ordered for the Works which have been delivered to the Contractor, or of which the Contractor is liable to accept delivery: this Plant and Materials shall become the property of (and be at the risk of) the Employer when paid for by the Employer, and the Contractor shall place the same at the Employer's

	disposal; (c) other Costs or liabilities which in the circumstances were reasonably and necessarily incurred by the Contractor in the expectation of completing the Works; (d) the Cost of removal of Temporary Works and Contractor's Equipment from the Site and the return of these items to the Contractor's works in his country (or to any other destination at no greater cost); and (e) the Cost of repatriation of the Contractor's staff and labor employed wholly in connection with the Works at the date of termination.
73. Release from Performance	73.1 Notwithstanding any other provision of this Clause, if any event or circumstance outside the control of the Parties (including, but not limited to, Force Majeure) arises, which makes it impossible or unlawful for either or both Parties to fulfill its or their contractual obligations or which, under the law governing the Contract, entitles the Parties to be released from further performance of the Contract, then upon notice by either Party to the other Party of such event or circumstance, (a) the Parties shall be discharged from further performance, without prejudice to the rights of either Party in respect of any previous breach of the Contract; and (b) the sum payable by the Employer to the Contractor shall be the same as would have been payable under GCC 72 if the Contract had been terminated under GCC 72.
Finishing the Contract	
74. Test on Completion	74.1 The Contractor shall carry out the **Tests on Completion (as stated in the SCC)** in accordance with this Clause and Clause 48.[Tests] after providing the documents in accordance with Clause 78[Operating and Maintenance Manuals]. 74.2 The Contractor shall give to the Employer not less than 21 days' notice of the date after which the Contractor will be ready to carry out each of the Tests on Completion. Unless otherwise agreed, Tests on Completion shall be carried out within 15 days after this date, on such day or days as the Employer shall instruct. 74.3 Unless otherwise **stated in the SCC**, the Tests on Completion shall be carried out in the following sequence: (a) pre-commissioning tests, which shall include the appropriate inspections and ("dry" or "cold") functional tests to demonstrate that each item of Plant can safely under-take the next stage,(b); (b) commissioning tests, which shall include the specified operational tests to demonstrate that the Works can be operated safely and as specified, under all available operating conditions; and

	(c) trial operation, which shall demonstrate that the Works perform reliably and in accordance with the Contract. 74.4 During trial operation, when the Works are operating under stable conditions, the Contractor shall give notice to the Employer that the Works are ready for any other Tests on Completion, including performance tests to demonstrate whether the Works conform with criteria specified in the Employer's Requirements and with the Performance Guarantees. 74.5 Trial operation shall not constitute a taking-over under Clause 76 [Taking Over of the Works]. Unless otherwise stated in the SCC, any product produced by the Works during trial operation shall be the property of the Employer. 74.6 In considering the results of the Tests on Completion, appropriate allowances shall be made for the effect of any use of the Works by the Employer on the performance or other characteristics of the Works. As soon as the Works, , have passed each of the Tests on Completion described in Clause 74.3 (a), (b) or (c), the Contractor shall submit a certified report of the results of these Tests to the Employer. 74.7 If the Tests on Completion are being unduly delayed by the Employer, Clause 48.7 and/or Clause 74.13, 74.14 shall be applicable. 74.8 If the Tests on Completion are being unduly delayed by the Contractor, the Employer may by notice require the Contractor to carry out the Tests within 21 days after receiving the notice. The Contractor shall carry out the Tests on such day or days within that period as the Contractor may fix and of which he shall give notice to the Employer. 74.9 If the Contractor fails to carry out the Tests on Completion; within the period of 21 days, the Employer's Personnel may proceed with the Tests at the risk and cost of the Contractor. These Tests on Completion shall then be deemed to have been carried out in the presence of the Contractor and the results of the Tests shall be accepted as accurate. 74.10 If the Works, , fail to pass the Tests on Completion, Clause 49.1 shall apply, and the Employer or the Contractor may require the failed Tests, and Tests on Completion on any related work, to be repeated under the same terms and conditions. 74.11 If the Works, fail to pass the Tests on Completion repeated under Clause 74.10, the Employer shall be entitled to: (a) order further repetition of Tests on Completion under Clause 74.10; (b) if the failure deprives the Employer of substantially the whole benefit of the Works , reject the Works (as the case may be), in which event the Employer shall have the same remedies as are provided in sub-paragraph (c) of 50.1; or (c) issue a Taking-Over Certificate.

	74.12 In the event of sub-paragraph (c), the Contractor shall proceed in accordance with all other obligations under the Contract, and the Contract Price shall be reduced by such amount as shall be appropriate to cover the reduced value to the Employer as a result of this failure. In such case, the extent of the failure shall be **defined in the SCC** or in the Employer's Requirements, minimum acceptable performance criteria shall also be specified. Unless the relevant reduction for this failure is stated (or its method of calculation is defined) in the Contract, the Employer may require the reduction to be (i) agreed by both Parties (in full satisfaction of this failure only) and paid before this Taking-Over Certificate is issued, or (ii) determined and paid under Clause 34. [Employer's Claims] and Clause 32. [Determinations]. 74.13 If the Contractor is prevented, for more than 15 days, from carrying out the Tests on Completion by a cause for which the Employer is responsible, the Contractor shall carry out the Tests on Completion as soon as practicable. 74.14 If the Contractor suffers delay and/or incurs Cost as a result of this delay in carrying out the Tests on Completion, the Contractor shall give notice to the Employer and shall be entitled subject to Clause 35. [Contractor's Claims] to: (a) an extension of time for any such delay, if completion is or will be delayed, under Clause 42 [Extension of Intended Completion Date], and (b) payment of any such Cost, which shall be added to the Contract Price. 74.15 After receiving this notice, the Employer shall proceed in accordance with Clause 32. [Determinations] to agree or determine these matters.
75. Tests after Completion	75.1 If Tests after Completion are specified in the Contract, this Clause shall apply. Unless otherwise stated in the SCC: (a) The Employer shall provide all electricity, fuel and materials, and make the Employer's Personnel and Plant available; (b) the Contractor shall provide any other plant, equipment and suitably qualified and experienced staff, as are necessary to carry out the Tests after Completion efficiently; and (c) the Contractor shall carry out the Tests after Completion in the presence of such Employer's and/or Contractor's Personnel as either Party may reasonably request. 75.2 The Tests after Completion shall be carried out as soon as is reasonably practicable after the Works have been taken over by the Employer. The Employer shall give to the Contractor 21 days' notice of the date after which the Tests after Completion will be carried out. Unless otherwise agreed, these Tests shall be carried out within 15 days after this date, on the day or days determined by the Employer.

	75.3 The results of the Tests after Completion shall be compiled and evaluated by the Contractor, who shall prepare a detailed report. Appropriate account shall be taken of the effect of the Employer's prior use of the Works. 75.4 If the Contractor incurs Cost as a result of any unreasonable delay by the Employer to the Tests after Completion, the Contractor shall (i) give notice to the Employer and (ii) be entitled subject to Clause 35. [Contractor's Claims] to payment of any such Cost, which shall be added to the Contract Price. 75.5 After receiving this notice, the Employer shall proceed in accordance with Clause 32. [Determinations] to agree or determine this Cost. 75.6 If, for reasons not attributable to the Contractor, a Test after Completion on the Works cannot be completed during the Defects Liability Period, then the Works shall be deemed to have passed this Test after Completion. 75.7 If the Works, fail to pass the Tests after Completion: (a) execute all work required to remedy defects or damage, as may be notified by the Employer on or before the expiry date of the Defects Liability Period for the Works , and (b) either Party may then require the failed Tests, and the Tests after Completion on any related work, to be repeated under the same terms and conditions. 75.8 If and to the extent that this failure and retesting are attributable to any of the matters listed below: (a) the design of the Works, (b) Plant, Materials or workmanship not being in accordance with the Contract, (c) improper operation or maintenance which was attributable to matters for which the Contractor is responsible (under Clauses 78 or otherwise), or (d) failure by the Contractor to comply with any other obligation. ;and cause the Employer to incur additional costs, the Contractor shall subject to Clause 34. [Employer's Claims] pay these costs to the Employer. 75.9 If the following conditions apply, namely: (a) the Works, fail to pass any or all of the Tests after Completion, (b) the relevant sum payable as non-performance damages for this failure is stated (or its method of calculation is defined) in the Contract, and (c) the Contractor pays this relevant sum to the Employer during the Defects Liability Period , then the Works shall be deemed to have passed these Tets after Completion.

	then the Works or Section shall be deemed to have passed these Tests after Completion. In such case, the method of calculating the non-performance damages (based on the extent of the failure) shall be **defined in the SCC or in the Employer's Requirements,** and the minimum acceptable performance criteria shall also be specified. Results lower than minimum acceptable performance criteria, shall be cause of rejection of the Works or Section and Cost shall be recovered from the Contractor as determined as per the Clause 32.[Determinations]. 75.10 If the Works, fail to pass a Test after Completion and the Contractor proposes to make adjustments or modifications to the Works or such Section, the Contractor may be instructed by (or on behalf of) the Employer that right of access to the Works cannot be given until a time that is convenient to the Employer. The Contractor shall then remain liable to carry out the adjustments or modifications and to satisfy this Test, within a reasonable period of receiving notice by (or on behalf of) the Employer of the time that is convenient to the Employer. However, if the Contractor does not receive this notice during the relevant Defects Liability Period, the Contractor shall be relieved of this obligation and the Works (as the case may be) shall be deemed to have passed this Test after Completion. 75.11 If the Contractor incurs additional Cost as a result of any unreasonable delay by the Employer in permitting access to the Works or Plant by the Contractor, either to investigate the causes of a failure to pass a Test after Completion or to carry out any adjustments or modifications, the Contractor shall (i) give notice to the Employer and (ii) be entitled subject to Clause 35. [Contractor's Claims] to payment of any such Cost, which shall be added to the Contract Price. 75.12 After receiving this notice, the Employer shall proceed in accordance with Clause 32. [Determinations] to agree or determine this Cost.
76. Taking Over of the Works	76.1 Except as stated in Clause 74.11 and 74.12, the Works shall be taken over by the Employer when (i) the Works have been completed in accordance with the Contract, and except as allowed in Clause 76.3(a) below, and (ii) a Taking-Over Certificate for the Works has been issued, or is deemed to have been issued in accordance with this Clause. 76.2 The Contractor may apply by notice to the Employer for a Taking-Over Certificate not earlier than 15 days before the Works will, in the Contractor's opinion, be complete and ready for taking over. 76.3 The Employer shall, within 30 days after receiving the Contractor's application: (a) issue the Taking-Over Certificate to the Contractor, stating the date on which the Works were completed in accordance with the Contract, except for any defects

	which will not substantially affect the use of the Works for their intended purpose (either until or whilst this work is completed and these defects are remedied); or (b) reject the application, giving reasons and specifying the work required to be done by the Contractor to enable the Taking-Over Certificate to be issued. The Contractor shall then complete this work before issuing a further notice under this Clause. 76.4 If the Employer fails either to issue the Taking-Over Certificate or to reject the Contractor's application within the period of 30 days, and if the Works (as the case may be) are substantially in accordance with the Contract, the Taking-Over Certificate shall be deemed to have been issued on the last day of that period
77. Final Account	77.1 Performance Certificate: Performance of the Contractor's obligations shall not be considered to have been completed until the Employer has issued the Performance Certificate to the Contractor, stating the date on which the Contractor completed his obligations under the Contract. The Employer shall issue the Performance Certificate within 30 days after the latest of the expiry dates of the Defects Liability Periods, or as soon thereafter as the Contractor has supplied all the Contractor's Documents and completed and tested all the Works, including remedying any defects. If the Employer fails to issue the Performance Certificate accordingly: (a) the Performance Certificate shall be deemed to have been issued on the date 30 days after the date on which it should have been issued, as required by this Clause, and (b) The Clause 89.1 and sub-paragraph (a) of Clause 77.7 shall be inapplicable. Only the Performance Certificate shall be deemed to constitute acceptance of the Works. 77.2 Within 60 days after receiving the Performance Certificate, the Contractor shall submit, to the Employer, six copies of a draft Final Account with supporting documents showing in detail in a form approved by the Employer: (a) the value of all work done in accordance with the Contract, and (b) any further sums which the Contractor considers to be due to him under the Contract or otherwise. 77.3 If the Employer disagrees with or cannot verify any part of the draft Final Account, the Contractor shall submit such further information as the Employer may reasonably require and shall make such changes in the draft as may be agreed between them. The Contractor shall then prepare and submit to the Employer the Final Account as agreed. This agreed statement is referred to in these Conditions as the "Final Account". 77.4 However if, following discussions between the Parties and any changes to the draft Final Account which are agreed, it becomes

	evident that a dispute exists, the Employer shall pay the agreed parts of the draft Final Account in accordance with Clause 55.[Interim Payment Certificate]. Thereafter, if the dispute is finally resolved under Clause 36.[Dispute Settlement] or Clause 37.[Dispute Settlement by Arbitration], the Contractor shall then prepare and submit to the Employer a Final Account. 77.5 When submitting the Final Account, the Contractor shall submit a written discharge which confirms that the total of the Final Account represents full and final settlement of all moneys due to the Contractor under or in connection with the Contract. This discharge may state that it becomes effective when the Contractor has received the Performance Security and the out-standing balance of this total, in which event the discharge shall be effective on such date. 77.6 Within 45 days after receiving the Final Account and written discharge, the Employer shall pay to the Contractor the amount which is finally due, less all amounts previously paid by the Employer and any deductions in accordance with Clause 34. [Employer's Claims] 77.7 The Employer shall not be liable to the Contractor for any matter or thing under or in connection with the Contract or execution of the Works, except to the extent that the Contractor shall have included an amount expressly for it, in the Final Account. However, this Clause shall not limit the Employer's liability under his indemnification obligations, or the Employer's liability in any case of fraud, deliberate default or reckless misconduct by the Employer.
78. Operating and Maintenance Manuals	78.1 As required under the Contract, the Contractor shall prepare, and keep up-to-date, a complete set of "as-built" records of the execution of the Works, showing the exact as-built locations, sizes and details of the work as executed. These records shall be kept on the Site and shall be used exclusively for the purposes of this Clause. Two copies shall be supplied to the Employer prior to the commencement of the Tests on Completion. 78.2 In addition, the Contractor shall supply to the Employer as-built drawings of the Works, showing all Works as executed, and submit them to the Employer for review under Clause 27. [Design by Contractor]. The Contractor shall obtain the consent of the Employer as to their size, the referencing system, and other relevant details. 78.3 Prior to the issue of any Taking-Over Certificate, the Contractor shall supply to the Employer the specified numbers and types of copies of the relevant as-built drawings, in accordance with the Employer's Requirements. The Works shall not be considered to be completed for the purposes of taking-over under Sub Clause 76. [Taking Over of the Works] until the Employer has received these documents. 78.4 As required under the Contract , prior to commencement of the Tests on Completion, the Contractor shall supply to the Employer provisional operation and maintenance manuals in sufficient

	detail for the Employer to operate, maintain, dismantle, reassemble, adjust and repair the Plant. The Works shall not be considered to be completed for the purposes of taking-over under Clause 76. [Taking Over of the Works] until the Employer has received final operation and maintenance manuals in such detail, and any other manuals specified in the Employer's Requirements. for these purposes.
79. Termination by Employer	79.1 If the Contractor fails to carry out any obligation under the Contract, the Employer may by notice require the Contractor to make good the failure and to remedy it within a specified reasonable time. 79.2 The **Employer** shall be entitled to terminate the Contract if the Contractor: (a) fails to comply with Clause 64 [Securities] or with a notice under Clause 79.1, (b) abandons the Works or otherwise plainly demonstrates the intention not to continue performance of his obligations under the Contract, (c) without reasonable excuse fails to proceed with the Works in accordance with Clause 41 [Program and Progress], (d) subcontracts the whole of the Works or assigns the Contract without the required agreement, (e) becomes bankrupt or insolvent, goes into liquidation, has a receiving or administration order made against him, compounds with his creditors, or carries on business under a receiver, trustee or manager for the benefit of his creditors, or if any act is done or event occurs which (under applicable Laws) has a similar effect to any of these acts or events, (f) If the Contractor, in the judgment of the Employer has engaged in corrupt or fraudulent practices in competing for or in executing the Contract, pursuant to GCC 84.1. However, lawful inducements and rewards to Contractor's Personnel shall not entitle termination. (g) The Contractor uses the advance payment for matters other than the contractual obligations, (h) the Contractor stops work for 30 days when no stoppage of work is shown on the current Program and the stoppage has not been authorized by the Employer; (i) the Employer gives Notice that failure to correct a particular Defect is a fundamental breach of Contract and the Contractor fails to correct it within a reasonable period of time determined by the Employer; (j) the Employer gives two consecutive Notices to update the Program and accelerate the works to ensure compliance with GCC Sub clause 26.1 and the Contractor fails to update the Program and demonstrate acceleration of the works within a reasonable period of time determined by the

	Employer; (k) the Contractor does not maintain a Security, which is required; (l) the Contractor has delayed the completion of the Works by the number of days for which the maximum amount of liquidated damages can be paid, **as defined in the SCC**; 79.3 In any of these events or circumstances, the Employer may, upon giving 15 days' notice to the Contractor, terminate the Contract and expel the Contractor from the Site. 79.4 However, in the case of sub-paragraph (e) or (f), the Employer may by notice terminate the Contract immediately. 79.5 The Employer's election to terminate the Contract shall not prejudice any other rights of the Employer, under the Contract or otherwise. 79.6 The Contractor shall then leave the Site and deliver any required Goods, all Contractors' Documents, and other design documents made by or for him, to the Employer. All Materials on the Site, Plant, Equipment, Temporary Works, and Works shall be deemed to be the property of the Employer. 79.7 However, the Contractor shall use his best efforts to comply immediately with any reasonable instructions included in the notice (i) for the assignment of any subcontract, and (ii) for the protection of life or property or for the safety of the Works. After termination, the Employer may complete the Works and/or arrange for any other entities to do so. The Employer and these entities may then use any Goods, Contractor's Documents and other design documents made by or on behalf of the Contractor. 79.8 The Employer shall then give notice that the Contractor's Equipment and Temporary Works will be released to the Contractor at or near the Site. The Contractor shall promptly arrange their removal, at the risk and cost of the Contractor. However, if by this time the Contractor has failed to make a payment due to the Employer, these items may be sold by the Employer in order to recover this payment. Any balance of the proceeds shall then be paid to the Contractor. 79.9 The Employer shall be entitled to terminate the Contract, at any time for the Employer's convenience, by giving notice of such termination to the Contractor. The termination shall take effect 30 days after, the later of the dates on which the Contractor receives this notice or the Employer returns the Performance Security. The Employer shall not terminate the Contract under this Clause in order to execute the Works himself or to arrange for the Works to be executed by another contractor. After this termination, the Contractor shall proceed in accordance with Clause 82.[Cessation of Work and Removal of Contractor's Equipment] and shall be paid in accordance with Clause 83 [Payment upon Termination].
80. Contractor's	80.1 If the Employer fails to comply with Clause 63. [Advance

Entitlement to Suspend Work	Payment] or Clause 56.1, the Contractor may, after giving not less than 45 days' notice to the Employer, suspend work (or reduce the rate of work) unless and until the Contractor has received the reasonable evidence or payment, as the case may be and as described in the notice. The Contractor's action shall not prejudice his entitlements to financing charges under Clause 56.2 and to termination under Clause 81. [Termination by Contractor]. 80.2 If the Contractor subsequently receives such evidence or payment (as described in the relevant Clause and in the above notice) before giving a notice of termination, the Contractor shall resume normal working as soon as is reasonably practicable. 80.3 If the Contractor suffers delay and/or incurs Cost as a result of suspending work (or reducing the rate of work) in accordance with this Clause, the Contractor shall give notice to the Employer and shall be entitled subject to Clause 35. [Contractor's Claims] to: (a) payment of any such Cost, which shall be added to the Contract Price. After receiving this notice, the Employer shall proceed in accordance with Clause 32. [Determinations] to agree or determine these matters.
81. Termination by Contractor	81.1 The Contractor shall be entitled to terminate the Contract if: (a) the Contractor does not receive the reasonable evidence within 45 days after giving notice under Clause 80.1 in respect of a failure to comply Employer's Obligation under the Clause 56.[Payments], (b) the Contractor does not receive the amount due within 90 days after the expiry of the time as per Clause 63.1 within which payment is to be made (except for deductions in accordance with Clause 34. [Employer's Claims]), (c) the Employer substantially fails to perform his obligations under the Contract, (d) the Employer fails to comply with Clause 7. [Assignment], (e) a prolonged suspension affects the whole of the Works as described in Clause 44.5, or (f) the Employer becomes bankrupt or insolvent, goes into liquidation, has a receiving or administration order made against him, compounds with his creditors, or carries on business under a receiver, trustee or manager for the benefit of his creditors, or if any act is done or event occurs which (under applicable Laws) has a similar effect to any of these acts or events. In any of these events or circumstances, the Contractor may, upon giving 15 days' notice to the Employer, terminate the Contract. However, in the case of subparagraph (e) or (f), the Contractor may by notice terminate the Contract immediately. 81.2 The Contractor's election to terminate the Contract shall not prejudice any other rights of the Contractor, under the Contract or

	otherwise.
82. Cessation of Work and Removal of Contractor's Equipment	82.1 After a notice of termination under Clause 79.9, Clause 81. [Termination by Contractor] or Clause 72 [Optional Termination, Payment and Release] has taken effect, the Contractor shall promptly: (a) cease all further work, except for such work as may have been instructed by the Employer for the protection of life or property or for the safety of the Works, (b) hand over Contractor's Documents, Plant, Materials and other work, for which the Contractor has received payment, and (c) remove all other Goods from the Site, except as necessary for safety, and leave the Site.
83. Payment upon Termination	83.1 As soon as practicable after a notice of termination under Clause 79. [Termination by Employer] has taken effect, the Employer shall proceed in accordance with Clause 32. [Determinations] to agree or determine the value of the Works, Goods and Contractor's Documents, and any other sums due to the Contractor for work executed in accordance with the Contract. 83.2 After a notice of termination under Clause 79. [Termination by Employer] other than Termination by Convenience as per Clause 79.9 has taken effect, the Employer may: (a) proceed in accordance with Clause 34. [Employer's Claims], (b) with-hold further payments to the Contractor until the costs of design, execution, completion and remedying of any defects, liquidated damages (if any), and all other costs incurred by the Employer, have been established, and/or (c) recover from the Contractor any losses and damages incurred by the Employer and any extra costs of completing the Works, after allowing for any sum due to the Contractor. After recovering any such losses, damages and extra costs, the Employer shall pay any balance to the Contractor. (d) forfeit the Performance Security If the total amount due to the Employer exceeds any payment due to the Contractor, the difference shall be a debt payable to the Employer. 83.3 After a notice of termination under Clause 81. [Termination by Contractor] or Termination by Convenience as per Clause 79.9 has taken effect, the Employer shall promptly: (a) return the Performance Security to the Contractor, (b) pay the Contractor in accordance with Clause 72. [Optional Termination, Payment and Release], and (c) pay to the Contractor the amount of any loss of profit or other loss or damage sustained by the Contractor as a result of this termination.
84. Fraud and	84.1 If the Employer determines that the Contractor has engaged in

Corruption	corrupt, fraudulent, collusive, coercive or obstructive practices, in competing for or in executing the Contract, then the Employer may, after giving 15 days notice to the Contractor, terminate the Contractor's employment under the Contract and expel him from the Site. 84.2 Should any employee of the Contractor be determined to have engaged in corrupt, fraudulent, collusive, coercive, or obstructive practice during the execution of the Works, then that employee shall be removed in accordance with GCC Clause 18. For the purposes of this GCC 84; (i) "corrupt practice" is the offering, giving, receiving or soliciting, directly or indirectly, of anything of value to influence improperly the actions of another party. (ii) "fraudulent practice" is any act or omission, including a misrepresentation, that knowingly or recklessly misleads, or attempts to mislead, a party to obtain a financial or other benefit or to avoid an obligation; (iii) "collusive practice" is an arrangement between two or more parties designed to achieve an improper purpose, including to influence improperly the actions of another party; (iv) "coercive practice" is impairing or harming, or threatening to impair or harm, directly or indirectly, any party or the property of the party to influence improperly the actions of a party; (v) "obstructive practice" is (aa) deliberately destroying, falsifying, altering or concealing of evidence material to the investigation or making false statements to investigators in order to materially impede a investigation into allegations of a corrupt, fraudulent, coercive or collusive practice; and/or threatening, harassing or intimidating any party to prevent it from disclosing its knowledge of matters relevant to the investigation or from pursuing the investigation; or (bb) acts intended to materially impede the exercise of the GON's/DP's inspection and audit rights provided for under GCC 33.4.
85. Black Listing	85.1 Without prejudice to any other rights of the Employer under this Contract, GoN, Public Procurement Monitoring Office (PPMO), on the recommendation of procuring entity, may blacklist a Bidder for its conduct for a period of one (1) to three (3) years on the following grounds and seriousness of the act committed by the bidder: (a) if it is established that the Contractor has committed substantial defect in implementation of the contract or has not substantially fulfilled its obligations under the contract or the completed work is not of the specified quality as per the contract.

	(b) If convicted from a court of law in a criminal offense liable to be disqualified for taking part in procurement contract, (c) If it is established that the Contractor has engaged in corrupt or fraudulent practices in competing for or in executing the Contract.
86. Release from Performance	86.1 If the Contract is frustrated by the outbreak of war or by any other event entirely outside the control of either the Employer or the Contractor, the Employer shall certify that the Contract has been frustrated. The Contractor shall make the Site safe and stop work as quickly as possible after receiving this certificate and shall be paid for all work carried out before receiving it and for any work carried out afterwards to which a commitment was made.
87. Suspension of DP Loan/Credit/Grant	87.1 In the event that the DP suspends the loan/ credit/grant to the Employer from which part of the payments to the Contractor are being made: (a) the Employer is obligated to notify the Contractor of such suspension within 7 days of having received the DP's suspension notice; and (b) if the Contractor has not received sums due him within the 30 days for payment provided for in GCC 56.1, the Contractor may immediately issue a 15-day termination notice.
88. Eligibility	88.1 The Contractor shall have the nationality of an eligible country **as stated in SCC**. The Contractor shall be deemed to have the nationality of a country if the Contractor is a citizen or is constituted, or incorporated, and operates in conformity with the provisions of the laws of that country. This criterion shall also apply to the determination of the nationality of proposed subcontractors or suppliers for any part of the Contract including related services. 88.2 The materials, equipment, and services to be supplied under the Contract shall have their origin in eligible source countries **as stated in SCC** and all expenditures under the Contract will be limited to such materials, equipment, and services. At the Employer's request, the Contractor may be required to provide evidence of the origin of materials, equipment, and services. 88.3 For purposes of GCC 88.2, "origin" means the place where the materials and equipment are mined, grown, produced, or manufactured, and from which the services are provided. Materials and equipment are produced when, through manufacturing, processing, or substantial or major assembling of components, a commercially recognized product results that differs substantially in its basic characteristics or in purpose or utility from its components.
89. Quarries and Spoil Dumps	89.1 Upon receiving the Performance Certificate, the Contractor shall remove any remaining Contractor's Equipment, surplus material, wreckage, rubbish and Temporary Works from the Site. 89.2 Any quarry operated as part of this Contract shall be

	maintained and left in a stable condition without steep slopes and be either refilled or drained and be landscaped by appropriate planting. Rock or gravel taken from a river shall be removed over some distance so as to limit the depth of material removed at any one location, not disrupt the river flow or damage or undermine the river banks. The Contractor shall not deposit excavated material on land in Government or private ownership except as directed by the Employer in writing or by permission in writing of the authority responsible for such land in Government ownership, or of the owner or responsible representative of the owner of such land in private ownership, and only then in those places and under such conditions as the authority, owner or responsible representative may prescribe. 89.3 If all these items have not been removed within 30 days after the Employer issues the **Performance Certificate**, the Employer may sell or otherwise dispose of any remaining items. The Employer shall be entitled to be paid the costs incurred in connection with, or attributable to, such sale or disposal and restoring the Site. 89.4 Any balance of the moneys from the sale shall be paid to the Contractor. If these moneys are less than the Employer's costs, the Contractor shall pay the outstanding balance to the Employer.
90. Local Taxation	90.1 The prices bid by the Contractor shall include all taxes that may be levied in accordance to the laws and regulations in being in Nepal on the date 30 days prior to the closing date for submissions of Bids on the Contractor's equipment, plant and materials acquired for the purpose of the Contract and on the services performed under the Contract. Nothing in the Contract shall relieve the Contractor from his responsibility to pay any tax that may be levied in Nepal on profits made by him in respect of the Contract.
91. Value Added Tax	91.1 The Contract is not exempted from value added tax. An amount specified in the schedule of taxes shall be paid by the Contractor in the concerned VAT office within time frame specified in VAT regulation.
92. Income Taxes on Staff	92.1 The Contractor's staff, personnel and labor will be liable to pay personal income taxes in Nepal in respect of their salaries and wages, as are chargeable under the laws and regulations for the time being in force, and the Contractor shall perform such duties in regard to such deductions as may be imposed on him by such laws and regulations. 92.2 The issue of the Final Account Certificate pursuant to clause GCC 77 shall be made only upon submittal by the Contractor of a certificate of income tax clearance from the Government of Nepal.
93. Duties, Taxes and Royalties	93.1 Unless otherwise **stated in the SCC**, the Contractor shall pay all royalties, rents and other payments for: (a) natural Materials obtained from outside the Site, and

	(b) the disposal of material from demolitions and excavations and of other surplus material (whether natural or man-made), except to the extent that disposal areas within the Site are specified in the Contract. 93.2 Any element of royalty, duty or tax in the price of any goods including fuel oil, and lubricating oil, cement, timber, iron and iron goods locally procured by the Contractor for the works shall be included in the Contract rates and prices and no reimbursement or payment in that respect shall be made to the Contractor. 93.3 The Contractor shall familiarize himself with GON the rules and regulations with regard to customs, duties, taxes, clearing of goods and equipment, immigration and the like, and it will be necessary for him to follow the required procedures regardless of the assistance as may be provided by the Employer wherever possible. 93.4 The Contractor shall pay and shall not be entitled to the reimbursement of cost of extracting construction materials such as sand, stone/boulder, gravel, etc. from the river beds or quarries. Such prices will be levied by the Local Level as may be in force at the time. The Contractor, sub-contractor(s) employed directly by him and for whom he is responsible, will not be exempted from payment of royalties, taxes or other kinds of surcharges on these construction materials so extracted and paid for to the Local Level.
94. Member of Government, etc, not Personally Liable	94.1 No member or officer of GoN or the Employer or the Employer 'Representatives shall be in any way personally bound or liable for the act or obligations of the Employer under the Contract or answerable for any default or omission in the observance or performance of any of act, matter or thing which are herein contained.
95. Compliance with Regulations for Explosives	95.1 No explosives of any kind shall be used by the Contractor without the prior consent of the Employer in writing and the Contractor shall provide, store and handle these and all other items of every kind whatsoever required for blasting operations, all at his own expense in a manner approved in writing by the Employer. 95.2 The Contractor shall comply with all relevant ordinances, instructions and regulations which the Government, or other person or persons having due authority, may issue from time to time regarding the handling, transportation, storage and use of explosives.
96. Permission for Blasting	96.1 The Contractor shall at all times maintain full liaison with and inform well in advance, and obtain such permission as is required from all Government authorities, public bodies and private parties whatsoever concerned or affected, or likely to be concerned or affected by blasting operation.
97. Records of	97.1 Before the beginning of the Defects Liability Period, the Contractor shall account to the satisfaction of the Employer

Explosives	for all explosives brought on to the Site during the execution of the Contract and the Contractor shall remove all unused explosives from the Site on completion of works when ordered by the Employer.
98. Traffic Diversion	98.1 The Contractor shall include the necessary safety procedures regarding and pedestrian traffic diversion that is needed in execution of the works. The Contractor shall include in his costing of works, any temporary works or diversion that are needed during the construction period. All traffic diversion should be designed for the safety of both the motoring public and the men at work. It shall ensure the uninterrupted flow of traffic and minimum inconvenience to the public during the period concerned. As such, adequate warning signs, flagmen and other relevant safety precautionary measures shall be provided to warn motorists and pedestrians well ahead of the intended diversion as directed by the Employer. All traffic devices used shall be designed in accordance with the instruction of Employer.

Section IX: Special Conditions of Contract

The following Special Conditions of Contract shall supplement the GCC. Whenever there is a conflict, the provisions herein shall prevail over those in the GCC

Special Conditions of Contract

A. General	
GCC 1.1 (m)	The Commencement Date shall be ***14th date from the date of agreement.***
GCC 1.1 (t)	The Employer is ***Department of Roads, Quality Research and Development Center, Chakupat, Lalitpur***
GCC 1.1 (u)	***Replace the definition as "Employer's Representative means the person named by the Employer in the Contract or appointed from time to time by the Employer under Clause 13. [The Employer's Representative], who acts on behalf of the Employer and is responsible for supervising the execution of the Works and administering the Contract"*** The Employer's Representative is ***Quality Research and Development Center and Representatives as appointed by the Employer from time to time as per Clause 13.***
GCC 1.1 (z)	The Intended Completion Date for the whole of the Works shall be ***Phase I Engineering, Procurement and Construction Works: 1825 calendar days from date of commencement as indicated in SCC ref. GCC 1.1(m)*** ***And*** ***Phase II Warranty, Operation and Maintenance Works: 1825 calendar days from the date of issuance of Taking Over Certificate.***
GCC 1.1 (ii)	***Siddababa Section of Siddhartha Highway as described in Employer's Requirements.***
GCC 1.1 (qq)	***The Works consist of Planning, Design, Engineering, Procurement, Construction, Commissioning and Five Years of Service Operation & Maintenance of One Double Lane Standard Highway Tunnel, Rock-shed Structure, Rock Fall Mitigation and Road Works of Siddababa Tunnel Project on Engineering Procurement Construction (EPC) basis all complete as described in Employer's Requirements.***
GCC 1.1 (rr)	***Replace with "Operation and Maintenance Period is the period from the date of Issuance of Taking Over Certificate where the contractor remains responsible for operation and performance-based maintenance of Works"***
GCC 2.2	Sectional Completions (Milestones) are: ***Not Applicable***
GCC 2.3(i)	The following documents also form part of the Contract : ***None***
GCC 3.1	The law that applies to the Contract is the law of NEPAL
GCC 3.4	The language of the contract is **ENGLISH** The ruling language of the contract is **ENGLISH**

GCC 10.1	***[Mention, if any] [this clause needs to be deleted]***
GCC 15.1(a)	The agreed electronic transmission shall be ***dorgrdc@gmail.com***
GCC 16.1	**For GoN Funded:** **Maximum percentage of subcontracting permitted is 25% of the total contract amount.** **Nature of Works that agreed to be subcontracted and Details of Sub-Contractors:** 1) Terminal Building Construction Works 2) Electrical and Mechanical Works **Qualification Criteria** The proposed sub-contractor shall meet the following **requirements**: 3) Experience of the work being subcontracted, equivalent to Completion of 80% of the quantity of such work 4) Average Annual Construction Turnover (Best of Three Fiscal Year) of Last Ten Years, for the proposed work should be at least 1.5 * V/T where V is the work being subcontracted and T is time to complete the proposed work in year. For contract duration of up to 1 year, T shall be "1". **Financial Resources:** The sub contract must demonstrate that it has the financial resources to meet its current contract commitment plus three months' requirements for the sub contracted work.
GCC 17.1	Schedule of other contractors: ***Employer shall notify the schedule if required.***
GCC 19.4	***Siddhartha Highway (Siddababa Section) from the date of handover of the site by the Employer until the date of completion of the works.***
GCC 23.2	The minimum insurance amounts and deductibles shall be: 1. The minimum cover for loss of or damage to the Works, Plant and Materials is: ***115%*** of the Contract Amount. 2. The maximum deductible for insurance of the Works and of Plant and Materials is: ***Nrs. 500,000.00*** 3. The minimum cover for loss or damage to Equipment is: ***Full Replacement Cost*** **4.** The maximum deductible for insurance of Equipment is: ***NRs. 50,000.00*** 5. The minimum for insurance of other property is: ***NRs. 10,000,000.00*** with unlimited number of occurrences 6. The maximum deductible for insurance of other property is: ***NRs. 50,000.00***

<table>
<tr><td></td><td>7. The minimum cover for personal injury or death insurance
i. for the Contractor's employees is that specified in the Labor act of Nepal and
ii. for other people including Employer's Representatives is :50,000,000.00 with an unlimited number of occurrences.
8. The minimum cover for Liability for breach of professional duty in an amount not less than 100% of the Contract Amount.
<u>The insurance mentioned in points 1-7 shall remain in effect until the end of the Operation and Maintenance Period.</u>
<u>The insurance mention in point 8 shall remain in effect until the end of Latent Defect Liability Period.</u></td></tr>
<tr><td>GCC 24.1</td><td>Site Data and Reports are: as attached in
<u>Annex 1 : Site Data and Reports.</u></td></tr>
<tr><td>GCC 26.1</td><td>Add the following at the end of the paragraph.
The milestone for the completion of
<table>
<tr><th>S.N</th><th>Description of Milestones</th><th>Time for Completion</th></tr>
<tr><td>1</td><td>Mobilization, Preliminary and Submission of Detail Design of Tunnel including Ventilation and Lighting, Pedestrian Rock Shed, Road Improvement Works with all ancillary Structures.</td><td>9 months from the date of commencement</td></tr>
<tr><td>2</td><td>Completion of the Tunnel Civil Works</td><td>30 months from the date of commencement</td></tr>
<tr><td>3</td><td>Completion of Tunnel Exploitation and Safety Equipment Works, Ventilation Works</td><td>42 months from the date of commencement</td></tr>
<tr><td>4</td><td>Completion of Rock Shed, Completion of Road Works, retaining wall, Rock Fall barriers, Slope Projection Works all Complete and Demobilization</td><td>60 months from the date of commencement.</td></tr>
</table></td></tr>
<tr><td>GCC 27.14</td><td>Replace the paragraph by "The Contractor shall carry out the training of Employers Personnel from an independent institute/agency in the design, construction, operation and maintenance of works as specified in Employers Requirement."</td></tr>
<tr><td>GCC 27.16</td><td>Add the Clause "The dimensions mentioned in scope of the work stipulated in Employers Requirement (Technical Requirement and Technical Specification) are minimum acceptable requirement.</td></tr>
<tr><td>GCC 30.1</td><td>The right of access to and Possession of Site Date(s) shall be:
7th day from the date of agreement</td></tr>
<tr><td>GCC 31.3</td><td>[insert additional clauses, if required] [This Clause can be deleted]</td></tr>
<tr><td>GCC 37.1</td><td>The place of arbitration shall be: Kathmandu. Nepal</td></tr>
</table>

GCC 38.12	The list of Key Personnel and their Qualifications: ***As per Section III: Evaluation and Qualification Criteria, Clause 2.5***
C. Time Control	
GCC 41.1	The Contractor shall submit for approval a Program for the Works within ***60 days*** from the date of the Letter of Acceptance.
GCC 41.7	***Quarterly, Bi-annual and Annual Progress Reports and Project Completion Report*** Add at the end of sub paragraph (h), delete "," and replace with ":" and add the following sub paragraphs, (i) details of all matters affecting, or likely to affect, the progress or cost of the Works and particulars of the preventative and remedial measures which have been, are being, or may be taken in respect of those matters; (j) any other particulars reasonably required by the Employers or Employers Representative (k) all incidents affecting the safety, health and welfare of persons, and causing damage to property together with such other records as the Engineer may require (from time to time) to be kept and provided.
GCC 45	***The management meeting shall be conducted on quarterly basis. The management meeting shall be attended by Authorized Representative from each Joint Venture Partners. In case of non-compliance, the payment to the contractor shall be withheld.***
D. Quality Control	
GCC 49.1	The Defects Liability Period is: ***1825 Calendar Days***
GCC 49.9	The Latent Defects Liability Period is: ***15 years from the date of issuance of Taking Over Certificate.*** ***Add the following paragraph,*** ***"Latent Defect" means any defect in the Works attributable to:*** ***(a) the design of the Works for which the Contractor is responsible;*** ***(b) Plant, Materials or workmanship not being in accordance with the Contract; or*** ***(c) failure of the Contractor to comply with any other obligation under the Contract, which reasonable examination by the Employer prior to expiry of the last Defects Notification Period would not have disclosed.***
E. Cost Control	
GCC 51.6	***[insert additional clauses, if required] [This clause can be deleted]***
GCC 55.1	***Monthly basis with amount not less than 2% of the accepted contract amount***
GCC 51.3	***Sum for Overhead charges and Profit : Five (5) %***

GCC 55.3	***As stated in the activity schedule and updated as approved by the Employer.***
GCC 55.4	***Schedule of Payment: Section VII-Activity Schedule (ACS)***
GCC 56.2	***Interest Percentage Five (5)***
GCC 59.1	The contract shall not be subjected to Price Adjustment.
GCC 60.1	The proportion of payments retained is: For GoN Funded: ***5 (five) percent***
GCC 61.1	***The liquidated damages for each milestone of the Works are 0.05 percent of the price of total works covered in each milestone in activity schedule per day.***
GCC 61.2	***The liquidated damages for the whole of the Works are 10 percent of the final Contract Price per day.***
GCC 61.3	***The maximum amount of liquidated damages for the whole of the Works is 10 percent of the Final Contract Price.***
GCC 62.1	The Bonus for the whole of the Works is 0.05 Percent per day.
GCC 62.2	The maximum amount of Bonus for the whole of the Works is 10 Percent of the **Final Contract Price.**
GCC 63.1	***The Advance Payments shall be: Ten (10) percentage of the Accepted Contract Amount excluding Provisional Sum and VAT payable in the currencies and proportions in which the Accepted Contract Amount is payable and shall be paid in two equal installments and to the Contractor.*** ***The total advance payment shall be made in two (2) installations as follows :*** ***First (1st) installment of 5.0 % within 28 days after the submission of Unconditional Bank Guarantee in the format agreed by the Employer, Insurance Policy Document and Work Schedule.*** ***Second (2nd) of 5% after completion of site investigation, survey and completion detail design and the Contractor's Mobilization of all required resources to the Site as agreed in the Contract document and with 28 days of the date of certification by the Employer Representative.***
GCC 63.4	Deductions from Payment Certificates will commence in the Cumulative value of works executed exceeds 30% of the Initial Contract Price. Deduction will be at the rate of ***20 percent*** of the respective Interim Payment Certificate until such time as the advance payment has been repaid; provided that the advance payment shall be completely repaid prior to the end of 80 % of the approved contract period.
GCC 64.1	***The Performance Security amount is:*** Performance Security Amount = [(0.85 x Cost Estimate –Bid Price) x 0.5]

	+ 5% of Bid Price. ***[Method of Calculation:*** i) If bid price of the bidder selected for acceptance is up to 15 (fifteen) percent below the approved cost estimate (including Provisional Sum amount) the performance security amount shall be 5 (five) percent of the bid price. ii) For the bid price of the bidder selected for acceptance is more than 15 (fifteen) percent below of the cost estimate (including Provisional Sum amount), the performance security amount shall be determined as follows: Performance Security Amount = [(0.85 x Cost Estimate –Bid Price) x 0.5] + 5% of Bid Price. The Bid Price and Cost Estimate shall be inclusive of Value Added Tax**]**
G. Finishing the Contract	
GCC 74.1	***As per the requirements stipulated in Employers Requirement (Technical Requirement and Technical Specification)***
GCC 74.5	***None***
GCC 74.12	***Refer to Employer's Requirement (Technical Requirement and Technical Specification)***
GCC 75.1	***As per the requirements stipulated in Employers Requirement (Technical Requirement and Technical Specification)***
GCC 75.9	***Refer the Employer's Requirements.*** ***and*** ***Works below acceptance criteria shall not be accepted.***
GCC 78.1	***The date by which operating and maintenance manuals are required is: 56 days prior to completion of Phase II (Warranty, Operation and Maintenance Period)***
GCC 78.2	***The date by which "as built" drawings are required is: 28 days prior to issuance of Taking Over Certificate.*** ***The amount to be withheld for failing to produce "as built" drawings and/or*** ***Operating and maintenance manuals is: NRs. 10,000,000.00***
GCC 79.2 (l)	The maximum number of days is: **200 Calendar Days**
GCC 88.1	**All Countries**
GCC 88.2	**All Countries**
GCC 93.1	***None or (this clause can be deleted)***

Section X: Contract Forms

This Section contains forms which, once completed, will form part of the Contract. The forms for Performance Security and Advance Payment Security, when required, shall only be completed by the successful Bidder after contract award.

Letter of Intent

[on letterhead paper of the Employer]

Date: ... ……

To: .....***Name and address of the Contractor***.....

Subject: …… Issuance of letter of intent to award the contract.....

This is to notify you that, it is our intention to award the contract ... . ***[insert date]*** .....for execution of the ..... ***[insert name of the contract and identification number, as given in the SCC]*** to you as your bid price ..... ***[insert amount in figures and words in the currency (NepaliNepali Rupees / US Dollar]*** as corrected and modified in accordance with the Instructions to Bidders is hereby selected as substantially responsive lowest evaluated bid.

Authorized Signature: ……

Name: ... …….

Title: …….

CC:
[Insert name and address of all other Bidders, who submitted the bid]

[Notes on Letter of Intent
The issuance of Letter of Intent is the information of the selection of the bid of the successful bidder by the Employer and for providing information to other unsuccessful bidders who participated in the bid as regards to the outcome of the procurement process. This standard form of Letter of Intent to Award should be filled in and sent to the successful Bidder only after evaluation and selection of substantially responsible lowest evaluated bid.]

Letter of Acceptance

[on letterhead paper of the Employer]

Date: ……..

To: ……***Name and address of the Contractor***……...

Subject: …….*Notification of Award*

This is to notify that your Bid dated .....***date*** ……..for execution of the……..***name of the contract and identification number, as given in the SCC*** ……... for the Contract price of Nepali Rupees ***[insert amount in figures and words in Nepali Rupees],*** as corrected in accordance with the Instructions to Bidders is hereby accepted in accordance with the Instruction to Bidders.

You are hereby instructed to contact this office to sign the formal contract agreement within 15 days with Performance Security of **NRs**. ……. in accordance with the Conditions of Contract, using for that purpose the Performance security Form included in Section X (Contract Forms) of this Bidding Document.

Authorized Signature: ……...

Name and Title of Signatory: ……

Contract Agreement

THIS AGREEMENT made the .....day of….between……. name of the Employer ***……(hereinafter "the Employer"),*** of the one part, and ……name of the Contractor ……(hereinafter "the Contractor"), of the other part:

WHEREAS the Employer desires that the Works known as …….... name of the Contract .....should be executed by the Contractor, and has accepted a Bid by the Contractor for the execution and completion of these Works including warranty, operation and maintenance and the remedying of any defects in the sum of NRs ***…….....…..[insert amount of contract price in words and figures including taxes]***(hereinafter "the Contract Price") through Engineering, Procurement and Construction (EPC) method as a Lumpsum Contract .

The Employer and the Contractor agree as follows:

1. In this Agreement words and expressions shall have the same meanings as are respectively assigned to them in the Contract documents referred to.

2. The following documents shall be deemed to form and be read and construed as part of this Agreement. This Agreement shall prevail over all other Contract documents.
   (a) Contract Agreement,
   (b) Letter of Acceptance,
   (c) Letters of Technical Bid and Price Bid,
   (d) Special Conditions of Contract,
   (e) General Conditions of Contract,
   (f) Employer's Requirements,
   (g) Activity Schedules, and
   (i) Any other document listed in the SCC as forming part of the Contract.

3. In consideration of the payments to be made by the Employer to the Contractor as indicated in this Agreement, the Contractor hereby covenants with the Employer to execute the Works and to remedy defects therein in conformity in all respects with the provisions of the Contract.

4. The Employer hereby covenants to pay the Contractor in consideration of the execution and completion of the Works and the remedying of defects therein, the Contract Price or such other sum as may become payable under the provisions of the Contract at the times and in the manner prescribed by the Contract.

IN WITNESS whereof the parties hereto have caused this Agreement to be executed in accordance with the laws of Nepal on the day, month and year indicated above.

Signed by …….
for and on behalf the Contractor in the presence of

Witness, Name Signature, Address, Date

Signed by……..
for and on behalf of the Employer in the presence of

Witness, Name, Signature, Address, Date

Performance Security

(On letterhead paper of the Commercial Bank or Financial Institution eligible to issue Bank Guarantee as per prevailing Law)

..... ***Bank's Name, and Address of Issuing Branch or Office*** .....

Beneficiary: ..... Name and Address of Employer …….....

Date: .....

Performance Guarantee No.:…….

We have been informed that ... ... ***[insert name of the Contractor]*** (hereinafter called "the Contractor") has been notified by you to sign the Contract No. …….. ***[insert reference number of the Contract]*** for the execution of …….. ***[insert name of contract and brief description of Works]*** (hereinafter called "the Contract").

Furthermore, we understand that, according to the conditions of the Contract, a performance guarantee is required.

At the request of the Contractor, we... ..... . ***[insert name of the Bank]*** hereby irrevocably undertake to pay you any sum or sums not exceeding in total an amount of .....***[insert name of the currency and amount in figures*] (... .. insert amount in words)*** such sum being payable in Nepali Rupees, upon receipt by us of your first demand in writing accompanied by a written statement stating that the Contractor is in breach of its obligation(s) under the Contract, without your needing to prove or to show grounds for your demand or the sum specified therein.

This guarantee shall expire, no later than the……..Day of …… **, and any demand for payment under it must be received by us at this office on or before that date.

……

Seal of Bank and Signature(s)

Note:

All italicized text is for guidance on how to prepare this demand guarantee and shall be deleted from the final document.

* The Guarantor shall insert an amount representing the percentage of the Contract Price specified in the Contract in Nepali Rupees.

** Insert the date thirty days after the date specified for the Defect Liability Period. The Employer should note that in the event of an extension of the time for completion of the Contract, the Employer would need to request an extension of this guarantee from the Guarantor. Such request must be in writing and must be made prior to the expiration date established in the guarantee. In preparing this guarantee, the Employer might consider adding the following text to the form, at the end of the penultimate paragraph: "The Guarantor agrees to a one-time extension of this guarantee for a period not to exceed [six months], in response to the Employer's written request for such extension, such request to be presented to the Guarantor before the expiry of the guarantee".

Letter of Commitment for Bank's Undertaking for Line of Credit

Bank's Name, and Address of Issuing Branch or Office
(On Letter head of the Commercial bank or any Financial Institution eligible to issue Bank Guarantee as per prevailing Law)

Date:
Contract No:

Name of Contract :

To:

[*Name and address of the Employer*]

CREDIT COMMITTMENT No: [*insert number*]

We are pleased to know that *[name of Contractor]* (hereinafter called "the Contractor") has been awarded the Contract for the execution of the Works of ***[description of works]*** for above contract.

Furthermore, we understand that, according to your conditions, the Contractor's Financial Capacity i.e. Liquid Asset must be substantiated by a Letter of Commitment of Bank's Undertaking for Line of Credit.

At the request of, and arrangement with, the Contractor, we *[name and address of the Bank]* do hereby agree and undertake that [*name and address of the Contractor*] will be provided by us with a revolving line of credit, for execution of the Works viz. [*insert name of the works*], for an amount not less than NRs …….[*in figure*] (*in words*) for the sole purpose of the execution of the above Contract. This Revolving Line of Credit will be maintained by us until ***[Insert "Initial Contract Period"]*** months by the Procuring Entity.

This committed line of credit shall not be terminated or cancelled without the prior written approval of Employer.

In witness whereof, authorised representative of the Bank has hereunto signed and sealed this Letter of Commitment.

Signature	Signature
Name :	Name :
Designation:	Designation:

Advance Payment Security

(On letterhead paper of the Commercial Bank or Financial Institution eligible to issue Bank Guarantee as per prevailing Law)

…….. Bank's Name, and Address of Issuing Branch or Office.....

Beneficiary: ……***Name and address of employer***

Date : ……

Advance Payment Guarantee No……..

We have been informed that ……has entered into Contract No. ..... ***Name and Address of Employer***……***name of the Contractor***……(hereinafter called "the Contractor")..reference number of the Contract……dated …… with you, for the execution of ...contract and brief description of Works ……. (hereinafter called "the Contract").

Furthermore, we understand that, according to the Conditions of the Contract, an advance payment in the sum……. name of the currency and amount in figures****…(.... amount in words .....)*** is to be made against an advance payment guarantee.

At the request of the Contractor, we... ..... . ***name of the Bank*** ……. hereby irrevocably undertake to pay you any sum or sums not exceeding in total an amount of…….name of the currency and amount in figures****.....…(…… amount in words ... .)*** upon receipt by us of your first demand in writing accompanied by a written statement stating that the Contractor is in breach of its obligation under the Contract because the Contractor used the advance payment for purposes other than the costs of mobilization in respect of the Works.

The maximum amount of this guarantee shall be progressively reduced by the amount of the advance payment repaid by the Contractor as indicated in copies of interim statements or payment certificates which shall be presented to us. This guarantee shall expire, at the latest, upon our receipt of a copy of the interim payment certificate indicating that eighty (80) percent of the Contract Price has been certified for payment, or on the ..... day of .....**, whichever is earlier. Consequently, any demand for payment under this guarantee must be received by us at this office on or before that date.

……
Seal of Bank and Signature(s)

Note:
All italicized text is for guidance on how to prepare this demand guarantee and shall be deleted from the final document.
*The Guarantor shall insert an amount representing the amount of the advance payment in Nepali Rupees of the advance payment as specified in the Contract.
** Insert the date Thirty days after the expected completion date. The Employer should note that in the event of an extension of the time for completion of the Contract, the Employer would need to request an extension of this guarantee from the Guarantor. Such request must be in writing and must be made prior to the expiration date established in the guarantee. In preparing this guarantee, the Employer might consider adding the following text to the form, at the end of the penultimate paragraph: "The Guarantor agrees to a one-time extension of this guarantee for a period not to exceed [six months], in response to the Employer's written request for such extension, such request to be presented to the Guarantor before the expiry of the guarantee".

ANNEX 1

Site Data and Reports

ANNEX 2

TOR of the employer's representative

To be provided later

Technical Requirement and

Technical specifications

ANNEXES

ANNEX A: CIVIL WORKS - DESIGN BASIS

ANNEX B: TUNNEL - TECHNICAL REPORT

ANNEX C: EXPLOITATION AND SAFETY EQUIPMENT - TECHNICAL REPORT AND DESIGN BASIS

ANNEX D: VENTILATION SYSTEM - TECHNICAL REPORT AND DESIGN BASIS

ANNEX E : MINIMUM SAFETY REQUIREMENTS FOR ROAD TUNNELS

ANNEX F : TECHNICAL REQUIREMENTS PLANT AND SYSTEMS (ESE) GENERAL TEST CRITERIA FACTORY AND SITE ACCEPTANCE

ANNEX G : WARRANTY, OPERATION AND MAINTENANCE WORKS

ANNEX A: CIVIL WORKS- DESIGN BASIS

ANNEX A: CIVIL WORKS - DESIGN BASIS

1.0 Standards and References

The following main standards shall be standard to be considered for design.

- ∇ **General Guidelines /norms**
  - ◊ Basis of structural design; Eurocodes
  - ◊ Actions on structures Eurocodes
  - ◊ Concrete structures design specifications, Eurocodes
  - ◊ Geotechnical design specifications; Eurocodes
  - ◊ Earthquake resistant structures requirements; Eurocodes
  - ◊ Road standards Nepal Road Standard 2070
- ∇ **Guidelines/norms for tunnel design**
  - ◊ Electrical standard; Eurocodes /Swiss Guidelines
  - ◊ Road signalling standards; Traffic Safety Manuals of DoR
  - ◊ Tunnel specifications; Eurocodes /Swiss Guidelines
  - ◊ Road tunnel safety systems specification. Eurocodes /Swiss Guidelines
- ∇ **Minimum Safety Requirements for Road Tunnels as per Explained un Employer's Requirements**

The Project standards adopted for design are detailed in the following paragraphs.

- ◊ Nepal Road Standard – 2070, 2013
- ◊ Nepal Standard Specifications for Road and Bridge works – 2073, 2013
- ◊ IRC:37-2018 :Guidelines For The Design of Flexible Pavements, (Fourth Revision),INDIAN ROADS CONGRESS
- ◊ Nepal Safety Barrier, 1997
- ◊ Nepal Delineation Measures, 1996
- ◊ Nepal Design Safe Side Drains, 1996
- ◊ Nepal Traffic Sign Manual, 1997
- ◊ EN 1990:2002, Eurocode 0: Basis of structural design.
- ◊ EN 1991 - all parts, Eurocode 1: Actions on structures.
- ◊ EN 1992-1-1:2004, Eurocode 2: Design of concrete structures. General rules and rules for buildings.
- ◊ EN 1992-2:2005, Eurocode 2: Design of concrete structures - Part 2: Concrete bridges - Design and detailing rules
- ◊ EN 1997-1:2004, Eurocode 7: Geotechnical design. General rules.
- ◊ EN 1998-1:2004, Eurocode 8: Design of structures for earthquake resistance. General rules, seismic actions and rules for buildings.
- ◊ EN 1998-2:2005, Eurocode 8: Design of structures for earthquake resistance – Part 2: Bridges

- ◊ EN 1998-5:2004, Eurocode 8: Design of structures for earthquake resistance. Foundations, retaining structure and geotechnical aspects.
- ◊ ASTRA 12006 (2008), effects of stone chips on protective galleries.
- ◊ ASTRA 11001 (2017), guideline: normal profiles. Federal Roads Office.
- ◊ ASTRA 13001 (2008), Guidelines: Ventilation of the road tunnels.
- ◊ ASTRA technical manual for operational and safety equipment 23 001.
- ◊ ASTRA technical manual tunnel / geotechnical 24 001.◊
- ◊ SIA 197 (2004), project planning tunnel, basics.
- ◊ SIA 197/2 (2004), project planning tunnel, road tunnel.
- ◊ ASTRA 12006 (2008), effects of rockfalls on protective galleries (rockfall load) [as applicable]
- ◊ VSS 640 202 (2017) – Road geometrical normal profile.
- ◊ CEB N°187 - Comité-Euro-International du Béton (1988). Concrete Structures under Impact and Impulsive Load, Bulletin d'information N° 187, Draft TG V/14, Lausanne.
- ◊ EOTA (2012). ETAG 027 – Falling rock protection kits. Guideline for european technical approval.
- ◊ EN 206:2016, Concrete – Specification, performance, production and conformity
- ◊ EN 197-1:2011, Cement – Part 1: Composition, specifications and conformity criteria for common cement
- ◊ EN 12620:2008, Aggregates for concrete
- ◊ EN 1537– Execution of special geotechnical works - Ground anchors
- ◊ EN ISO 22477-5:2018 - Geotechnical investigation and testing - Testing of geotechnical structures - Part 5: Testing of grouted anchors

Swiss Federal road administration (FEDRO) directives for design of tunnel operating and safety systems (***supplement to Minimum Safety Requirements for Road Tunnels as per Explained un Employer's Requirements***):

- ◊ FEDRO 13001 ventilation of the road tunnels (2008 V2.03)
- ◊ FEDRO 13002 ventilation of the safety tunnels of road tunnels (2008 V1.06)
- ◊ FEDRO 13004 fire detection in road tunnels (2007 V2.10)
- ◊ FEDRO 13005 video systems (2012 V1.01)
- ◊ FEDRO 13006 radio systems in road tunnels (2018 V5.00)
- ◊ FEDRO 13010 signaling of safety devices in road tunnels (2011 V2.06)
- ◊ FEDRO 13011 doors and gates in road tunnels (2009 V1.05)
- ◊ FEDRO 13015 lighting systems (2017 V1.11)

Standard for tunnel ventilation system

- ◊ Road Tunnels: Vehicle Emissions and Air Demand for Ventilation, Technical Committee D.5 Road Tunnels, PIARC, World Road Association, 2018R038EN
- ◊ Swiss Tunnel Ventilation Design Code (Federal Roads Office “FEDRO”; Richtlinie Lüftung der Strassentunnel, Systemwahl, Dimensionierung und Ausstattung), V2.03, 2008
- ◊ Jet fans in portals and in niches, arrangement and efficiency, CFD, Franz Zumsteg, 2007

2.0 Recommended Software

- ◊ MIDAS/Civil 2019, Ver. 1.1. Developed by MIDAS Information Technology Co., Ltd. (Seongnam, Gyeonggi-do, 463-824, Korea).
- ◊ Plaxis 2D 2019, Plaxis bv, The Netherlands
- ◊ Unwedge, Rockscience, Toronto
- ◊ Larix 7, Cubus AG, Zürich
- ◊ Statik 7, Cubus AG, Zürich
- ◊ Fagus 7, Cubus AG, Zürich
- ◊ WXDEF, for section checks
- ◊ ecorisQ Rockyfor3D
- ◊ 2D RocFall
- ◊ Elastic Multi – Layer software KENPAVE (University of Kentucky)

3.0 Input Data Provided by the Client

- ➢ Road Width
- ➢ Traffic Data
- ➢ Precipitation Data
- ➢ Temperature Data
- ➢ Wind Data

4.0 Geotechnical Characterization and Rockfall Hazard

4.1 Geotechnical and geomechanical characterization of the rock mass

Tunnel alignment : The tunnel shall be divided into homogeneous sections (“TO”). Each section shall be characterized by specific rock mass parameters (such as RMR,Q-Value, RQD, GSI, Jv, Jc, ecc.), as well as geotechnical parameters according to the chosen failure criterion, joint parameters and permeability values.

Note : While preparing the section, Geotechnical Design Memorandum (GDM) based Geotechnical Data Report (GDR) shall be used.

Road alignment : The road shall be divided into homogeneous sections (“TO”). Each section shall be characterized by specific rock mass parameters (such as RMR,Q-Value, RQD, GSI, Jv, Jc, ecc.), as well as geotechnical parameters according to the chosen failure criterion, joint parameters and permeability values.

4.2 Tunnel hazard scenarios

The prognosis hazard scenarios shall be assessed. At least the following hazards shall be evaluated :

- ◊ Rock falling/wedges
- ◊ Shear zone and fault gouge
- ◊ Detachment of slabs
- ◊ Tunnel face instability
- ◊ Loosening
- ◊ Plastic deformation
- ◊ Rockburst
- ◊ Water inflow
- ◊ Gas fields

4.3 Rockfall hazard evaluation (if applicable)

4.3.1 Evaluation of rockfall hazard probability

3D analyses and simulations to detect the trajectories for the rockfall process shall be performed, in order to evaluate all areas subjected to rockfall risk, based on a detailed topographic 3D model of the whole mountain side (from the top to the river) where the existing road is located.

4.3.2 Design rock block dimension

Characteristic and, hence, design rock block dimension must be evaluated, based on field data (geological mapping and recording, analysis of orthophotos,…) and statistic analysis of recorded block sizes along the existing road.

4.3.3 Design rockfall energy

Based on 2D/3D rockfall simulations in different characteristic sections along the road alignment and on the assumed design boulder volume, the design impact energy for rock protections must be estimated along the road alignment. For the rockfall simulation, proper surface parameters must be assumed based on proper site surveys.

4.4 Hydrogeology

Hydrogeology of the project area must be investigated, considering that:

- o The morphology presents multiple streams that run along the slope, whose water flow rate varies greatly depending on the season.
- o During periods of heavy and persistent rainfall, the presence of a ground water circulation at the interface bedrock - soil cover can be expected.
- o Suspended aquifers and water pockets in the rock mass are possible, locally and/or seasonally.
- o The conditions of the joints, in particular the opening and the interlocking degree of the rock mass, are the determining factors for water circulation in the bedrock.

5.1 Materials

The main properties of the materials foreseen within the project are detailed in the following paragraphs for the different specific civil works and then summarized in table within paragraph 5.1.7.

5.1.1 Tunnel

5.1.1.1 Concrete

Temporary Shotcrete (Tunnel) for rock excavation support

- Reference Code: UNI EN 1992 1-1, EN 206:2016
- Concrete Class: C25/30
- fck = 25 MPa
- Cement Type: III-IV (EN 197-1)
- Exposure Class: XC2
- Slump Class: S4
- Maximum Aggregate: 8mm (EN 12620)
- Steel fibres (where foreseen):
    - Diameter/Length: 0.55 mm/33 mm
    - L/D aspect ratio: 60
    - Tensile strength: > 1100 MPa
    - Elongation at break: < 4%
    - Dosage: 50 kg/m3

Permanent shotcrete for Portal Excavation Support

- Reference Code: UNI EN 1992 1-1, EN 206:2016
- Concrete Class: C30/37
- Cubic compressive strength Rck ≥ 37 MPa
- Cement Type: III-IV (UNI EN 197-1)
- Exposure Class: XC4 and XD1
- Alkali Aggregate Reaction (AAR) resistant
- Slump Class: S4
- Maximum Aggregate: 16mm (EN 12620)

Concrete for inner lining

- Concrete class, C30/37
- Exposure classes XC4, XD1 and XF1
- Maximum aggregate diameter, 32 mm
- Cubic compressive strength Rck ≥ 37 MPa
- Concrete cover = 50mm
- Alkali Aggregate Reaction (AAR) resistant

Lean Concrete

- Concrete class, C12/15
- Cubic compressive strength Rck ≥ 15 MPa
- Min. cement content: 150kg/m^3

Cement-Based Grout For Rock bolts/Anchors Injection

- Type: High strength, non-shrink cementitious construction grout with aggregate size suitable for the effective pouring thickness
- Plasticizer: 1% - 2% on weight
- Strength: 5MPa after 48h, 25MPa after 28d

5.1.1.2 Steel

Steel for reinforcement

a. STEEL RIBBED BARS:

- Bar diameter, D = according to calculations (between 14 mm and 22 mm)
- Steel grade B500 B
- Yield Strength, fyk ≥ 500 MPa

b. WIRE MESH

- Bar diameter, D = 5mm
- Steel grade min. B500 A
- Yield Strength, fyk ≥ 500 MPa

Structural Steel

a. STEEL RIBS: for excavation support

- Profile: HEB 180
- Steel grade S355
- Yield Strength, fyk ≥ 355 MPa

b. LATTICE GIRDERS for tunnel excavation support

- Profile: according to tunnel support classes
- Type: JB-3-Gurt or similar
- Steel grade S235; S500
- Yield Strength, fyk ≥ 235MPa; 500 MPa

Rock bolts

a. ROCK BOLTS, SWELLEX PM 16 for tunnel rock excavation support

- Tensile Strength Ftk ≥ 160 kN
- Yield Strength, Fyk ≥ 130 kN
- Drilling diameter ≥ 50 mm

b. ROCK BOLTS, SWELLEX PM 24 for tunnel rock excavation support

- Tensile Strength Ftk ≥ 240 kN
- Yield Strength, Fyk ≥ 200 kN
- Drilling diameter ≥ 50 mm

c. CEMENTED ROCK BOLTS, M33 for tunnel rock excavation support

- Tensile Strength Ftk ≥ 460 kN
- Yield Strength, Fyk ≥ 364 kN

- Type: Belloli Belcem M33 or similar
- Drilling diameter ≥ 60 mm

d. CEMENTED ROCK BOLTS, M27 for tunnel rock excavation support

- Ftk ≥ 350 kN
- Yield Strength, Fyk ≥ 280 kN
- Type: Belloli Belcem M27 or similar
- Drilling diameter ≥ 60 mm

e. CEMENTED ROCK BOLTS, M24 for tunnel rock excavation support

- Tensile Strength Ftk ≥ 250 kN
- Yield Strength, Fyk ≥ 200 kN
- Type: Belloli Belcem M24 or similar
- Drilling diameter ≥ 60 mm

f. PERMANENT ROCK BOLTS, GEWI BAR 32 for portal excavation support

1. Nominal Diameter : 32mm
2. Cross Sectional Area: 804mm2
3. Steel grade: S500/550
4. Yield Strength, Fyk≥500 MPa
5. Tensile Strength, Ftk ≥550 MPa
6. Load at yield Py: 402 kN
7. Ultimate load Pt: 442 kN
8. Weight: 6.31 kg/m
9. Other requirements: DCP
10. Weight DCP: 9.50 kg/m
11. Drilling Diameter: 120mm

g. PERMANENT ROCK BOLTS, GEWI PLUS 43, for portal excavation support

1. Nominal Diameter : 43mm
2. Cross Sectional Area: 1452mm2
3. Steel grade: S670/800
4. Yield Strength, Fyk≥ 670 MPa
5. Tensile Strength, Ftk≥ 800 MPa
6. Load at yield: 973 kN
7. Ultimate load: 1162 kN
8. Weight: 11.40 kg/m
9. Other requirements: DCP
   - Weight DCP: 15.80 kg/m
   - Drilling Diameter: 120mm

Steel for Pre-tensioned Anchors

TEMPORARY PRE TENSIONED GROUTED ANCHOR for portal excavation support

- Harmonic Steel: 0.6''
- Steel grade: S1670/1860
- Yield Strength, Fyk≥ 1670 MPa
- Tensile Strength, Ftk≥ 1860 MPa
- Number of strands: 5
- Nominal Strand area, Ai: 140 mm2
- Load at yield, Py: 234 kN/strand
- Ultimate Load, Pt: 260 kN/strand
- Prestress Load: 70 kN/strand
- Drilling Diameter: 200mm

Steel for Forepoling

a. FOREPOLING BARS for rock tunnel excavation support

- fyk ≥ 550 MPa
- Type: Minova MAI SDA R51L or similar

b. FOREPOLING TUBES

- Steel grade S355
- External diameter 114.3 mm, thickness 16 mm

5.1.1.3 Fiberglass anchors

- Ftk ≥ 800 kN
- Drilling diameter ≥ 100mm
- Type: tubes 60 mm (external diameter) / 40 mm (internal diameter) or similar

5.1.1.4 Waterproofing

The waterproofing system will be considered in the calculation of the final lining. According to our experience into similar projects, waterproofing layer can be modelled by means of elastic springs, having the following stiffness: k_{wtpf} = 60000 KN/m^3

5.1.2 Tunnel technical Buildings (if applicable)

5.1.2.1 Concrete

a. Concrete for foundations

- Concrete class, C25/30
- Exposure classes XC2
- Maximum aggregate diameter, 32 mm
- Cubic Characteristic strength Rck ≥ 30 MPa
- Cement Type: III-IV (EN 197-1)
- Slump Class: S4
- Concrete cover = 50mm

- Alkali Aggregate Reaction (AAR) resistant

b. Concrete for external walls

- Concrete class, C30/37
- Exposure classes XC4, XD1 and XF1
- Maximum aggregate diameter, 32 mm
- Cubic Characteristic strength Rck ≥ 37 MPa
- Cement Type: III-IV (EN 197-1)
- Slump Class: S4
- Concrete cover = 50mm
- Alkali Aggregate Reaction (AAR) resistant

c. Concrete for internal walls and slab

- Concrete class, C30/37
- Exposure classes XC3
- Maximum aggregate diameter, 32 mm
- Cubic Characteristic strength Rck ≥ 37 MPa
- Cement Type: III-IV (EN 197-1)
- Slump Class: S4
- Concrete cover = 50mm

d. Concrete for top slab

- Concrete class, C30/37
- Exposure classes XC4, XF3
- Maximum aggregate diameter, 32 mm
- Cubic Characteristic strength Rck ≥ 37 MPa
- Cement Type: III-IV (EN 197-1)
- Slump Class: S4
- Concrete cover = 50mm
- Alkali Aggregate Reaction (AAR) resistant

e. Lean Concrete

- Concrete class, C12/15
- Cubic compressive strength Rck ≥ 15 MPa
- Min. cement content: 150kg/m^3

5.1.2.2 Steel reinforcement

Steel ribbed bars for reinforcement:

- Bar diameter, D = according to calculations (between 10 mm and 22 mm)
- Steel grade B500 B

- Yield Strength, fyk ≥ 500 MPa
- Tensile Strength, ftk ≥ 550 MPa
- Minimum value k, ftk/ fyk ≥ 1.08
- Elastic Modulus, E, 210000 MPa

5.1.3 Rockshed (if applicable)

5.1.3.1 Concrete

a. Concrete for foundations

- Concrete class, C25/30
- Exposure classes XC2
- Maximum aggregate diameter, 32 mm
- Cubic Characteristic strength Rck ≥ 30 MPa
- Cement Type: III-IV (EN 197-1)
- Slump Class: S4
- Concrete cover = 50mm
- Alkali Aggregate Reaction (AAR) resistant

b. Concrete for walls

- Concrete class, C30/37
- Exposure classes XC4, XD1 and XF1
- Maximum aggregate diameter, 32 mm
- Cubic Characteristic strength Rck ≥ 37 MPa
- Cement Type: III-IV (EN 197-1)
- Slump Class: S4
- Concrete cover = 50mm
- Alkali Aggregate Reaction (AAR) resistant

c. Concrete for top slab

- Concrete class, C30/37
- Exposure classes XC4, XF3
- Maximum aggregate diameter, 32 mm
- Cubic Characteristic strength Rck ≥ 37 MPa
- Cement Type: III-IV (EN 197-1)
- Slump Class: S4
- Concrete cover = 50mm
- Alkali Aggregate Reaction (AAR) resistant

Lean Concrete

- Concrete class, C12/15
- Cubic compressive strength Rck ≥ 15 MPa
- Min. cement content: 150kg/m^3

5.1.3.2 Steel reinforcement

Steel ribbed bars for reinforcement:

- Bar diameter, D = according to calculations (between 10 mm and 28 mm)
- Steel grade B500 B
- Yield Strength, fyk ≥ 500 MPa
- Tensile Strength, ftk ≥ 550 MPa
- Minimum value k, ftk/ fyk ≥ 1.08
- Elastic Modulus, E, 210000 MPa

5.1.3.3 Cushion layer

Lightweight Expanded Clay Aggregate type Leca 0-30mm or similar, placed in stratum 50cm high, compacted by vibrating plate.

- Specific weight of the supplied material = 390 kg/m^3
- Design specific weight = 6 kN/m^3
- Grains resistance to crushing ≥ 1.5 N/mm^2
- Water absorption after 24 hours < 25%
- Design Young Modulus: E = 25000 kPa
- Friction angle: Φk= 40°
- Max granulometry dimension: Dmax= 30 mm

5.1.4 Culverts

5.1.4.1 Concrete

a. Concrete for foundations

- Concrete class, C25/30
- Exposure classes XC2
- Maximum aggregate diameter, 32 mm
- Cubic Characteristic strength Rck ≥ 30 MPa
- Cement Type: III-IV (EN 197-1)
- Slump Class: S4
- Concrete cover = 50mm
- Alkali Aggregate Reaction (AAR) resistant

b. Lean Concrete

- Concrete class, C12/15
- Cubic compressive strength Rck ≥ 15 MPa
- Min. cement content: 150kg/m^3

5.1.4.2 Steel

a. Steel for reinforcement – Ribbed Bars:

- Bar diameter, D = according to calculations (between 14 mm and 22 mm)
- Steel grade B500 B
- Yield Strength, fyk ≥ 500 MPa

5.1.5 Retaining Walls

5.1.5.1 Concrete

- Concrete class, C30/37
- Exposure classes XC4, XD1 and XF1
- Maximum aggregate diameter, 32 mm
- fck = 30 MPa
- Concrete cover = 50mm
- Alkali Aggregate Reaction (AAR) resistant

5.1.5.2 Steel for reinforcement

- Bar diameter, D = according to calculations
- Steel grade B500 B
- Yield Strength, fyk = 500 MPa

5.1.5.3 Rockbolts

a. CEMENTED BOLTS FOR ANCHORS

- Type: Permanent Gewi diam. 25 mm (steel grade B500B) with preinjected corrugated sheating or equivalent
- Tensile Strength, Ftk ≥ 285 kN
- Yield Strength, Fyk ≥ 246 kN
- Drilling diameter ≥ 110 mm

5.1.5.4 Micropiles

b. CEMENTED BOLTS FOR MICROPILES

- Type: Permanent Gewi diam. 32 mm (steel grade B500B) with preinjected corrugated sheating or equivalent
- Tensile Strength Ftk ≥ 466 kN
- Yield Strength, Fyk ≥ 402 kN
- Drilling diameter ≥ 110 mm

c. CEMENTED BOLTS FOR MICROPILES

- Type: Permanent Gewi diam. 40 mm (steel grade B500B) with preinjected corrugated sheating or equivalent
- Tensile Strength Ftk ≥ 728 kN
- Yield Strength, Fyk ≥ 628 kN

- Drilling diameter ≥ 110 mm

5.1.6 Slope Stabilisation with Shotcrete + anchor bolts

5.1.6.1 Shotcrete (Permanent)

- Reference Code: UNI EN 1992 1-1, EN 206-1
- Concrete Class: C30/37
- Characteristic Cubic Strength: Rck >37 MPa
- Cement Type: III-IV (UNI EN 197-1)
- Exposure Class: XC4/XD1/XF1
- Resistant at AAR
- Slump Class: S4
- Maximum Aggregate: 8 mm (EN 12620)
- Steel fiber (where applicable) : minimum 50kg/cum

5.1.6.2 Steel for reinforcement

a. STEEL WIRE MESH

- Bar diameter, D = 6mm
- Mesh spacing = (100x100)mm
- Steel grade min. B500 A
- Yield Strength fyk = 500 MPa

5.1.6.3 Steel for bolts

a. ROCKBOLTS:

- Type: Permanent Gewi diam. 25 mm (steel grade B500B) with preinjected corrugated sheating or equivalent
- Tensile Strength Ftk ≥ 357 kN
- Yield Strength Fyk ≥ 308 kN
- Drilling diameter ≥ 110 mm

5.1.7 Summary of materials

5.1.7.1 Cementitious Materials

Table 5.1 : Lean and Structural Concrete

LEAN AND STRUCTURAL CONCRETE:

	CONCRETE STRENGTH CLASS	MINIMUM CHARACTERISTIC CUBIC STRENGTH R_{ck} (MPa)	EXPOSURE CLASS	MAXIMUM NOMINAL AGGREGATE SIZE (mm)	CONSISTENCE CLASS	MINIMUM CONCRETE COVER (mm)
LEAN CONCRETE	C12/15 (M15/20mm)	15	X0	20	S2	-
TUNNEL LINING	C30/37 (M40/32mm)	37	XC4, XD1, XF1	32	S4	50
ROCKSHED AND TECHNICAL BUILDINGS (FOUNDATIONS)	C25/30 (M30/32mm)	30	XC2	32	S4	50
ROCKSHED AND TECHNICAL BUILDINGS (EXTERNAL WALLS)	C30/37 (M40/32mm)	37	XC4, XD1, XF1	32	S4	50
ROCKSHED AND TECHNICAL BUILDINGS (TOP SLAB)	C30/37 (M40/32mm)	37	XC4, XF3	32	S4	50
TECHNICAL BUILDINGS (INNER WALLS AND SLABS)	C30/37 (M40/32mm)	37	XC3	32	S4	50
BURIED CULVERTS	C25/30 (M30/32mm)	30	XC2	32	S4	50
RCC WALLS AND EXTERNAL CULVERTS	C30/37 (M40/32mm)	37	XC4, XD1, XF1	32	S4	50
TIE BEAMS FOR EXCAVATIONS WORKS	C30/37 (M40/32mm)	37	XC4, XD1, XF3	32	S4	50

Table 5.2 : Shotcrete

SHOTCRETE:

	STRENGTH CLASS	MINIMUM CHARACTERISTIC CUBIC STRENGTH R_{ck} (MPa)	EXPOSURE CLASS	MAXIMUM NOMINAL AGGREGATE SIZE (mm)	CONSISTENCE CLASS	MINIMUM CONCRETE COVER (mm)
SHOTCRETE FOR TUNNEL (INTERNAL AREAS)	C25/30 (M30/8mm)	30	XC4, XD3	8	S4	50
SHOTCRETE FOR ROCK PROTECTION (EXTERNAL AREAS)	C30/37 (M40/8mm)	37	XC4, XD1, XF1	8	S4	50

Table 5.3: Cement-based grout for rock bolts/anchor

CEMENT-BASED GROUT FOR ROCK BOLTS/ ANCHORS INJECTION

TYPE:	HIGH STRENGTH, NON-SHRINK CEMENTIOUS CONSTRUCTION GROUT WITH AGGREGATE SIZE SUITABLE FOR THE EFFECTIVE POURING THICKNESS
PLASTICIZER:	1% - 2% ON WEIGHT
STRENGTH:	5 MPa AFTER 48h, 25 MPa AFTER 28d

5.1.7.2 Steel Materials

Table 5.4 : Steel for reinforcement

STEEL REINFORCEMENT

1. MIN. COVER REINFORCEMENT = 50mm (TYPICAL), UNLESS NOTED OTHERWISE
2. MIN. OVERLAPPING: 50 Ø, UNLESS NOTED OTHERWISE
3. PROPERTIES:

Table 5.5: Structural Steel

STRUCTURAL STEEL FOR STEEL RIBS AND LATTICE GIRDERS

STRUCTURAL STEEL	PROFILE	TYPE	STEEL GRADE	F_{yk}
STEEL RIBS	HEB 180	-	S355	355 MPa
LATTICE GIRDER	ACCORDING TO TUNNEL SUPPORT CLASSES	JB-3-GURT OR SIMILAR	S235/S500	235/500

Table 5.6: Temporary Rockbolts for tunnel excavation

ROCKBOLTS

	SWELLEX PM 16	SWELLEX PM 24	BELLOLI BELCEM M33 OR SIMILAR	BELLOLI BELCEM M27 OR SIMILAR	BELLOLI BELCEM M24 OR SIMILAR
DIAMETER	ø 16 mm	ø 24 mm	ø 33 mm	ø 27 mm	ø 24 mm
TENS. STRENGTH, f_{tk}	≥ 160 kN	≥ 240 kN	≥ 460 kN	≥ 350 kN	≥ 250 kN
YIELD STRENGTH, f_{yk}	≥ 130 kN	≥ 200 kN	≥ 364 kN	≥ 280 kN	≥ 200 kN
DRILLING DIAMETER	≥ 50 mm	≥ 50 mm	≥ 60 mm	≥ 60 mm	≥ 60 mm

* LENGTH AND SPACING ACCORDING TO TUNNEL SUPPORT CLASSES.

Table 5.7 : Permanent rock bolts for slope stability

ROCK BOLTS

	GEWI BAR 32 OR SIMILAR	GEWI PLUS 43 OR SIMILAR
NOMINAL DIAMETER Ø	32 mm	43 mm
CROSS SECTIONAL AREA	804 mm^2	1452 mm^2
GRADE	S500/550	S670/800
YIELD STRENGTH, f_{yk}	≥ 500 MPa	≥ 670 MPa
TENSILE STRENGTH, f_{tk}	≥ 550 MPa	≥ 800 MPa

Table 5.8 : Temporary Pre-tensioned anchor for excavation stability at portals

PRE-TENSIONED GROUTED ANCHOR

HARMONIC STEEL	0.6"
GRADE	S1670/1860
YIELD STRENGTH, f_{yk}	1670 MPa
TENSILE STRENGTH, f_{tk}	1860 MPa
NUMBER OF STRANDS	5
NOMINAL STRAND AREA, Ai	140 mm^2
LOAD AT YIELD	234 kN/STRAND
ULTIMATE LOAD	260 kN/STRAND
PRESTRESS LOAD, $P_0 = 0.3P_y$	70 kN/STRAND
DRILLING DIAMETER	200 mm

Table 5.9: Forepoling

FOREPOLING BARS

F_{yk}:	≥ 550 MPa
TYPE:	MINOVA MAI SDA R51L OR SIMILAR
LENGTH:	3 m
SPACING (TRANSVERSAL):	0.375 m

FOREPOLING TUBES

STEEL GRADE:	S355
EXTERNAL DIAMETER:	114.3 mm, THICKNESS 16 mm
LENGTH:	>15 m
SPACING (TRANSVERSAL):	0.4 m

5.1.7.3 Fiberglass

Table5.10 : Fiberglass

FIBER GLASS ANCHORS

F_{tk}:	≥ 800 kN
DRILLING DIAMETER:	≥ 100 mm
TYPE:	TUBES 60 mm (EXTERNAL DIAMETER) / 40 mm (INTERNAL DIAMETER) OR SIMILAR
LENGTH AND OVERLAPPING:	ACCORDING TO TUNNEL SUPPORT CLASSES

5.2 Design Working Life

Design Working Life of structures is defined as “the period of time during which the construction is assumed to be used for intended purposes, with anticipated maintenance, but without substantial repairs”.

According to EN 1990 (Eurocode 0) the design working lives (Tunnel and Rock Shed) of Category 5 – Monumental building structures, bridges and other civil engineering structures – 100 years.

According to EN 1990 (Eurocode 0) the design working lives (Technical Building and Other Road structures,Slope stabilization and mitigation related) of Category 4 – Building structures and other common structures – 50 years.

This requirement has to be met by means of a design that includes an appropriate selection of the structural solutions and construction materials, a careful construction compliant with the design and a suitable inspection of the design, where appropriate. Construction and operation activities, together with an appropriate use and maintenance of the structures are as well of major importance to guarantee such requirement.

For temporary structures, such as for the excavation works at the tunnel portals, a design working life of 10 years has been considered.

Table 5.11 Design Working Life (EN 1990)

Elements	Design working life category	Design working life (years)
Tunnel and Rock Shed related structures	5	100
(Technical Building and Other Road structures,Slope stabilization and mitigation related)	4	50

5.3 Design Approach

Structural and geotechnical design is carried out according to Eurocodes, with reference to the semi-probabilistic method (limit state). Load Combinations, safety and partial factor coefficients, design and verifications are considered both at the Ultimate Limit State (USL) and at the Serviceability Limit State (SLS), according to Eurocodes.

5.3.1 Design conditions

The relevant design conditions are considered taking into account the circumstances under which the structure is requested to fulfil its function, which can be classified as:

- transient situations, with reference to temporary conditions applicable to a structure, e.g. an executive phase or repair;
- persistent situations, which refer to normal service conditions;
- accidental or exceptional situations, which refer to exceptional conditions applicable to a structure, ex. rockfall, collisions, fires, explosions, etc..;
- seismic situations, which refer to conditions applicable to the structure when subjected to seismic events.

Table 5.12 Design Conditions

Design conditions	Description
Persistent	Condition of normal use
Transient	Temporary conditions, e.g. during execution or repair
Accidental	Exceptional conditions structure/exposure, e.g. fire, explosion
Seismic	Condition when structure subject to seismic events

Note that each category requires a specific analysis of the time horizon in which it occurs; the design situations can occur throughout the design life of a structure or be limited to a specific executive phase or repair.

5.3.2 Principles of Limit State Design

5.3.2.1 Ultimate Limit State (ULS) – Structure design

The Ultimate Limit States (ULS) for structural design concern:

- The safety of people, and/or
- The safety of the structure.

The following ultimate limit states are relevant for structures design (EN 1990):

- **EQU**: loss of equilibrium of structure, considered as rigid body;
- **STR:** internal failure or excessive deformation of the structure or structural members,

When considering a limit state of static equilibrium of the structure (EQU), it shall be verified that:

Ed,dst ≤ Ed,stb

where:

Ed,dst is the design value of the effect of destabilising actions ; Ed,stb is the design value of the effect of stabilising actions.

When considering a limit state of rupture or excessive deformation of a section, member or connection (STR), it shall be verified that:

Ed ≤ Rd

where:

Ed is the design value of the effect of actions such as internal force, moment or a vector representing several internal forces or moments;

Rd is the design value of the corresponding resistance.

When considering a limit state of rupture or excessive deformation of a section, member or connection (STR), it shall be verified that:

Ed ≤ Rd

where:

Ed is the design value of the effect of actions such as internal force, moment or a vector representing several internal forces or moments;

Rd is the design value of the corresponding resistance.

ULS load combinations considered for design are here briefly summarized.

5.3.2.2 Ultimate Limit State (ULS) – Geotechnical design

When defining the design situations and the limit states, the following factors should be considered:

- site conditions with respect to overall stability and ground movements;
- nature and size of the structure and its elements, including any special requirements such as the design life;
- conditions with regard to its surroundings (e.g.: neighbouring structures, traffic, utilities, vegetation, hazardous chemicals);
- ground conditions;
- ground-water conditions;
- regional seismicity;
- influence of the environment (hydrology, surface water, subsidence, seasonal changes of temperature and moisture).

Limit states can occur either in the ground or in the structure or by combined failure in the structure and the ground.

The following ultimate limit states are relevant for project structures (EN 1997):

- EQU: loss of equilibrium of the ground, considered as a rigid body, in which the strengths of the ground are insignificant in providing resistance.
- GEO: failure or excessive deformation of the ground where the strengths of soil are significant in providing resistance.

When considering a limit state of static equilibrium or of overall displacements of the structure or ground (**EQU**), it shall be verified that:

$E_{d,dst} \leq E_{d,stb} + T_d$

where:

$E_{d,dst}$ is the design value of the effect of destabilising actions ;

$E_{d,stb}$ is the design value of the effect of stabilising actions;

T_d is design value of total shearing resistance that develops around a block of ground in which a ground of tension piles is placed, or on the part of the structure in contact with the ground.

When considering a limit state of rupture or excessive deformation of a section, member or connection (**GEO**), it shall be verified that:

$E_d \leq R_d$

where:

E_d is the design value of the effect of actions such as internal force, moment or a vector representing several internal forces or moments;

R_d is the design value of the corresponding resistance.

According to EN 1997-1 ultimate state limit design for STR and GEO the manner in which equations of “design resistance” and “design effects on action” are applied shall be determined using one of three Design Approaches.

Design Approach 1 has been considered in the project and it is detailed in the following.

5.3.2.2.1 Design Approach 1

According to Eurocode EN 1990, design of structural members (STR) involving geotechnical actions and the resistance of ground (GEO) should be verified using only one of the different three approaches supplemented for geotechnical actions and resistances, by EN 1997.

For the structural verifications in this DPR, Approach 1 has been adopted, where partial factors are applied to actions and to ground strength parameters.

Except for the design of axially loaded piles and anchors, it shall be verified that a limit state of rupture or excessive deformation will not occur with either of the following combinations of sets of partial factors:

Combination 1: A1 “+” M1 “+” R1

Combination 2: A2 “+” M2 “+” R1

where “+” implies: “to be combined with”.

For the design of axially loaded piles and anchors, it shall be verified that a limit state of rupture or excessive deformation will not occur with either of the following combinations of sets of partial factors:

Combination 2: A2 “+” M2 “+” R4

In Combination 1, partial factors are applied to actions and to ground strength parameters. In Combination 2, partial factors are applied to actions, to ground resistances and sometimes to ground strength parameters.

In Combination 2, set M1 is used for calculating resistances of piles or anchors and set M2 for calculating unfavourable actions on piles owing e.g. to negative skin friction or transverse loading.

If it is obvious that one of the two combinations governs the design, calculations for the other combination need not be carried out. However, different combinations may be critical to different aspects of the same design..

5.3.2.3 Serviceability Limit State (ULS) – Structure design

The Serviceability Limit State (SLS) concerns:

- the functioning of the structure or structural members under normal use;
- the comfort of people;
- the appearance of the construction works.

The verification of serviceability limit states is based on criteria concerning the following aspects:

a) deformations that affect

- the appearance,
- the comfort of users, or

- the functioning of the structure, or that cause damage to finishes or non-structural members;

b) damage that is likely to adversely affect

- the appearance,
- the durability, or
- the functioning of the structure.

The combination of actions to be taken into account in the relevant design situation should be appropriate for the serviceability requirements and performance criteria being verified:

Ed ≤ Cd

Ed design value of the effects of actions specified in the serviceability criterion, determined on the basis of the relevant combination.

Cd limiting design value of the relevant serviceability criterion: stress limitation, crack control and deformation control.

5.3.2.4 Serviceability Limit State (ULS) – Geotechnical

Verification for serviceability limit states in the ground or in a structural section, element or connection, shall either require that:

Ed ≤ Cd

Ed design value of the effects of actions specified in the serviceability criterion, determined on the basis of the relevant combination.

Cd limiting design value of the relevant serviceability criterion: stress limitation, crack control and deformation control.

A limiting value for a particular deformation is the value at which a serviceability limit state is deemed to occur in the supported structure. For retaining structures, such as wall as according to Swiss standard,

5.3.3 Combination of Actions

For each critical load case, the design value of the effect of actions shall be determined by combining the values of actions are considered to occur simultaneously. Each combination of actions should include a leading variable action, or an accidental action.

The combination of actions for ULS are defined symbolically by the following expressions.

5.3.3.1 ULS fundamental static load combination

$$E_d = E\left\{\gamma_{G,j}G_{k,j}\,;\,\gamma_P P\,;\,\gamma_{Q,1}Q_{k,1}\,;\,\gamma_{Q,i}\psi_{0,i}Q_{k,i}\right\} \quad j \geq 1\,;\, i > 1$$

$$\sum_{j\geq 1}\gamma_{G,j}G_{k,j}\text{"+"}\gamma_P P\text{"+"}\gamma_{Q,1}Q_{k,1}\text{"+"}\sum_{i>1}\gamma_{Q,i}\psi_{0,i}Q_{k,i}$$

where:

x partial factor taking account of possible unfavourable deviations of the action from the representative values of the actions

Ψ partial factor depending on the limit state considered.

$\Psi_0 Q_k$ combination value, chosen so that the probability the effects caused by the combination will be exceeded is approximately the same as by the characteristic value of an individual action

G_k characteristic value of permanent action

Q_k characteristic value of variable action

P relevant representative value of a prestressing action = 0

5.3.3.2 ULS accidental load combination

$$E_d = E\left\{G_{k,j}\,;\,P\,;\,A_d\,;\,(\psi_{1,1}\text{ or }\psi_{2,1})Q_{k,1}\,;\,\psi_{2,i}Q_{k,i}\right\} \quad j \geq 1\,;\,i > 1$$

$$\sum_{j\geq 1} G_{k,j}\text{"+"}P\text{"+"}A_d\text{"+"}(\psi_{1,1}\text{ or }\psi_{2,1})Q_{k,1}\text{"+"}\sum_{i>1}\psi_{2,i}Q_{k,i}$$

where:

γ partial factor depending on the LS considered;

$\Psi_1 Q_k$ frequent value of the variable action to be considered

$\Psi_2 Q_k$ quasi-permanent value of the variable action to be considered

G_k characteristic value of permanent action;

Q_k characteristic value of variable action;

P relevant representative value of a prestressing action = 0;

Ad design value of the accidental action considered (*rockfall*)

5.3.3.3 ULS seismic load combination

$$E_d = E\left\{G_{k,j}\,;\,P\,;\,A_{Ed}\,;\,\psi_{2,i}Q_{k,i}\right\} \quad j \geq 1\,;\,i \geq 1$$

$$\sum_{j\geq 1} G_{k,j}\text{"+"}P\text{"+"}A_{Ed}\text{"+"}\sum_{i\geq 1}\psi_{2,i}Q_{k,i}$$

where:

Ψ partial factor depending on the LS considered;

$\Psi_2 Q_k$ quasi-permanent value, chosen so that the total period of time for which it will be exceeded is a large fraction of the reference period;

G_k characteristic value of permanent action;

Q_k characteristic value of variable action;

P relevant representative value of a prestressing action = 0;

AEd design value of the seismic action.

5.3.3.4 Serviceability Limit states

The combinations of actions to be taken into account in the relevant design situations should be appropriate for the serviceability requirements and performance criteria being verified.

Characteristic combination (adopted for irreversible limit state)

$$\sum_{j\geq 1} G_{k,j} \text{"+"} P \text{"+"} Q_{k,1} \text{"+"} \sum_{i>1} \psi_{0,i} Q_{k,i}$$

Frequent combination (adopted for reversible limit state)

$$\sum_{j\geq 1} G_{k,j} \text{"+"} P \text{"+"} \psi_{1,1} Q_{k,1} \text{"+"} \sum_{i>1} \psi_{2,i} Q_{k,i}$$

Quasi-permanent combination (adopted for long-term effects and appearance of the structure)

$$\sum_{j\geq 1} G_{k,j} \text{"+"} P \text{"+"} \sum_{i\geq 1} \psi_{2,i} Q_{k,i}$$

5.3.4 Partial Safety Factors

5.3.4.1 Ultimate Limit States Partial Factors

The partial factors are briefly summarized in the following tables. For further details and specific situations, see the relevant reports.

Table 5.13 *STR/GEO ULS static condition coefficients*

		Coefficient γ_F	EQU	STR/GEO A1	STR/GEO A2
Permanent load (structures)	Favorable	γ_{G1}	0.90	1.00	1.00
	Unfavorable		1.10	1.35	1.00
Permanent load (not structures) (defined)	Favorable	$\gamma_{G2\,(A)}$	0.90	1.00	1.00
	Unfavorable		1.10	1.35	1.00
Live load: wind, snow, others	Favorable	γ_{Qi}	0.00	0.00	0.00
	Unfavorable		1.50	1.50	1.30
Shrinkage, creep, settlements	Favorable	$\gamma_{\varepsilon 2}$, $\gamma_{\varepsilon 3}$, $\gamma_{\varepsilon 4}$	0.00	0.00	0.00
	Unfavorable		1.20	1.20	1.00

Table 5.14 For traffic load, where relevant, the following coefficients have been considered.

		Coefficient, γ_F	EQU	STR/GEO A1	STR/GEO A2
Live load: Traffic load	Favorable	$\gamma_{Q(TS)}$	0.00	0.00	0.00
(if relevant, where applied)	Unfavorable		1.35	1.50	1.15

According to EN 1997-1 the same partial factors on actions are applied in geotechnical structures design for verification of equilibrium limit sate (EQU).

The partial factors for actions for the ultimate limit states *in the accidental and seismic design situations* have been assumed equal to 1.0, according to Eurocode EN 1990.

Table 5.15 Partial coefficient for nominal soil/rock nominal parameters (M)

Material	*Normal Strength*		*EQU*	*STR/GEO M1*	*STR/GEO/M2*
Ground	*Friction Angle tanΦ'$_k$*	*$\gamma_{\Phi'}$*	*1.25*	*1.00*	*1.25*
	Cohesion c'$_k$	*$\gamma_{c'}$*	*1.25*	*1.00*	*1.25*
	Undraind Strength c$_{uk}$	*γ_{cu}*	*1.40*	*1.00*	*1.40*
	Unit Self Weight, γ_T	*γ*	*1.00*	*1.00*	*1.00*

For the ground partial factors, for the ultimate limit states *in seismic design situations*, M2 values are adopted, according to EN 1998-5, par. 3.

Table 16 Partial coefficient for nominal material strengths (M) (EN 1992-1-1)

Material	Nominal strength		Transient/ Permanent	Seismic/ Accidental
Concrete	Compression/tension/ shear strength f_{ck}, f_{ctk} , v_k	γ_c	1.50	1.20
Steel reinforcement	Yield strength f_{yk}	γ_s	1.15	1.0

Table 17 Partial coefficient for global strengths (R)

Element	**Strength**	**Symbol**	**R1**	**R4**
Shallow foundation (EN 1997, A.5)	Bearing capacity Sliding	γ_R γ_R	1.00 1.00	- -
Piles foundation (EN 1997, A.6)	Base Bearing capacity Lateral Bearing capacity (compr.) Total bearing capacity (compr.)	$\gamma_{R,b}$ $\gamma_{R,s}$ $\gamma_{R,s}$	1.00 1.00 1.00	1.3 1.3 1.3
	Lateral Bearing capacity (tensile)	$\gamma_{R,s,t}$	1.25	1.6
Pre-tensioned Anchoring (EN 1997, A.12)	Transient	$\gamma_{R,a,t}$	1.1	1.1
	Permanent	$\gamma_{R,a,p}$	1.1	1.1
Retaining structures (EN 1997, A.13)	Bearing capacity	$\gamma_{R,V}$	1.00	-
	Sliding	$\gamma_{R,H}$	1.00	-
	Downstream Earth Strength	$\gamma_{R,E}$	1.00	-
Global stability (EN 1997, A.14)	Earth Resistance	$\gamma_{R,E}$	1.00	-

For verifications of structural (STR) and geotechnical (GEO) limit states of pile foundations, the following correlation factors ξ shall be applied to derive the characteristic resistance of axially loaded piles:

- ξ3 on the mean values of the calculated resistances from ground test results;

- ξ4 on the minimum value of the calculated resistances from ground test results;

Correlation factors ξ3, ξ4, to derive characteristic values from ground test results (n - the number of profiles of tests).

Table 18 Correlation factors for piles

ξ for n =	1	2	3	4	5	7	10
ξ3	1.40	1.35	1.33	1.31	1.29	1.27	1.25
ξ4	1.40	1.27	1.23	1.20	1.15	1.12	1.08

5.3.4.2 Serviceability Partial Factors

Table 19 SLS actions partial factors

Category	Actions	Description	Ψ_0	Ψ_1	Ψ_2
B	Imposed loads in buildings	office areas	0.70	0.50	0.30
E	Imposed loads in buildings	storage areas	1.00	0.90	0.80
G	Traffic area, 30kN < vehicle weight ≤160 kN	roads on surface	0.70	0.50	0.30
-	Snow loads on buildings		0.70	0.50	0.20
-	Wind loads on buildings		0.60	0.20	0.00
-	Temperature (non-fire) in buildings		0.60	0.50	0.00
	Actions (construction)	Description	Ψ_0	Ψ_1	Ψ_2
	Construction loads	Qc	1.00	-	1.00

Ψ- values are valid also for seismic and accidental conditions, but considering that during accidental events other live loads such as snow and wind have not to be considered as simultaneously with the accidental action.

5.3.5 Durability

The structure is designed such that deterioration over its design working life does not impair the performance of the structure below that intended, having due regard to its environment and the anticipated level of maintenance.

In order to achieve an adequately durable structure, the following should be taken into account:

- the intended or foreseeable use of the structure;
- the required design criteria;

- the expected environmental conditions;
- the composition, properties and performance of the materials and products;
- the properties of the soil;
- the choice of the structural system;
- the shape of members and the structural detailing;
- the quality of workmanship, and the level of control;
- the particular protective measures;
- the intended maintenance during the design working life.

The environmental conditions is identified at this design stage, so that their significance can be assessed in relation to durability and adequate provisions can be made for protection of the materials used in the structure.

5.3.5.1 Environmental exposure classes

According to standards EN 206-1, EN 1992-1-1, the following classes of environmental exposure and minimum strength class of concrete have been considered for the different structural elements of the main protective structures, as reported in the following table. The maximum water-cement ratio and minimum cement or combination content are given referring to normal-weight concrete with 20 mm maximum aggregate size. For further details on materials see specific report and drawing.

Table 20 Exposure classes and concrete strength classes for durability according to EN 206

	Exposure Class	Min. Concrete strength class	Max Water/Cement Ratio	Min Cement Content (kg/cum)
Rockshed				
Foundations	XC2	C25/30	0.60	280
Walls and Columns	XC4, XD1, XF1	C30/37	0.50	300
Top Slab	XC4, XF3	C30/37	0.50	320
Tunnel				
Shotcrete (temporary)	XC2	C25/30	0.60	280
Inner lining	XC4, XD1, XF1	C30/37	0.50	300
Excavation supports				
Shotcrete (permanent)	XC4, XD1, XF1	C30/37	0.50	300
Retaining Walls				
Concrete	XC4, XD1, XF1	C30/37	0.50	300
Tunnel technical building				
Foundations	XC2	C25/30	0.60	280
Perimetral Walls	XC4, XD1, XF1	C30/37	0.50	300
Top Slab	XC4, XF3	C30/37	0.50	320
Internal Slab/Walls	XC3	C30/37	0.50	300

5.3.5.2 Concrete cover

The concrete cover equal to the distance between the surface of the reinforcement closest to the nearest concrete surface (including links and stirrups) and the nearest concrete surface.

Nominal cover $c_{nom} = c_{min} + \Delta c_{dev}$

where:

Δc_{dev} additional cover for tolerances (= 10mm)

cmin minimum cover = max[$c_{min,b}$; $c_{min,dur}+\Delta_{cdur,\gamma}-\Delta c_{dur,st}-\Delta c_{dur,add}$;10mm]

cmin,b minimum cover due to bond requirements: reinforcement steel -> separated rebars:

$c_{min,b}$ = diameter of bar ($c_{min,b,max}$ = 28mm)

$c_{min,dur}$ minimum cover due to environmental conditions ($c_{min,dur}$ = 35mm for XD1)

$\Delta c_{dur,\gamma}$ additive safety element = 5mm

$\Delta c_{dur,st}$,stainless steel (= 0)

$\Delta c_{dur,add}$,additional protection (e.g. coating) (= 0)

Concrete cover value is given for reinforcement steel just for durability assessment.

The following concrete covers for main reinforcement have been adopted, according to the considered exposure classes and providing an unified specification for all structural elements:

50 mm for all formed concrete exposed to weather or in contact with the ground or weather.

50 mm for concrete slabs and walls and for bars and girders neither exposed to weather nor in contact with the ground.

5.3.6 Design verifications

Ultimate limit states (ULS) and serviceability limit state (SLS) verifications have been considered according to Eurocodes.

Safety checks are performed by means of the Partial Factors Method: for all relevant design situations, verifying if the limit states are not exceeded when design values of the actions, material properties and geometric dates are introduced in structural and load models.

The non-exceedance limit check allows to state that the probability of reaching a certain limit situation is less than the value set by the standard during the structure life or during a timeframe of reference in case of execution/constructive phase.

The verifications ensure that:

- Assumed design actions do not cause the collapse of the structure or the ground (even in exceptional/accidental situations);
- Effects of the assumed design actions do not exceed the design strength of the structure at the ultimate limit state;
- Effects of the assumed actions do not exceed the functionality criteria for the service limit state.

Ultimate limit states connected both to the structure collapse (or the whole structure-ground) and to a partial failure are considered; Service ultimate states that match the conditions beyond which specific operational requirements connected to the structure or its elements are no longer met are taken into account. For geotechnical verifications refer also to 5.6.

5.3.6.1 Performance Level of structures

ULS

For the design of new structures these performances are considered at ULS for permanent/transient loads conditions

Table 21 ULS permanent/transient structures performance.

Behaviour	Performance
Non-linear materials/sections. Linear/Non-linear structure behaviour.	Safety, no collapse: $E_d \leq R_d$

For the design of new structures these performances are considered at ULS for accidental loads conditions:

Table 22 ULS accidental structures performance.

Behaviour	Performance
Non-linear materials/sections. Linear/Non-linear structure behaviour.	Safety, no collapse: $E_d \leq R_d$ Fire, REI

SEISMIC PERFORMANCE

According to EN 1998 to the design and construction of civil engineering works in seismic regions, structures and geotechnical structures of new structures should ensure that in the event of earthquakes:

- human lives are protected;
- damage is limited;
- structures important for civil protection remain operational.

5.3.6.2 SLS verifications

5.3.6.2.1 SLS Stress limits for concrete structures

According to EN 1992-1 the compressive stress in the concrete is limited in order to avoid longitudinal cracks, micro-cracks or high levels of creep, where they could result in unacceptable effects on the function of the structure.

Characteristic load combination: $\sigma_c \leq k_1 \times fck = 0.60 \times f_{ck}$

Quasi-permanent load combination: $\sigma_c \leq k_2 \times fck = 0.45 \times f_{ck}$

According to EN 1992-1 the tensile stresses in the reinforcement are limited in order to avoid inelastic strain, unacceptable cracking or deformation.

Characteristic load combination: $\sigma_s \leq k_3 \times f_{yk} = 0.8 \times f_{yk}$

Imposed deformations: $\sigma_s \leq k_4 \times f_{yk} = 1.0 \times f_{yk}$

5.3.6.2.2 SLS Crack control for concrete structures

A limiting calculated crack width, w_{max}, taking into account the function and nature of the structure and the costs of limiting cracking, is established according to EN 1992-1-1 (Table 7.1N), for the different exposure classes.

For steel reinforced concrete, suggested values are reported.

Table 23 Concrete crack control

Exposure class	Reinforced members Quasi-permanent load combination
XC2 –XC4 - XD1	W_{max} = 0.3 mm

For temporary structures, that develops loads for short time of construction, crack control will be neglected.

Measures to control leakage such as drains and water stops shall be used.

5.3.6.2.3 Deflection control

According to Eurocode EN 1992-1-1, deflections of slabs and beams should satisfy the following limits to avoid irreparable damages of the element and of adjacent parts of the structure, respectively:

$\delta \leq L/250$, for quasi-permanent load combinations during constructions;

$\delta \leq L/500$, for quasi-permanent load combinations after constructions (live load).

The appearance and general utility of the structure could be impaired when the sag of a beam, slab or cantilever subjected to quasi-permanent loads exceeds span/250. The sag is assessed relative to the supports.

Deflections that could damage adjacent parts of the structure should be limited. For the deflection after construction, span/500 is normally an appropriate limit for quasi-permanent and frequent loads. Other limits may be considered, depending on the sensitivity of adjacent parts.

5.4 Design Load

Design loads for all structures will be determined in accordance with the criteria described below, unless the applicable building code requirements are more stringent.

5.4.1 Tunnel

5.4.1.1 Concrete dead load

Characteristic value of the shotcrete self-weight is: 25 KN/m^3

Characteristic value of the cast in situ concrete is: : 25 KN/m^3

5.4.1.2 Unstable blocks

The weight of the rock shall be assumed for all lithologies according to the geological/geotechnical evaluations.Moreover, parameters for joints resistance shall be assumed in the calculations, based on performed geomechanical characterization.

5.4.1.3 Rock loosening and soil pressure

Loosening of the rock mass around the tunnel shall be estimated through well recognized design approaches as a parabolic-linear load, according to Terzaghi's theory) or derived by FEM calculations. Loosening heights and the resulting maximum loads (at the tunnel key) both on primary lining and on inner lining must be defined according to geomechanical characteristics estimated along the tunnel.

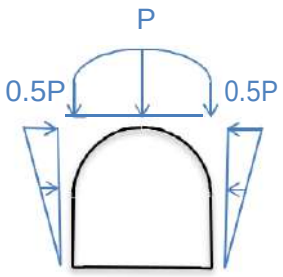

Figure 5.1: Example of loosening load at the tunnel contour

5.4.1.4 Seismic load

Earthquake is not considered for the underground part of the tunnel, as no shear lines (faults) has been detected along the tunnel.

5.4.2 Tunnel Technical Building

5.4.2.1 Dead load

Characteristic value of the cast in situ concrete is:

Characteristic value of the shotcrete self-weight is: 25 KN/m^3

Characteristic value of the cast in situ concrete is: : 25 KN/m^3

Moreover, loads from permanent equipments and installations shall be considered according to the final design to be provided by the Contactor.

5.4.2.2 Overburden

The following minimum self weight of the filling ground shall be assumed: 2 KN/m^3

Overburden loads follow the geometry of the filling ground according to the project.

5.4.2.3 Earth thrust

Earth pressure at rest is calculated based on the filling ground parameters, by means of the Jaky's formula:

$K_0 = 1- \sin(\Phi_d)$

where Φ_d = design angle of friction.

5.4.2.4 Live load

On the buildings slabs, a minimum distributed live load equal to 3 kN/m^2 has to be assumed. Moreover, live loads according to technical specifications of the equipment designed by the Contractor shall be considered.

5.4.2.5 Seismic load

Earthquake horizontal and vertical acceleration shall be considered, based on a peak value of ground horizontal acceleration for reference period of 475 years for the project area a_g ***[Specify as per project area, ex. 0.31g].***

5.4.3 Cut & Cover tunnel

5.4.3.1 Dead load

Characteristic value of the cast in situ concrete is: 25 KN/m^3

5.4.3.2 Overburden

The following minimum self weight of the soil shall be assumed: 21 KN/m^3

Overburden loads follow the geometry of the filling ground according to the project.

5.4.3.3 Live load

The following surface live load shall be considered in the cut & cover tunnel stretch: 5 KN/m^3

5.4.3.4 Earth thrust

Earth pressure at rest is calculated based on the filling ground parameters, by means of the Jaky's formula:

$K_0 = 1- \sin(\Phi_d)$

where Φ_d = design angle of friction.

5.4.3.5 Seismic load

Earthquake horizontal and vertical acceleration must be considered.

Pseudo static analyses, with the peak horizontal acceleration expected for a given return period, shall be performed.

The peak value of ground horizontal acceleration for reference period of 475 years for the project area is a_g ***[Specify as per project area, ex. 0.31g].***

According to EC8:

$$k_h = \alpha \frac{S}{r}$$

$$k_v = \pm 0{,}5\, k_h$$

According to provided geological information indicating a ratio between components of the seismic action a_v/a_h=0.67, k_v will be assumed as:

$k_v = 0.7\ k_h$.

The following parameters shall be assumed:

$\alpha = a_g / g$ (i.e. 0.31g/g = 0.31);

S =1.2 (soil factor on rock shall be 1.0. In the present case 1.2 is assumed as a conservative value);

r = 1.0 (rigid structure).

Therefore:

Ex.: Kh = 0.37; Kv = 0.26.

5.4.4 Rockshed

5.4.4.1 Dead Load

Self-Weight

The self-weight of the structural members has been calculated assuming a characteristic unit weight of reinforced concrete of 25 kN/m^3.

Cushion material on top slab

The equivalent distributed loads over the top slab have been determined in relation to the effective design cushion layer thickness “Hl” upon the top slab and assuming a lightweight expanded clay unit weight equal to γ = 6 kN/m^3 (dry unit weight).

The resulting pressure is given by:

P=γ H

Surcharge on ground

The vertical pressure acting on ground level is evaluated considering the contribution of the Leca cushion and backfill material loading the ground level at the top slab level. Considering the relevant height and

unit weight equal to γ_{Fill} = 6 kN/m^3 for the Leca and γ_{Fill} = 20 kN/m^3 for the filling material , the resulting pressure is given by:

$P=\gamma H$

Backfill horizontal earth pressure

Based on the vertical pressure due to the surcharge on ground, earth pressure acting on the mountain wall side has been calculated as hydrostatic pressure acting on the total wall height, according to equation:

$P = \gamma H(z) k_0$

Where :

γ= backfill unit weight (kN/m^3)

$K_0 = 1 – \sin(\Phi')$ = at rest coefficient of lateral earth pressure

Φ' = internal friction angle of the backfill

H = calculation total height of the rockshed

For design, a selected granular filling, well compacted and placed in stratum 50cm high, with Self weight =20 kN/m^3 and Angle of friction $\Phi \geq 40°$ have been assumed.

5.4.4.2 Live Load

Traffic Load

According to Eurocode surface traffic load due to pedestrian has been considered as an uniform pressure acting on the bottom slab.

Snow Load

According to Nepal weather conditions, different climates according to altitude can be observe. Since according to temperature temperatures during the year except altitude 3000m,are generally greater than 0°C, snow load could been neglected.

Wind Load

Horizontal forces due to the wind action, both inward (towards mountain side) and outward (towards valley side) has been assumed negligible for this kind of structure.

5.4.4.3 Temperature

A temperature variation on the top slab, given by two components:

A uniform temperature component ΔT_U = +/- 15°C

A linearly varying temperature difference component along z-axis, ΔT_{MZ} = +/-5°

shall been considered, assuming a thermal expansion coefficient for concrete equal to α=1.2E^{-5} [1/°C],

5.4.4.4 Shrinkage

The shrinkage effects have been considered according to Standards approaches and a uniform temperature component ΔT, equal to:

$$\Delta T = \varepsilon_{sh} / \alpha$$

has been applied to the concrete top slab, where the thermal expansion coefficient for concrete equal to α = 1.2 E-5 [1/°C], and ε_{sh} is the shrinkage coefficient.

5.4.4.5 Accidental Load

Rockfall Load

According to the rockfall hazard analysis, the following assumptions has to be considered to estimate the rockfall design energy:

- The calculation volume is equal to the characteristic volume ($V_{cal} = V_k$) if the rockfall trajectories do not show significant rebounds;
- if the rockfall trajectories show at least 2 significant rebounds, it can be assumed that the characteristic boulder is shattered into elements equal in size to the average volume (V_m) of the boulders resulting by the static analysis of the recorded volumes by site surveys. This phenomenon is considered plausible considering the degree of interlocking of the rock mass and the conditions of the joints. In this case, the design coulder volume shall be increased by a partial factor equal to 1.5: $V_{cal} = 1.5 \times V_m$

Impact energy has to be determined according to the rockfall hazard analysis but the characteristic impact energy assumed for design should be at least Ec ≥ 15670 kJ (minimum design value). ***[Specify as per project area].***

The load estimation has been carried out according to ASTRA Swiss Guidelines, considering a pseudo-static approach based on an equivalent static force Ad that considers the impact load Fk of the rockfall on the rockshed, according to the following Equations:

$$A_d = C \cdot F_k$$

$$F_k = 2.8 \cdot e^{-0.5} \cdot r^{0.7} \cdot M_{E,k}{}^{0.4} \cdot \tan\varphi_k \cdot \left(\frac{m_k, v_k{}^2}{2}\right)^{0.6}$$

where:

- A_d Static equivalent force on design level [kN]
- C Coefficient to account for ductile (C=0.4) or brittle (C=1.2) failure of the structure [-]
- F_k Impact load [kN]
- e Thickness of cushion layer [m]
- r Radius of an equivalent sphere [m]
- $M_{E,k}$ Soil modulus of the cover layer [kN/m^2]
- ϕ_k Internal friction angle of the cover layer [°]
- m_k Characteristic block mass [t]
- v_k Characteristic impact velocity [m/s]

It is worth noting that the application of the guideline is limited to a penetration depth in the cushion layer of smaller than half of the cushion thickness; thus it is evident that cushion layer properties are of great importance to gain the potential enhancement of the loading capacity of existing structures.

This model is based on the following assumptions:

- The concrete structure is sufficiently rigid to neglect, in the elastic range, the influence of structure on the transmitted impact force;
- The concrete slab is sufficiently rigid to allow the impact load redistribution along the transversal and the longitudinal dimensions;
- The horizontal component of impact can be regarded separately;
- The loading surface is plane;
- The soil stiffness is independent from the impact velocity;
- The direct shear failure in soil is not considered;
- The concentrations of the transmitted forces do not exhibit premature punching failure;
- The diameter of the punching cone is determined with the maximum possible penetration, that must be smaller than half of the cushion thickness.

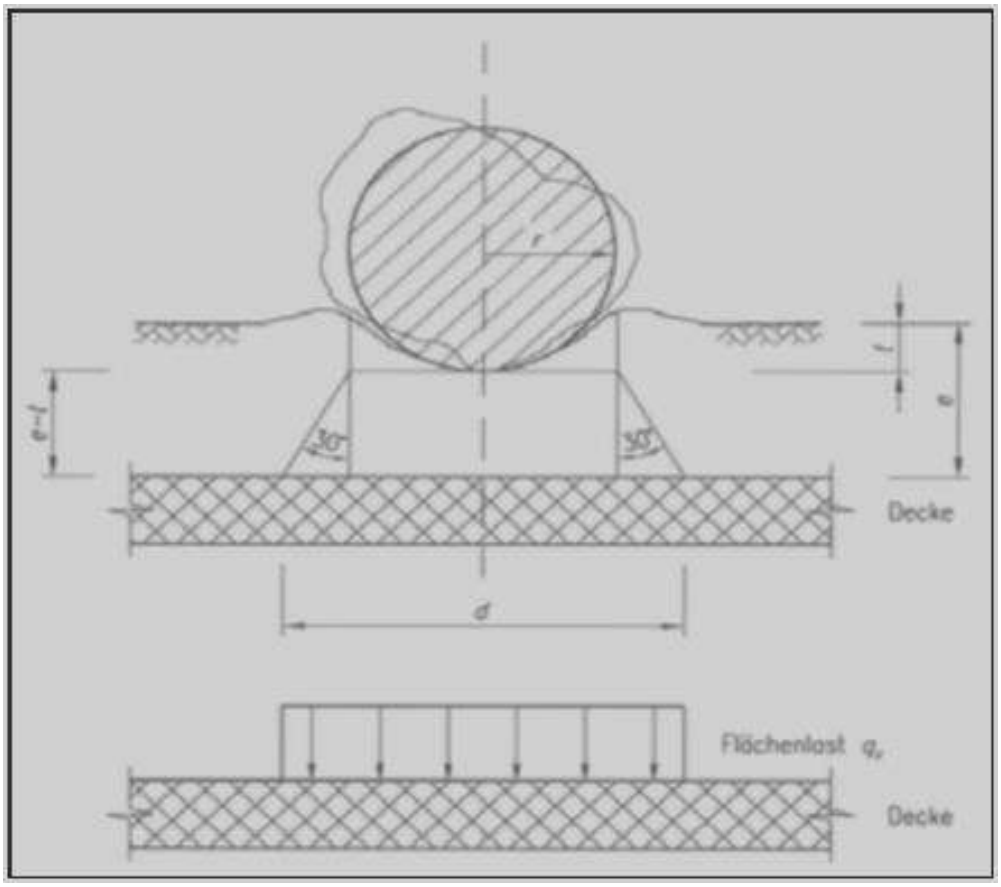

Figure 5.2 - *Load distribution of the equivalent static load according to [ASTRA, 2008]*

A transversal and longitudinal redistribution of the design equivalent static force on a square area given by the rockfall analyses and according to the damping cushion thickness and Swiss guidelines recommendations, has to be considered. The load has to be assumed to distribute with an angle of 45° up to the top slab medium plane.

An horizontal component of the impact has to be considered conservatively as 10% of the vertical load.

In order to evaluate a complete scenario of presumable rockfall impact locations, different location of the rock boulder have to be analysed.

5.4.4.6 Seismic Load

According to EN 1998-1/5, the structure has to be designed to fulfil its function during and after an earthquake, without suffering significant structural damage.

A pseudo-static method has to be used for assessing the safety of the structure, the seismic action is represented by a set of horizontal and vertical static forces equal to the product of the gravity forces and a seismic coefficient.

The peak ground design acceleration has to be assumed according to the maximum value provided by the Geological Report, considering a reference period for the ground horizontal peak acceleration equal to 475 years and a proper soil factor.

The horizontal (k_H) and vertical (k_V) seismic coefficients affecting all the masses have to be evaluated as:

$k_H = \alpha \ S/r$

$k_V = +/- 0.5 \ k_H \ (a_{vg}/a_g) > 0.6$

where:

- α, is the ratio of the design ground acceleration, a_g, to the acceleration of gravity, g
- S, is the soil parameter (S=1)
- r, factor depending on the type of retaining structure (r=1 for rigid structure)

The components of the seismic forces have been calculated through seismic coefficients, k_H, k_V and applied to the relevant structural element according to the pseudo-static approach

- $F_H = k_h (\gamma_{ds} V)$, Horizontal Inertia forces of concrete elements
- $Fv = kv (\gamma_{ds} V)$, Vertical Inertia forces of concrete elements

  where V is the volume of the concrete element
- $F_V = k_H (\gamma_{cushion} V)$ Horizontal Cushion layer Inertia force on the top slab
- $F_H = k_v (\gamma_{cushion} V)$ Vertical Cushion layer Inertia force on the top slab
- $\Delta SE = k_H \gamma H^2$ Backfill soil increment of pressure, according to Wood assuming a perfectly rigid wall

5.4.5 Retaining Wall

5.4.5.1 Dead load

Characteristic value of the cast in situ concrete is: 25 kN/m^3

5.4.5.2 Traffic load

Traffic load on the existing road has to be assumed equal to: 20 kN/m^3

5.4.5.3 Earth thrust

Earth pressure at rest is calculated based on the filling ground parameters, by means of the Jaky's formula:

$K_0 = 1- \sin (\Phi d)$

where Φd = design angle of friction.

Active earth pressure is calculated based on the filling ground parameters, by means of the Rankine's theory.

5.4.5.4 Seismic load

See 5.4.3.5.

5.4.6 Excavation stabilisation

5.4.6.1 Self-weight

Characteristic value of the shotcrete self-weight is: 25 kN/m^3

The weight of reinforcement by wiremeshes is considered included.

5.4.6.2 Soil and rock thrust

The rock thrust acting on the excavation surface is the main load component for the excavation walls stabilization measures.

Weight, resistance and stiffness parameters shall be considered according to geotechnical-geomechanical evaluations (see chapter 4).

5.4.6.3 Earthquake load

Earthquake horizontal and vertical acceleration has to be considered.

Pseudo static analyses, with the peak horizontal acceleration expected for a given return period, will be performed to determine seismic stability of the excavation.

The peak value of ground horizontal acceleration for reference period of 475 years for the project area is a_g ***[Specify as per project area, ex. 0.31g].***

The response of ground slopes to the design earthquake can be calculated using pseudo-static methods of stability analysis, where the design seismic inertia forces Fh and Fv acting on the ground mass, are defined:

$$F_H = 0{,}5\,\alpha \cdot S \cdot W$$

$F_V = \pm 0{,}5\,F_H$ if the ratio a_{vg}/a_g is greater than 0,6

$F_V = \pm 0{,}33\,F_H$ if the ratio a_{vg}/a_g is not greater than 0,6

Assuming S (soil factor) equal to unit, the value of peak ground acceleration is equal to 0.155g.

In the ratio between components of the seismic action is defined as a_V =67% a_H: this leads to a definition of design acceleration values, as:

- agH_permanent = **0.155 g**
- agV_permanent = **0.5 x agH** = **0.078 g**

5.4.7 Culverts

5.4.7.1 Hydraulic dimensioning

<u>Precipitation data</u>

"Precipitation data of DHM's Hydrological Station no. 703 at Butwal was adopted, according to value reported in ch. 3.3. Since the precipitation station is nearby the study area, it has been assumed that the characteristic precipitation of the area under study are correctly represented by the station recording.

Precipitation data of the selected station over 61 years, from 1957 to 2017 has been used in calculation. The data observed in this station is 24 hours accumulated rainfall over the year for 61 years; from the available data 24 hour maximum rainfall has been chosen for frequency analysis."

Design Intensity

Considering the life period of the crossing structures, probable risk during heavy rainfall and overall investment on the construction, generally 25 year of return period intensity is adopted for crossing design, according to Nepal Road Safety Notes 2, “Design Safe Side Drains”.

The max forecasted intensity of 25 years of return period predicted by different common methods (Gumbel, log Person III, Log Normal) has been considered for analysis and design of crossing by-passes.

Exception to this assumption has been considered for watershed presenting very high possibility of debris flow, considering a 100 years flood, with about 40% extra space for debris flow (against the generally assumed 30% of extra space).

Design Flood

Design flood has been evaluated using rational method, commonly adopted for computing peak discharge for small basins.

To generally consider the debris presence, highlighted also by the site visit, and to guarantee an optimal working of crossing structures in the accidental case of partial obstruction, the design flood has been increased of 30%. Therefore, final design flood is:

$$Q_d = 1.30 \times Q_{catchment}$$

To ease construction stage at site, the cross-sections of culverts was uniformed as far as possible.

Catchment Area

Main catchment area have to be evaluated on the basis of the available topography survey map. Area intercludes between main catchment basins has to be evaluated on the basis of the topography study.

5.4.7.2 Structure dimensioning

Dead Load

Self-Weight

The self-weight of the structural members has been calculated assuming a characteristic unit weight of reinforced concrete of 25 kN/m^3.

Ground pressure on top slab

The equivalent distributed loads over the top slab have been determined assuming a design cushion “hfill” upon the top slab and backfill unit weight equal to γ = 20 kN/m^3 (dry unit weight). The resulting pressure is given by:

$P=\gamma H$

Surcharge on ground

The vertical pressure acting on ground level is evaluated considering the contribution of soil loading the ground level at the top slab level, assuming $\gamma = 20\ kN/m^3$. For the assumed height the resulting pressure is given by:

$P=\gamma H$

Backfill horizontal earth pressure

Based on the vertical pressure due to the surcharge on ground, horizontal earth pressure acting on the wall has been calculated as hydrostatic pressure acting on the total wall height, according to equation:

$P = \gamma\ H(z)\ k_0$

Where :

γ = backfill unit weight (kN/m^3), assumed equal to = $20\ kN/m^3$

$K0 = 1 – \sin(\Phi')$ = at rest coefficient of lateral earth pressure

Φ' = internal friction angle of the backfill

H = calculation total height of the wall

Internal water pressure

Vertical water pressure acting on the foundation slab has been considered according to the following equation:

$P=\gamma H$

assuming H equal to the whole internal free height of the culvert, to be on the safe side and G = $10\ kN/m^3$.

Horizontal earth pressure acting on the wall has been calculated as hydrostatic pressure acting on the total wall height, according to equation:

$P = \gamma\ H(z)$

Live Load

Traffic Load

According to Eurocode surface traffic load due to pedestrian has been considered as an uniform pressure acting on the top slab.

Snow Load

According to Nepal weather conditions, different climates according to altitude can be observe. Since according to temperature temperatures during the year except altitude 3000m,are generally greater than 0°C, snow load could been neglected.

Wind Load

Wind Load has not been considered.

Temperature

A temperature variation on the top slab, given by two components:

- A uniform temperature component ΔT_U = +/- 15°C
- A linearly varying temperature difference component along z-axis, ΔT_{MZ} = +/-5°

has been considered, assuming a thermal expansion coefficient for concrete equal to $\alpha = 1.2E^{-5}$ [1/°C]

Shrinkage

The shrinkage effects have been considered according to Standards approaches and a uniform temperature component ΔT, equal to: $\Delta T = \varepsilon_{sh} / \alpha$

has been applied to the concrete top slab, where the thermal expansion coefficient for concrete equal to α = 1.2 E-5 [1/°C], and &' is the shrinkage coefficient.

Seismic Load

According to EN 1998-1/5, the structure has to be designed to fulfil its function during and after an earthquake, without suffering significant structural damage.

A pseudo-static method has to be used for assessing the safety of the structure, the seismic action is represented by a set of horizontal and vertical static forces equal to the product of the gravity forces and a seismic coefficient.

The peak ground design acceleration has to be assumed according to the maximum value provided by the Geological Report, considering a reference period for the ground horizontal peak acceleration equal to 475 years and a proper soil factor.

The horizontal (k_H) and vertical (k_V) seismic coefficients affecting all the masses have to be evaluated as:

$k_H = \alpha S/r$

$k_V = +/- 0.5\ k_H\ (a_{vg}/a_g) > 0.6$

where:

- α, is the ratio of the design ground acceleration, a_g, to the acceleration of gravity, g
- S, is the soil parameter (S=1, ground type A)
- r, factor depending on the type of retaining structure (r=1 for rigid structure)

5.5 Methods of Analyses

5.5.1 FEM Models

The structural design has to be performed by means of 2D and 3D finite elements model representing the arrangement of the structures to estimate the resulting internal actions and deformations of the different elements.

Generally, models has to be developed considering:

- mono-dimensional elements (beam element type)
- bi-dimensional elements (plate type)

Nodes between concrete elements are generally considered rigid connections.

Design loads have to be generally modelled as:

- point load on nodes
- uniform/variable forces on mono-dimensional elements;
- uniform pressure on bi-dimensional elements.

Soil-structure interaction has to be evaluated by means of elastic boundaries (linear or nonlinear), with properties defined according to geotechnical characterization.

Linear and non-linear analyses has to be performed.

5.6 Specific design criteria

5.6.1 Tunnel support measures

5.6.1.1.1 Unstable blocks scenario

Assuming the tunnel axis, rock discontinuities and joints orientations, the unstable blocks stability analyses and anchors verifications must be run.

It can be assumed that blocks with a volume < $1m^3$ will detach during excavation operations or will be safely supported by the first shotcrete layer.

Joint dips and dip directions shall be evaluated, as well as joints properties.

The design of stabilization measures for tunnel excavation profile shall check the following conditions:

- Structural verification (STR) of all structural elements:
  - Internal resistance of reinforced shotcrete layer (shear, bending moment and punching);
  - Internal resistance of redistribution plates at the bolts head;
  - Internal resistance of bolts.
- Geotechnical verification (GEO) of all structural elements:
  - External resistance (anchorage) of bolts.

5.6.1.1.2 Loosening

Anchors verification

Considering the geometry of the primary lining, it shall be assumed that loosening will be supported by means of anchors, loaded by tensile forces.

It will be verified that:

- effective anchorage is beyond the loosened rock mass.
- the maximum applied design load is lower than both internal and external (friction) resistance, i.e.:
  - Structural verification (STR):

    Internal resistance of redistribution plates at the bolts head; Internal resistance of bolts.
  - Geotechnical verification (GEO): External resistance (anchorage) of bolts.

Shotcrete verification

It shall be assumed that shotcrete lining, reinforced with lattice girders, steel ribs, wire meshes or a combination of them, will support actions imposed by the rock mass. Punching, bending moments and shear load will be checked according to Eurocodes.

Tunnel face stability

Verification of tunnel face stability shall be provided according to the Kovari & Anagnostou theory.

Forepoling umbrella verification

Verification of the forepoling umbrella shall be provided, where foreseen.

Invert verification

Where necessary, invert can be adopted to face strong lateral pressures.

Shotcrete invert lining shall be verified as well, by means of bending moments and shear load verifications according to Eurocodes.

5.6.2 Tunnel final lining and technical buildings

Reinforced concrete lining bears the total loosening load. By means of a proper static model the following shall be verified according to Eurocodes:

- ULS (Ultimate limit states)
  - Bending moments (interaction domain MN);
  - Shear load.
- SLS (Serviceability limit states)
  - deformations;
  - cracking.

Asymmetry of the loosening load shall be considered in the analyses.

Structural and geotechnical verifications (STR/GEO) must be provided for the foundation of all structures.

5.6.3 Tunnel specific design basis

For the design basis regarding tunnel parts and elements such as inner space, safety systems, auxiliary systems and draining systems, please refer to the BASIC PREREQUISITES FOR TUNNEL OPERATION and MINIMUM SAFETY REQUIREMENT FOR ROAD TUNNEL section of the Employer's Requirements of the Contract Document.

5.6.4 Rockshed

By means of a proper static model the following shall be verified for the reinforced concrete elements according to Eurocodes:

- ULS (Ultimate limit states)
  - Bending moments (interaction domain MN);
  - Shear load.
- SLS (Serviceability limit states)
  - deformations;
  - cracking.

Structural and geotechnical verifications (STR/GEO) must be provided for the foundation of all structures. Moreover, the Global stability (EQU) of the slope have to be considered.

As for design approach, load combinations and partial safety factors, reference is made to previous point «design approach» (point 5.3). All verifications shall be in accordance to relevant Eurocodes.

5.6.4.1 Rockfall Energy

According to Rockfall analyses the design energy has been evaluated assuming that the calculation volume is equal to the characteristic volume ($V_{cal} = V_k$), if the rockfall trajectories do not show significant rebounds; otherwise it is equal to the average "factorised" volume ($V_{cal} = 1.5xV_m = 5m^3$ " Project Specific Input") if the rockfall trajectories show at least 2 significant rebounds.

Thus, it assumed that during the fall of the boulders from imported heights, where the boulder, due to the steep topography, bounces several times, these are shattered into elements equal in size to the average volumes of the boulders listed. This phenomenon is considered plausible considering the degree of interlocking of the rock mass and the conditions of the joints.

5.6.5 Retaining walls

Wall structure, micropiles and anchors shall be verified according to Eurocodes.

The design of permanent micropiles and anchors shall check the following conditions:

- Structural verification (STR):
  - Internal resistance of reinforced concrete (shear and bending moment);
  - Internal resistance of permanent anchors and micropiles.
- Geotechnical verification (GEO):
  - External resistance (anchorage) of permanent anchors and micropiles ;
  - Foundation verifications wherever necessary.
- Global stability (EQU) of the slope.

As for design approach, load combinations and partial safety factors, reference is made to previous point «design approach» (point 5.3). All verifications shall be in accordance to relevant Eurocodes.

5.6.6 Excavation walls stabilisation

The design of stabilization measures for permanent excavation walls along the road shall check the following conditions:

- Structural verification (STR) of all structural elements:
  - Internal resistance of reinforced shotcrete layer (shear, bending moment and punching);
  - Internal resistance of redistribution plates at the bolts head;
  - Internal resistance of permanent bolts
- Geotechnical verification (GEO) of all structural elements:
  - External resistance (anchorage) of permanent bolts
- Global stability (EQU) of the slope at every excavation phase.

As for design approach, load combinations and partial safety factors, reference is made to previous point «design approach» (point 5.3). All verifications shall be in accordance to relevant Eurocodes.

5.6.7 Culverts

5.6.7.1 Hydraulic design

To get verification of culverts, Manning's equation was applied:

$$Q_{max} = K_s \cdot A \cdot R^{2/3} \cdot j^{1/2}$$

Where:

- Q_{max} = maximum discharge through crossing structure (m^3/s);
- Ks = 1/n = Stickler coefficient;
- n = Manning coefficient;
- A = wet area (m^2);
- R = hydraulic radius (m) = A/P;
- P = wet perimeter (m);
- j = culvert longitudinal slope (m/m).

In table below, all adopted design parameters are resumed.

Table 24: Design and verification parameters

Parameter	Value
Return period (TR)	25 years
Rainfall time	24 hours
Rainfall distribution	LogNormal
Rainfall maximum height	Data analyses
Run-off coefficient (C)	0.80
Culvert percentage storage	80%
Manning coefficient (n)	From standard charts

5.6.7.2 Structure design

For structural verifications, by means of a proper static model the following shall be verified for the reinforced concrete elements according to Eurocodes:

- ULS (Ultimate limit states)
  - Bending moments (interaction domain MN);
  - Shear load.
- SLS (Serviceability limit states)
  - deformations;
  - cracking.

Structural and geotechnical verifications (STR/GEO) must be provided for the foundation of all structures. Moreover, the Global stability (EQU) of the slope have to be considered.

5.6.7.3 Additional protection measures

The construction of a protection wall between the road and the water pit to protect the road from boulder has to be envisaged together with proper measures to limit and, possibly, avoid the debris flow obstruction of these structures.

Proper maintenance has to be addressed to keep correctly working the structure.

To avoid erosion phenomena along the valley slope, proper protection measures from the localized water flow coming from the culverts outlet, have to be foreseen along the valley and mountain side.

6 ROAD ALIGNMENT DESIGN

"The project, focused on the rockfall protection of the Siddhababa Section along the Siddhartha Highway, foresees both the rehabilitation of the existing road, from chainage 28+200.00 to 29+100.00 (called *Main Road 1 (MR1)*) and from chainage 30+050.00 to 30+600.00 (called *Main Road 2 (MR2), North)*, and the variation of the alignment lay-out to connect the new tunnel road approximately 1126 m long, by deviating from the old alignment towards East around chainage 29+100, near the existing «Siddhababa Mandir» and towards West around chainage 30+050, near the existing «Ramapithecus Park» .

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

An existing track diversion in a new two lanes tunnel for cars only (one lane for each direction), along the whole high hazard sections, departing from the existing road near the Siddha Baba Mandir and reconnecting to it near the hydropower plant, with a total length of about 1126 m, has been foreseen.

The new tunnel extends between chainages 0+908.46 (south portal) and 2+034.52 (north portal) and the position of the tunnel portals has been chosen considering a suitable site to minimize necessary excavation, hence entering the mountain almost perpendicularly to the slope, as well as to avoid the whole high hazard stretch.

The U-shape of the tunnel horizontal alignment has been chosen in order to reach as soon as possible a sufficient depth (tunnel overburden) to minimize the tunnel excavation in low overburden areas, where weaker and altered rock can be foreseen, as well as larger water income.

Bicycles and pedestrian keep on following the existing road alignment (called *Pedestrian Road (PE)*), but protected, along the identified high hazard section, by a rockshed with reduced internal dimensions of **5.0mx5.0m**, suitable to house only pedestrians and ambulance (or emergency car), in case of emergency situations. Thus, the existing road has been converted into a pedestrian-only road around chainage 29+100 and 30+050, comprehensive of two emergency aprons for reversal of traffic direction in case of tunnel closure during emergency. Moreover, each apron could be used as heliport in case of emergency. On the pedestrian road, the construction of a covered path with a rockshed has been foreseen from chainage around 29+215 to 29+995. The rockshed is connected to the three pedestrian by-passes foreseen along the tunnel, with a spacing smaller than 300m, so that, in case of emergency, the tunnel users can evacuate in the shortest possible time from the danger zone, leading directly to a safe space within the bypass tunnel itself and, from there, to the pedestrian rockshed along the existing road. No emergency escape route for vehicular access is foreseen due to the length of the tunnel (< 1.2 km).

The design parameters adopted for the road design of the Siddhababa stretch follow DoR Nepal Rural Road Standard (2070), 2013. Cross sections every 10m chainage have been considered to study and obtain the presented design alignment; however sections every 20m are reported.

The design of this pedestrian road and escape route does not undergo car traffic road design presented in the following paragraphs for the main road.

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

In the following are briefly summarized the road design main characteristics; for further details refer to the relevant specific reports.

Table 25:Principal stretches of main road

AXIS	TYPE OF INTERVENTION	ABSOLUTE CHAINAGE*		DESIGN CHAINAGE	
		From (km)	To (km)	From (km)	To (km)
Main road 1 (MR1)	Adjustment	28+200.00	29+104.55	0+000.00	0+904.55
Tunnel (MT)	Variation	29+104.55	30+050.00	0+904.55	2+034.52
Main road 2 (MR2)	Adjustment	30+050.00	30+600.00	2+034.52	2+587.40

* *Absolute chainages referred to the existing Siddhartha Highways must be abandoned; here are reported just as general reference, not to be adopted for design.*

Table 26:Principal stretches of pedestrian road

Pedestrian Road (PR)				
ZONE	ABSOLUTE CHAINAGE*		DESIGN CHAINAGE	
	From (km)	From (km)	From km	To km
South apron	About 29+114	About 29+214	0+000.00	0+110.00
Rockshed	About 29+214	About 29+994	0+110.00	0+890.00
North apron	About 29+994	About 30+051	0+890.00	0+944.70

* *Absolute chainages referred to the existing Siddhartha Highways must be abandoned; here are reported just as general reference, not to be adopted for design. "*

6.1 Road Classification

Road main features limits according to DoR Nepal Road Standard 2070 have to be assumed.

"The design road falls under the category of National Highway[1] since the Siddhababa sections belongs to the Siddharta highway, which is a major highway in Nepal connecting the Terai region in southern Nepal with the mountain region in northern Nepal. The highway starts at Nepal–India border near Siddharthanagar and terminates at Pokhara. This highway intersects with the east–west Mahendra Highway at Butwal.

According to the technical and functional classification provided by Nepal Road Standard 2070, the design road falls within Class II [2], in mountainous and steep terrain, strongly depending on the harsh conditions of the surroundings and the alignment of the existing road."

6.2 Design Speed

The design speed has a crucial role in geometric parameters of the roads. The design speed depends on various factors like; super elevation, sight distance, radius and length of horizontal curve, extra widening of pavement, and the length of vertical curve (summit and valley) etc.

"According to the design standards (Nepal Road Standard 2070), the ruling design speed adopted along the Siddhababa section of the rehabilitated road and the new road tunnel has been defined according is 40 km/h along the rehabilitated existing road stretches before and after the new tunnel, with exception of the road sections between chainages 2+320.00 and 2+420.00, where the design speed has to be limited to 25 km/h, according to the existing road geometrical alignment limits.

Indeed, within the tunnel, a design speed of 60 km/h has been adopted since this new road section can be designed according to the design speed for class II in mountainous terrain being a alignment; the upgraded speed of 60m/h at the south portal starts within the rock tunnel, at the begin of the tunnel road line."

6.3 Alignment Design Requirements

Main design parameters are briefly summarized in the following table, according to Nepal Road Standard 2070.

"Table 27 Design parameters for Siddhababa section according to Nepal Road Standard 2070

S.N.	Design parameters	National Highway, Mountainous
1	Design Capacity - in both directions (Vehicle per day/P.C.U. per day)[3]	20000
2	Design speed (km/h)	40 (MR1 and MR2) 25 (MR2 from ch. 2+320.00 to 2+420) 60 (Tunnel)
3	Lanes width (m)	3.75
4	Carriageway width (m)	7.50
5	Shoulder width, either side (m)	0.50
6	Stopping distance (m)	50.00
7	Minimum radius of horizontal curves (m)	40.00
8	Maximum super elevation (%)	7.00
9	Minimum length of transition curves (m)	40.00 9.00 (for 40 km/h) 7.00 (for 60 km/h)
10	Maximum gradient (%)	200.00 (for 9.00%)
11	Maximum length of gradient(m)	300.00 (for 7.00%) 29.00 (for 40 km/h)
12	Minimum value of K for summit curves (m/%)	94.00 (for 60 km/h)
13	Minimum value of K for valley curves (m/%)	17.00 (for 40 km/h); 42.00 (for 60 km/h)

"

6.3.1 Excavation and fill

Excavation and Fill Excavation has been balanced and limited as far as possible.

6.4 Safety Barriers, Pavement Marking and Traffic Signs

Dimensioning of safety barrier shall be provided according to the requirements of Nepal Safety Barrier, 1997. Marking/Signing shall be provided accordingly to Nepal Road Standard (2070), Nepal Traffic Sign Manual, 1997

6.4.1 Additional requirements for Tunnel Road alignment

For additional requirements for the Tunnel Road alignment please refer to the BASIC PREREQUISITES FOR TUNNEL OPERATION and MINIMUM SAFETY REQUIREMENT FOR ROAD TUNNEL section, and other relevant sections of the Employer's Requirements of the Contract Document.

6.5 Pavement Design

6.5.1 Design Life

According to Nepal Design Guidelines for flexible pavement 15 years have to be considered for highways pavement. In addition 5 years have been considered to account for the estimated design and construction time, so that a total design life of 20 years.

6.5.2 Traffic Study

According to traffic data provided by the Client and presented in ch. 3.1, all traffic in the classified count has been classified into the following types of vehicles as per the DoR practice:

- Heavy truck (three axles or more);
- Heavy two axles;
- Mini truck/tractor;
- Large bus;
- Bus.

For analytical purpose, the AADT at the road is expressed both in terms of vehicle per day (CVPD) and daily passenger unit (PCU/day):

Table 28:Traffic data according to survey on site

Traffic data		
AADT	12444	CVPD
AADT excluding motorcycle and rickshaw	3336	CVPD
AADT	9478	PCU
AADT in PCU excluding motorcycle and rickshaw	4912	PCU

The traffic spectrum derived from survey is:

Table 29: Traffic spectrum according to survey on site

Vehicle type	**%**
Heavy truck (three axles or more)	0.93%
Heavy two axles	8.28%
Mini-truck/tractor	0.85%
Large bus	9.80%
Bus	8.97%

“

According to Nepal Road Standard 2070, the following converting factors has been assumed to correlate PCU to AADT,

Table 4-1 Vehicle types, Equivalency Factors

SN	Vehicle Type	Equivalency Factor
4	Bicycle,Motorcycle	0.5
1	Car, Auto Rickshaw, SUV,Light Van and Pick Up	1.0
2	Light (Mini) Truck, Tractor, Rickshaw	1.5
3	Truck,Bus,Minibus,Tractor with trailer	3.0
5	Non-motorized carts	6

The traffic forecast is computed according the growth formula mentioned in the IRC:37-2018 :Guidelines for The Design of Flexible Pavements, (Fourth Revision),INDIAN ROADS CONGRESS

6.5.2.2 Vehicle Damage Factor (Vdf)

For Vdf, IRC:37-2018 :Guidelines for The Design of Flexible Pavements, (Fourth Revision),INDIAN ROADS CONGRESS relevant clause shall be followed.

6.5.2.3 Lane Distribution Factor (D)

Total traffic AADT (both way) is distributed over the whole carriageway for design of pavement. For D, IRC:37-2018 :Guidelines for The Design of Flexible Pavements, (Fourth Revision),INDIAN ROADS CONGRESS relevant clause shall be followed.

6.5.2.4 Design Traffic

The design traffic load in terms of cumulative number of standard axles (ESA) shall be calculated as per IRC:37-2018 :Guidelines for The Design of Flexible Pavements, (Fourth Revision),INDIAN ROADS CONGRESS relevant clause.

6.5.3 Subgrade properties

The proposed pavement for the main road has been designed considering a subgrade made of the rock outcrop according to properties detailed in the geotechnical report.

Where the rock is not present as a sub-grade and it is necessary to fill it with granular material, it must have a minimum CBR = 5 (E = 50 MPa) as the bearing capacity.

6.5.4 Pavement Design

The pavement design for both roadway section and tunnel section shall be designed as per IRC:37-2018 :Guidelines for The Design of Flexible Pavements, (Fourth Revision),INDIAN ROADS CONGRESS relevant clause.

6.6 Road water management system

6.6.1 Rainfall data

Rainfall data and catchment area are assumed according to data reported in ch. 3.3

6.6.2 Main Road

For surface water management, the mountain side camber principle has to be adopted for proper management of surface water and side drains on the road mountain side has been adopted along the whole road stretches.

Side drains are assumed to receive the road surface water and the water coming from next mountain ridge that is not regimented by culverts.

A carriageable concrete cover has to be foreseen on side drains, allowing them to be used as walkaways in order to reduce the road total width, thus limiting earth works and rock excavation.

6.6.3 Tunnel Road

Dirty and polluted waters coming from the inner tunnel space are collected by a linear drainage channel, thanks to the transversal gradient of the carriageway and transported to the first chamber of the syphoned wells.

Special provisions has to be considered to allow to avoid direct communication between the inner space of the tunnel and the main water collector and, hence, avoid propagation of fire liquids along the tunnel in case of accidents/fire.

Since some waters could also leak under the carriageway and seep through the filling gravel, a dedicated drainage system has to be considered

Water basin, that allows to collect waters and, whenever necessary, to avoid the direct discharge into the local sewage systems has to be considered

6.6.4 Pedestrian Road

Before and after pedestrian rockshed, proper side drains has to be foreseen, considering a carriageable cover also for pedestrian traffic, where they have to be used as walkaways such as at the tunnel south portal near the Siddhaba Temple.

Along the road sections interested by the rockshed structure, a proper drainage system has to be designed for the possible rain water incoming due to the wall openings along the valley side.

A proper drainage system of the cushion layer and backfill materials due to water coming from the mountain, not collected into culverts has to be foreseen.

7 ROCKFALL MITIGATION MEASURES DESIGN

7.1 Materials

7.1.1 Rockfall protection Barriers (Geobrug RXE type or equivalent)

a. Barrier type GEOBRUGG RXE 2000 or similar

- Absorption capacity 2000 kJ
- Energy class EOTA 5
- Height 4 m
- Post spacing 8-12 m (average 10 m)

b. Barrier type GEOBRUGG RXE 3000 or similar

- Absorption capacity 3000 kJ
- Energy class EOTA 6
- Height 4 m
- Post spacing 8-12 m (average 10 m)

c. Barrier type GEOBRUGG RXE 5000 or similar

- Absorption capacity 5000 kJ
- Energy class EOTA 8
- Height 5 m
- Post spacing 8-12 m (average 10 m)

7.1.2 Adherence Net system (Tecco type)

Adherence net

High-tensile steel wiremesh type Tecco G65/4 or equivalent

Rock bolts

- Type: Gewi diam. 32 mm (steel grade B500B) or equivalent
- Tensile Strength Ftk ≥ 466 kN
- Yield Strength Fyk ≥ 402 kN
- Drilling diameter ≥ 110 mm

7.1.3 Additional measures for mudstone layers

Permanent shotcrete:

- Reference Code: UNI EN 1992 1-1, EN 206-1
- Concrete Class: C30/37
- Characteristic Cubic Strength: Rck >37 MPa
- W/C: 0.5
- Cement Type: III-IV (UNI EN 197-1)
- Exposure Class: XC4/XD1/XF1
- Resistant at AAR
- Slump Class: S4
- Maximum Aggregate: 8 mm (EN 12620)

Steel wiremesh (shotcrete reinforcement):

- Bar diameter, D = 6mm
- Mesh spacing = (100x100)mm
- Steel grade min. B500 A
- Yield Strength fyk = 500 MPa

Rockbolts:

- Type: Permanent Gewi diam. 28 mm (steel grade B500B) with preinjected corrugated sheating or equivalent
- Tensile Strength Ftk ≥ 357 kN
- Yield Strength Fyk ≥ 308 kN
- Drilling diameter ≥ 110 mm

7.2 Design Working Life

See previous para. 5.2

7.3 Design Approach

See previous para. 5.3

7.4 Design Loads

7.4.1 Rockfall protection barriers

Rockfall protection barriers shall be designed in order to withstand the design impact energy foreseen by rockfall simulations, based also on the design rock block dimensions.

All structural elements, including foundation micropiles and retaining anchors, shall be dimensioned to withstand actions consequent to such impact events.

Reference to the rockfall barrier supplier technical specifications shall be also made.

7.4.2 Slope stabilization systems (adherence mesh and shotcrete layer)

The adherence net as well as the shotcrete layer on mudstone layers must be designed to stabilize superficial blocks that can be unstable between provided bolts, accordingly to performed geomechanical characterization of the slope.

As for the rock bolts, they must be dimensioned considering different load conditions:

- to support, by tension and shear, the adherence nets and shotcrete layers, assuming the above mentioned load condition;
- to support, by shear, possible unstable blocks, accordingly to performed geomechanical characterization of the slope

7.4.3 Slope below road works

Rock stabilization shall be provided where highly fractured rock is observed on the slope below the existing road, where erosion and weathering cause the gradual fall of boulders and/or detachment of rock slabs.

Anchors shall be designed to stabilize superficial blocks or slabs that can be unstable.

They are dimensioned considering to support, by shear, possible unstable blocks/slabs.

As unstable block, the average block dimension can be considered, as resulting by geological mapping and survey, and the main joint families orientation shall be considered in order to estimate block shape.

As example, based on such analysis, the design block estimated in the project has a volume of 10 m^3/m. Such assumption shall be checked and confirmed or revised by Tenderer/Contractor based on its own evaluation and possible additional surveys.

Shotcrete layer design follows what suggested in 7.4.2

7.5 Specific design criteria

7.5.1 Rockfall protection barriers

The design of slope stabilization systems shall check the following types of failure/resistances:

- **Protection barrier**
  - O Structural verification according to the supplier certified system, based on impact energy.
- **Anchors and micropiles (rope anchorage and barrier foundation):**
  - O Structural verification (STR) of all structural elements:
    - Internal resistance of anchors and micropiles (axial and shear).
  - O Geotechnical verification (GEO) of all structural elements:
    - External resistance of anchors and micropiles.
- **Global stability (EQU) of the existing slope considering the load transfer by the barrier foundation micropiles to the rock.**

7.5.2 Slope stabilization systems (adherence mesh and shotcrete layer)

The design of slope stabilization systems shall check the following types of failure/resistances:

- **adherence mesh system (Tecco net type of equivalent and its bolts) :**
  - O Structural verification (STR) of all structural elements:
    - Internal resistance of the net itself, including redistribution plates;
    - Internal resistance of the perimetric rope ;
    - Internal resistance of perimetric wire anchors;
    - Internal resistance of bolts (axial and shear).
  - O Geotechnical verification (GEO) of all structural elements:
    - External resistance (anchorage) of perimetric wire anchors
    - External resistance (anchorage) of bolts ;
- **Shotcrete layer on mudstone layers and its bolts :**
  - O Structural verification (STR) of all structural elements:

- Internal resistance of the reinforced shotcrete (shear, bending moment and punching);
- Internal resistance of redistribution plates at the bolts head;
- Internal resistance of bolts (axial and shear).

O Geotechnical verification (GEO) of all structural elements:

- External resistance (anchorage) of bolts ;

· **Global stability (EQU) of the existing slope.**

As for design approach, load combinations and partial safety factors, reference is made to previous point «design approach» (point 5.3); all verifications shall be in accordance to relevant Eurocodes.

7.5.3 Slope below road works

The design of slope stabilization systems shall check the following types of failure/resistances:

· **Shotcrete and Anchors:**

O Structural verification (STR) of all structural elements:

- Internal resistance of the reinforced shotcrete (shear, bending moment and punching);
- Internal resistance of redistribution plates at the bolts head;
- Internal resistance of bolts (axial and shear).

O Geotechnical verification (GEO) of all structural elements:

- External resistance (anchorage) of bolts;

· **Global stability (EQU) of the existing slope (existing situation and final situation with rockshed loads).**

As for design approach, load combinations and partial safety factors, reference is made to previous point «design approach» (point 5.3); all verifications shall be in accordance to relevant Eurocodes.

ANNEX B: TUNNEL - TECHNICAL REPORT

Project Specific Section

ROCKFALL PROTECTION ALONG SIDDHABABA SECTION OF SIDDHARTHA HIGHWAY

Ch. 28+200 km – Ch. 30+600 km

TABLE OF CONTENTS

1 INTRODUCTION

The Siddhababa stretch of Siddhartha Highway between Chainage 28+200 Km to 30+600 Km is a very hazardous road section due to the highly fractured rockfall site at the hillside of the road, characterized by an unfavorably discontinuity orientation with respect to the road alignment, and to high and steep slopes easily split by monsoon precipitation.

A relevant number of rockfall events has been registered during the time, therefore requiring the adoption of useful measures capable of minimizing the hazard of rock slope instability and debris flow by means of permanent structures for rockfall protections.

The project is aimed to avoid any risk related to rockfall and slope instability in the high hazard section for car traffic, but at the same time finding an attractive solution also for pedestrians.

A new tunnel only for cars will be executed along the whole high hazard section with a new alignment that departs from the existing road near the Siddha Baba Mandir and reconnect to it near the existing hydropower dam, for a total length of about 1126 m.

As for bicycles and pedestrian, they will keep on using existing road, but protected along the whole high hazard section by a rockshed, having a reduced width suitable to house only pedestrians and bicycles or, in case, emergency vehicles.

Local protection measures, such as rocknets, local installation of adherence wire meshes and local stabilization systems by shotcrete and rock bolts, are foreseen along medium risk areas.

2 DESIGN CRITERIA

2.1 References

2.1.1 Project references

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2.1.2 Project standards

- EN 1990:2002, Eurocode 0: Basis of structural design.
- EN 1991- all parts, Eurocode 1:Actions on structures. General actions. Densities, self-weight, imposed loads for buildings.
- EN 1992-1-1:2004, Eurocode 2: Design of concrete structures. General rules and rules Published for buildings.
- EN 1992-2:2005, Eurocode 2: Design of concrete structures - Part 2: Concrete bridges - Design and detailing rules
- EN 1997-1:2004,Eurocode 7: Geotechnical design. General rules.
- EN 1998-1:2004,Eurocode 8: Design of structures for earthquake resistance. General rules, seismic actions and rules for buildings.
- EN 1998-2:2005, Eurocode 8: Design of structures for earthquake resistance – Part 2: Bridges
- EN 1998-5:2004,Eurocode 8: Design of structures for earthquake resistance. Foundations, retaining structure and geotechnical aspects.
- Nepal Road Standard – 2070, 2013
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- SIA 197/2 (2004), project planning tunnel, road tunnel.
- UNI EN 206:2016, Concrete – Specification, performance, production and conformity

- UNI EN 197-1:2011, Cement – Part 1: Composition, specifications and conformity criteria for common cement
- UNI EN 12620:2008, Aggregates for concrete
- UNI EN 1537– Execution of special geotechnical works - Ground anchors
- UNI EN ISO 22477-5:2018 - Geotechnical investigation and testing - Testing of geotechnical structures - Part 5: Testing of grouted anchors
- VSS 640 202 (2017) – Road geometrical normal profile.
- CEB N°187 - Comité-Euro-International du Béton (1988). Concrete Structures under Impact and Impulsive Load, Bulletin d'information N° 187, Draft TG V/14, Lausanne.
- EOTA (2012). ETAG 027 – Falling rock protection kits. Guideline for european technical approval.
- NBC 105:1994 Seismic design of buildings in Nepal

2.2 Design Working Life

Design Working Life of structures is defined as "the period of time during which the construction is assumed to be used for intended purposes, with anticipated maintenance, but without substantial repairs".

According to EN 1990 (Eurocode 0) the design working lives (Tunnel and Rock Shed) of Category 5 – Monumental building structures, bridges and other civil engineering structures – 100 years.

According to EN 1990 (Eurocode 0) the design working lives (Technical Building and Other Road structures) of Category 4 – Building structures and other common structures – 50 years.

This requirement has to be met by means of a design that includes an appropriate selection of the structural solutions and construction materials, a careful construction compliant with the design and a suitable inspection of the design, where appropriate. Construction and operation activities, together with an appropriate use and maintenance of the structures are as well of major importance to guarantee such requirement.

2.3 Design Approach

Structural and geotechnical design is carried out, as usually done in European countries, with reference to the semi-probabilistic method (limit state) according to various international standards (Eurocodes, SIA). Load Combinations, safety and partial factor coefficients, verifications and concrete check (both at USL and SLS) are defined according to Eurocodes.

2.3.1 Design conditions

When accomplishing the design situations that are important for the design check, all possible circumstances the structure have toface during its life should be taken into account.

As far as rockfall protective structures are concerned, the design situations to account for can be in general classified as:

- temporary situations, with reference to temporary conditions applicable to a structure, e.g. an executive phase or repair;
- persistent situations, which refer to normal service conditions;
- accidental or exceptional situations, which refer to exceptional conditions applicable to a structure, ex. rockfall, collisions, fires, explosions, ecc.;
- seismic situations, which refer to conditions applicable to the structure when subjected to seismic events.

The design situations to be taken into account in detailed verification are classified in the above mentioned categories. Note that each category requires a specific analysis of the time horizon in which it occurs; the design situations can occur throughout the design life of a structure or be limited to a specific executive phase or repair.

2.3.2 Design verifications

Ultimate limit states and serviceability limit state verifications are considered according to international standards such as Eurocode.

Safety checks are performed by means of the Partial Factors Method: for all relevant design situations, it is verified if the limit states are not exceeded when design values of the actions, material properties and geometric dates are introduced in structural and load models.

The non-exceedance limit check allows to state that the probability of reaching a certain limit situation is less than the value set by the standard during the structure lifeor during a timeframe of reference in case of execution/constructive phase.

The verifications shall ensure that:

- Assumed design actions do not cause the collapse of the structure or the ground (even in exceptional/accidental situations);
- Effects of the assumed design actions do not exceed the design strength of the structure at the ultimate limit state;
- Effects of the assumed actions do not exceed the functionality criteria for the service limit state.

Ultimate limit states connected both to the structure collapse (or the whole structure-ground) and to a partial failure are considered; Service ultimate states that match the conditions beyond which specific operational requirements connected to the structure or its elements are no longer met are taken into account.

Design dimensioning and verifications can be found in the relevant Calculation Reports.

3 UNDERGROUND WORKS

In the following, basic design principles and technical requirements of the new tunnel are presented, together with a description of design solutions and material properties. Design dimensioning and verifications can be found in the relevant Calculation Reports.

The tunnel design is performed in accordance to relevant guidelines and rules usually adopted during design and construction of road tunnels in Switzerland. Such guidelines are indeed the result of the experience gathered during design and construction of a number of road tunnels starting since more than a century ago and, hence, arehereby considered as the main reference.

3.1 Horizontal alignment

Having a total length of 1.126km, the tunnel extends between chainages 0+908.46 (south portal) and 2+034.52 (north portal).The position of the tunnel portals has been chosen considering a suitable site to minimize necessary excavation, hence entering the mountain almost perpendicularly to the slope, as well as to avoid the whole high hazard stretch.

At the south portal, the tunnel begins about40 m to the north of the existing «Siddhababa Mandir», having a curved alignment to the east direction (curve radius = 95m).

At the north portal, the tunnel begins about 40 m to the north of the existing «Ramapithecus Park» view point, near the Tinaauhydropower dam, having a straight alignment.

In the central part, assuming the north driving direction, the tunnel consists of a long curve to the west (curve radius = 150 m), followed by an almost straight stretch up tothe north portal. Due to such a curve, an enlarged section is necessary to guarantee visibility. Enlargement amounts 60 cm (according to Nepalese RoadStandard 2070) to the inside of the curve, between chainages 1+095.24 and 1+330.78.

Figure 1: Horizontal alignment of the tunnel

The U-shape of the horizontal alignment has been chosen in order to reach as soon as possible a sufficient depth (tunnel overburden) to minimize the tunnel excavation in low overburden areas, where weaker and altered rock can be foreseen, as well as larger water income.

3.2 Vertical alignment

According to swiss standards (SIA 197-2), the maximum longitudinal gradient shall not exceed 5% due to increased danger (accident frequency, spread of smoke). However, a maximum 4% longitudinal gradient was considered in accordance to the more stringent requirements of Nepalese Road Standard 2070.

In the present case, the requirement of 4% longitudinal gradient could be met considering the maximum height difference between south portal (about 200 m above sea level) and north portal (about 235 m above sea level) and, having the highest point about 44 m from the north portal (chainage 1+990.319). In the middle of the tunnel, between chainages 1+391.5 and 1+628.5, a reduced gradient equal toabout 0.5% is necessary, according to Nepalese Road Standard 2070 in order to avoid stretches with a constant longitudinal gradient longer than 600 m.

The chosen vertical alignment avoids the risk of water stagnation inside the tunnel, easing water discharge towards both ends of the tunnel, but mainly towards the south portal.

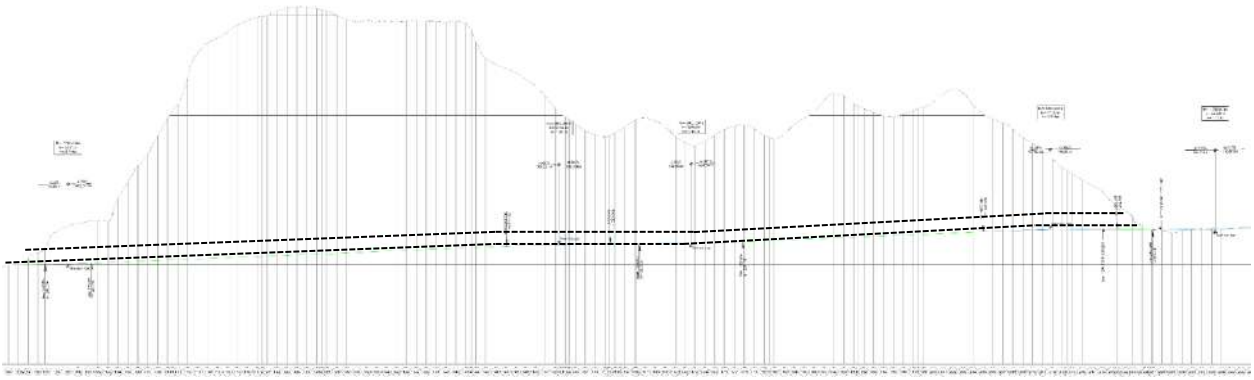


Figure 2: Vertical alignment of the tunnel

3.3 Definition of the inner space

The space above the carriageway is determined by the required usable space, as well as the constructional and technical execution requirements.

The usable space consists of the following elements:

- Usable space for traffic, consisting of:
  - clearance profile for passage through the tunnel;
  - space for walkways (service and emergency escape route);
  - space for equipment including any free space (safety margin).

- Usable space for constructional purposes, consisting of:
  - space for tolerances (a), which takes into account the deviations due to execution errors;
  - space for later constructional measures (b), which may be necessary during the service phase.

- Usable space for ventilation.

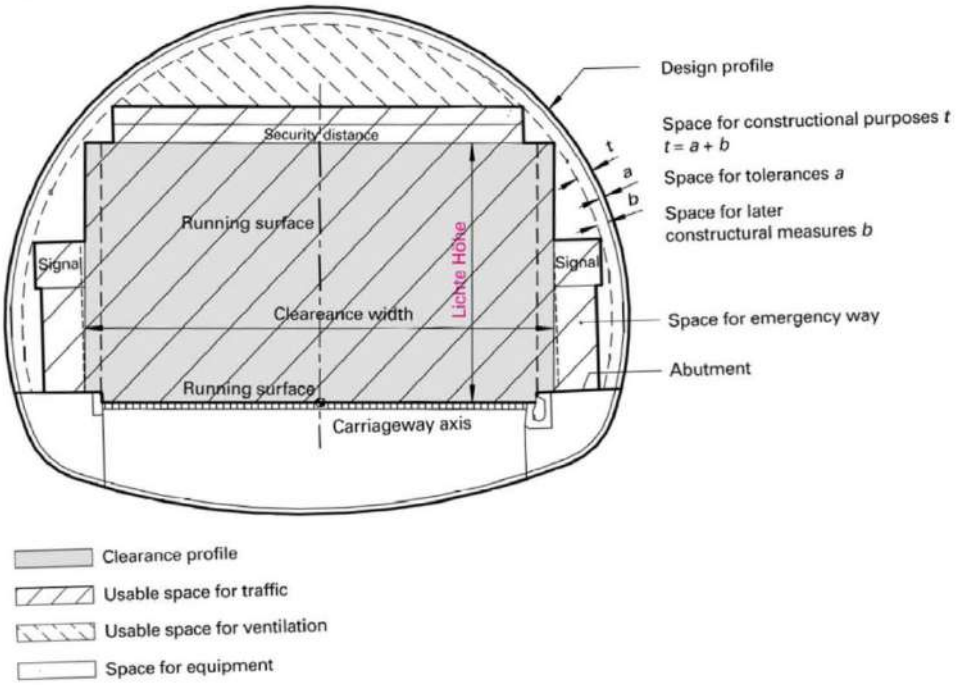


Figure 3: Definition of the usable space (road tunnels) according to SIA 197-2.

The minimum space requirements for traffic are defined according to Figure 4on the base of SIA197-2 and ASTRA 11001, where main dimensions are as follows:

- Walkways (to be used only in case of emergency) width ≥ 1 m;
- Available height on carriageway for traffic ≥ 4.5 m + 0.3 m (safety margin);
- Additional available height for signalling and equipment≥ 0.4 m.

The carriageway width is defined according to the requirements agreed with the Client and equivalent to the ones of DPR 2016, i.e. a carriagewaywidth equal to 7.5 m.Moreover an extra space equal to 0.25 m is considered on both sides. Thus, a total width of 8 m will be available.

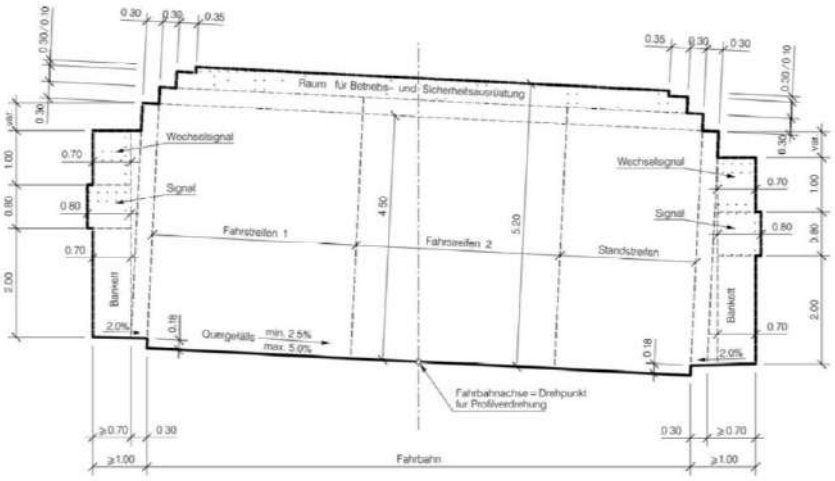


Figure 4: Operational envelope for traffic according to SIA 197-2

As far as the space for tolerances is concerned (a), nominal values for deviations according to *Table 1* taken from SIA 197 will be considered, whereas no space for later constructional measures is required in this project:

- space for tolerances (a) = 10 cm;
- space for later constructional measures (b) = 0 cm.

Method of excavation (see code SIA 198)	Recommended values in cm (measures as radius)	
	Excavation width ≤5 m	Excavation width >5 m
Drill and blast	5	10
Mechanised excavation in rock	5	10
TBM – excavation in rock	15	15
Mechanised excavation in soil		
– without shield	10	15
– with shield	15	20

Bypass Main tunnel

Table 1:Space to accommodate execution inaccuracies

Thanks to the almost circular section, upon the operation traffic space, there is enough space for ventilation.

The space for ventilation equipment is considered into the ventilation design (see relevant E&M Report). In the present case, since the ventilation system consists of longitudinal ventilation, no smoke extraction is necessary, hence, no intermediate slab is required. The space for ventilation equipment is necessary to accommodate jet fans, having an impeller of 1120 mm.

For the minimum space requirements for emergency escape routes (bypass) see 3.4.2.

3.4 Construction measures for safety purposes

Th construction measures to ensure the safety of the tunnel user include:

- Lay-by bays;
- Emergency escape routes;
- SOS niches.

The spacing of the construction safety measures along the tunnel are based on a grid of 150 m.

3.4.1 Lay-by bays

Generally, lay-by bays shall be provided every 600 to 900 m. Two lay by bays are foreseen in the middle of the tunnel, one for each traffic direction:

- North direction: between chainages 1+453.45 and 1+495.00 (41.55 m);
- South direction: between chainages 1+561.55 and 1+520.00 (41.55 m).

In order to reduce difficulties during excavation and heavier safety measures, the two lay-by bays will be located staggered.

The additional emergency lane in the lay-by will be 3.00 m wide, having a transversal gradient equal to that of the main carriageway.

An emergency alarm cabin and a fire hydrant will be located at the end of each lay-by bay.

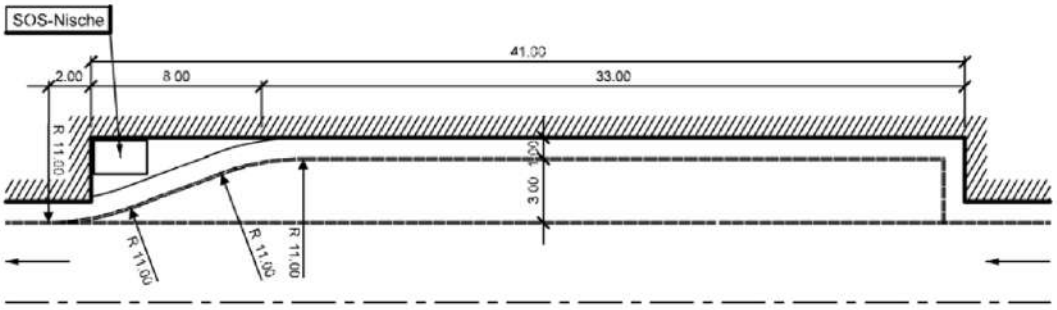


Figure 5: typical lay-by bay geometry according to SIA 197-2 (swiss traffic direction)

3.4.2 Emergency escape route (bypass)

The emergency escape routes will be placed at regular intervals along the river side of the tunnel. In case of emergency, escape routes allow the tunnel users to evacuate in the shortest possible time from the danger zone, leading directly to a safe space within the bypass tunnel itself and, from there, to the pedestrian rockshed along the existing road.

Three pedestrian bypasses will be provided along the tunnel, having a maximum spacing of 300 m. No emergency escape route for vehicular access is foreseen due to the length of the tunnel (< 1.2 km).

- Bypass 1 (ch. 1+145.00): about 155 m long, longitudinal gradient 2% towards the main tunnel (40.5 m) and 1% towards rockshed.
- Bypass 2 (ch. 1+445.00): about 145 m long, longitudinal gradient 2% towards the main tunnel (20 m) and 7.5% towards rockshed.
- Bypass 3 (ch. 1+745.00): about 131 m long, longitudinal gradient 2% towards the main tunnel (40.5 m) and 12.3% towards rockshed.

The requirements for the definition of the inner space of a pedestrian bypass are:

- a minimum free space 1.50 m wide and 2.20 m high;
- space for tolerances (a) = 5 cm, according to Table 1 (excavation width < 5 m);
- space for later constructional measures (b) = 0 cm.

On both sides of the bypass platform, water discharge channels 20 cm x 5 cm will be provided. A transversal discharge channel with a grid will be placed at both ends of the bypass and connected to the sewage discharge system.

A fire resistant sliding door is foreseen at the beginning of the bypassas well as proper painting and marking in order to clarify its position to drivers in case of emergency (see example in Figure 6); moreover, two additional doorsare foreseen at the other end of the bypass ("air lock" section, see chapter 3.11), so that a proper ventilation system can be installed in order to guarantee an overpressure within the emergency escape route compared to the road tunnel, in order to make it a safe place as no smoke can enter in case of fire. The safety concept of the provided escape routes is described in Figure 7. Additional information and details could be found in the tunnel ventilation report (see relevant E&M technical report).

Bypass door shall fulfil the following requirements:

- Pressure resistance — between -2'000 Pa and +2'000 Pa in 0.3 seconds
- Fire resistance — REI 120
- Tightness — max. 0.15 m^3/s with ΔP = 50 Pa
- Opening force — max. 120 N with ΔP = 400 Pa
- Closure system — automatic
- Materials — min. stainless steel 1.4571
- Anchors and components — min. stainless steel 1.4529
- Design life — ≥ 30 years
- Door opening system — sliding door from left to right
- Door dimensions (once open) — min. width 120 cm, height 210 cm
- Final painting — RAL 6029 (green) on both sides.

Figure 6: Example of emergency escape route with sliding fire resistant door and proper marking

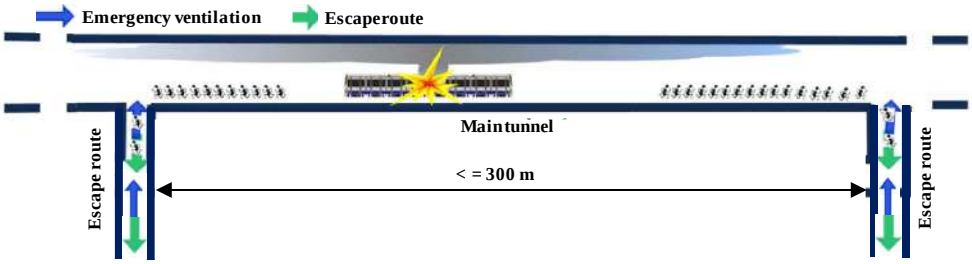


Figure 7: Emergency escape route adopted system

3.4.3 SOS niches

SOS niches will be provided every 150 m, alternatively on the two sides of the tunnel.

Minimum dimensions of the niches are:

- Depth 2.10 m (between door and bottom wall)
- Width 1.80 m
- Height 2.40 m (between pavement and ceiling)

Inside each SOS niche, an alarm cabinet will be provided and installed on a concrete footing, connected to the cable shaft in front of the niche by electrical pipes (see 3.7).

The SOS niches pavement will be made of concrete (same concrete of the adjacent walkway), with a transversal gradient equal to 2% towards the carriageway.

SOS niches are not intended as safety rooms, i.e. no ventilation of the niches is provided.

SOS niches door shall fulfil the following requirements:

- Pressure resistance between -2'000 Pa and +2'000 Pa in 0.3 seconds
- Fire resistance no requirement
- Tightness max. 0.15 m^3/s with ΔP = 50 Pa
- Closure system automatic
- Materials min. stainless steel 1.4571
- Anchors and components min. stainless steel 1.4529
- Design life ≥ 30 years
- Door opening system swing door, to the inside
- Door dimensions width 80 cm, height 210 cm
- Door window width 30 cm, height 170 cm
- Final painting RAL 2004 (orange) on both sides.

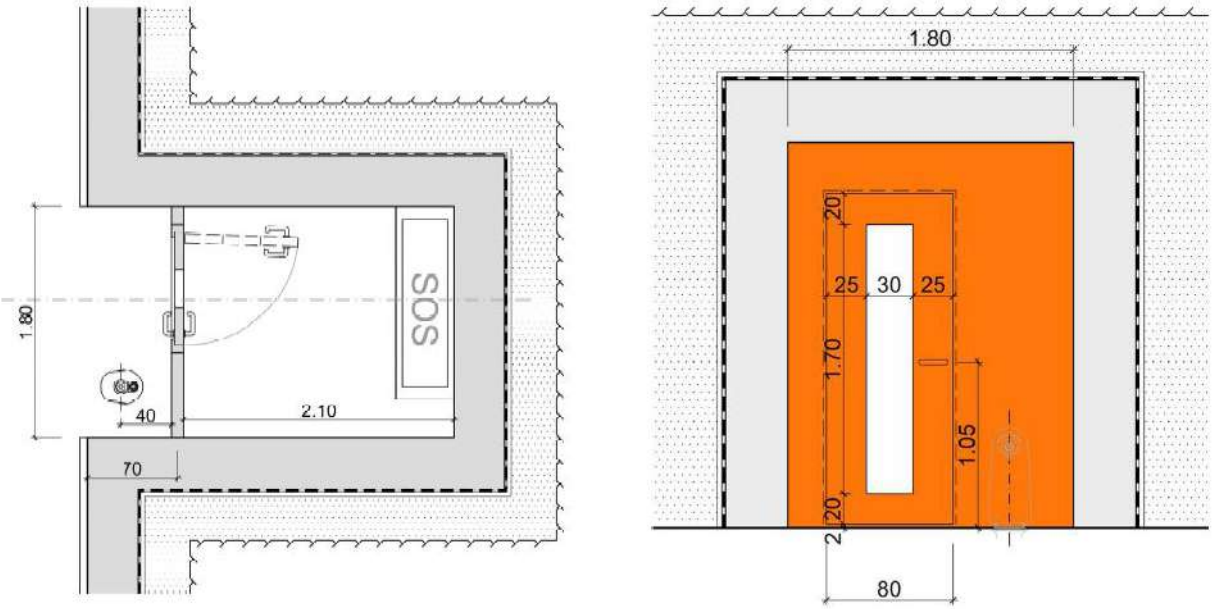


Figure 8: Typical SOS Niche

3.5 Carriageway

The super elevation of the carriageway in tunnel is variable, according to the road design. It shall not exceed a maximum value of 5% in curved stretches.

Whenever in a straight stretch, a minimum transversal gradient of 2.5% shall be guaranteed.

The super elevation is necessary to allow waters coming from the outside during rainfall, waters coming from tunnel washing operations or liquids leaking during an incident to drain away quickly.

The tunnel platform rotates around the design axis and affects the total height of the walkways at both sides of the carriageway.

The following bituminouscourses will be provided:

- Wearing course 5 cm BM 80/100 bitumen
- Binder course 5 cm BM 60/70 bitumen
- Base layer 20 cm Unbound granular mix (crusher-run macadam, according to grading II, table 12.8 of Standard Specifications for Road and Bridge Works).
- Filling gravel 0/45 (minimum compaction grade 100 MN/m^2)

Road markings of the tunnel carriageway consist of:

- Lateral continuous white line (width 25 cm);
- Central double and continuous white line (width 20 cm, free space 15 cm);
- "Cat's eye" retroreflective safety devices in the middle of the road between continuous lines (longitudinal step 6.5 m).

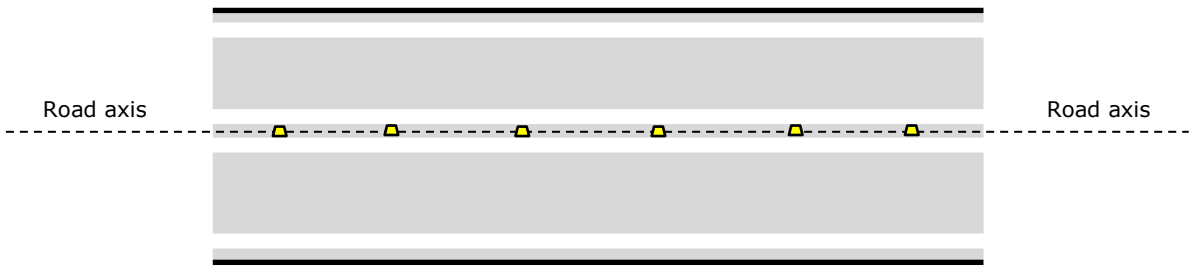


Figure 9: Main tunnel road markings

3.6 Walkways

Walkways are used as escape routes in case of incident inside the tunnel. They permit to reach SOS niches, bypass or tunnel portals in case of emergency. They also accommodate cable ducts, cable shafts and water supply pipe.

The minimum walkway width shall be 1 m, including the kerb. Transversal gradient shall be at least 2% towards the carriageway, whereas the step height will be 18 cm.

The walkways limits on the carriageway side can be:

- Kerbs (precast polymer concrete or natural stone elements such as granite or gneiss – see Figure 10);
- Linear road drainage channel (precast polymer concrete halogen free– at the minimum points of the road gradient – see Figure 11).

Both kerbs and drainage channels must be placed on a concrete foundation (min. 200 mm, C25/30, XC4, XF1).

Linear road drainage channel must have a minimum drainage capacity of 100 l/s.

According to Figure 4, the free space above the walkways is equal to at least 2 m. Moreover, the space requirement for traffic signals located against the tunnel walls consists of a squared area 80 x 80 cm, that must be kept free on both sides of the tunnel above the walkway.

A 3 cm thick bituminous layer MA 8 N or similar will be provided on the walkways surface.

In order toimprove visibility and traffic management, LED "cat's eye" devices will be installed above the kerb on both walkways (see E&M Technical Report).

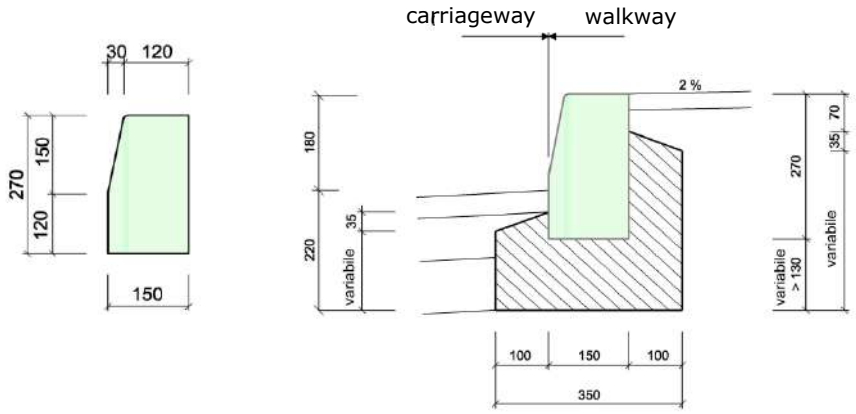


Figure 10: Walkways kerb (ASTRA 24 001-10402)

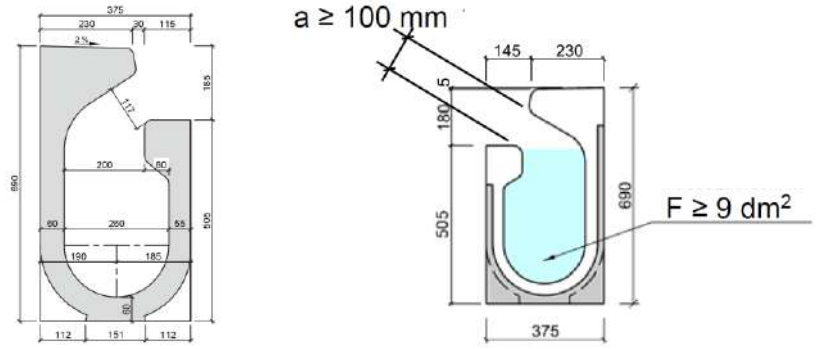


Figure 11: Linear road drainage channel, typical according to ASTRA 24 001-10602

3.7 Cable pipes and cable shafts

Cable pipes will be accommodated under both walkways, embedded in concrete. The following pipes for each walkway will be provided, having a minimum net distance between each other of 5 cm and a minimum distance from the walkway surface of 10 cm.

- 4x HDPE electrical pipes DN 120 (inside diameter 120 mm, outside diameter 132 mm), in a 2x2 pattern. No PVC pipes are allowed;
- 2x HDPE electrical pipes DN 150 (inside diameter 148 mm, outside diameter 163 mm), in a 2x1 pattern, at the bottom of the pipes group. No PVC pipes are allowed.

At regular intervals (see Tunnel Layout plan), cable shafts will be provided inside the walkways, having the following minimum dimensions in tunnel:

- Shaft type A2 (45 cm wide, 185 cm long), according to ASTRA 23 001-14300;
- Shaft type A3 (45 cm wide, 279 cm long), according to ASTRA 23 001-14300;
- Bypass pits (45 cm wide, 45 cm long).

Suitable sleeves must be used at the interface between electrical pipes ends and cable shaft walls,in order topermit a favourable installation of cables form inside the shafts.

Manholes covers will be suitable for vehicles (minimum load class C 250, according to ASTRA 23 001-14300) and sealed so as to prevent flammable liquids from entering the shafts. Besides, a drainage pipe (diameter 60 mm) at the bottom of the shafts will permit condensation water to drain away into the gravel filling under the carriageway.

Along the tunnel, electrical cable connections will be provided (see Tunnel Layout plan for more details):

- Connections to a SOS niche.
  3x HDPE electrical pipes DN 80 (inside diameter 80 mm, outside diameter 92 mm) will connect the cable shaft in front of a SOS niche and the foundation of the alarm cabin inside the niche.

- Connections to the technical buildings.
  10x HDPE electrical pipes DN 120 will connect the cable shaft in front of the technical building and the low voltage room.
  2x HDPE electrical pipes DN 120 will connect the cable shaft in front of the technical building and the medium voltage room.

- Connections to/along a bypass
  2x HDPE electrical pipes DN 120 (inside diameter 120 mm, outside diameter 132 mm) will connect the cable shaft in front of a bypass and the bypass electrical pit.

- Connections to the vault.
  A minimum of 5x HDPE electrical pipes DN 80 (inside diameter 80 mm, outside diameter 92 mm) will connect the cable shaft with suitable openings inside the vault at a height of 4.5 m from the walkways. Openings minimum dimensions are as follows: height 30 cm, depth into the vault 25 cm, longitudinal length according to the number of electrical pipes, having a 5 cm space between them. The minimum concrete cover of the pipes is 7 cm.

- Connections to the bypass vault.
  2x HDPE electrical pipes DN 80 (inside diameter 80 mm, outside diameter 92 mm) will connect the bypass pit with the bypass vault at a height of 3.0 m.

Electrical pipes and relevant shafts will be extended to the north and to the south of the tunnel portals (at least 200 m), along the road stretches approaching the tunnel.

3.8 Groundwater management

Water collection along the tunnel is based on the so called "separate" water management system. It pursues the separation between clean groundwater, collected outside the tunnel lining perimeter, and polluted waters, collected inside the tunnel lining perimeter.

3.8.1 Tunnel waterproofing

Groundwater, coming from the surrounding rock mass, is collected at the foot of the tunnel vault, thanks to the drainage and waterproofing layers around the tunnel. The tunnel waterproofing system consists of the following package of layers (in setting sequence, from top to bottom):

- Geocomposite drainage layer (Enkadrain or similar);
- Waterproofing PVC membrane (SIKAPLAN WP 2110-21HL or similar), thickness ≥ 2 mm;
- Waterproofing protection sheet (SIKAPLAN WP Protection Sheet 20H or similar).

Before setting of the geocomposite layer, the surface of the shotcrete primary lining must be accurately checked and, wherever necessary, regularized and smoothed. Waterproofing membrane shall be continuous; hence, any connection between adjacent strips of membrane shall be welded together by a double line of welds and continuous welding shall be guaranteed and tested by proper pressure tests.

At the north and south portal, where cut and cover stretches are foreseen, the following system will be provided (in setting sequence, from bottom to top):

- Waterproofing PVC membrane (SIKAPLAN WP 2110-21HL or similar), thickness ≥ 2 mm, hot-glued over the entire surface of the concrete lining (smooth and clean);
- Waterproofing protection sheet (SIKAPLAN WP Protection Sheet 20H or similar)
- Cement mortar (10 cm) reinforced with a wire mesh (ϕ6 mm 10x10 cm) as a final protection layer, with respect to subsequent filling and compaction.

The tunnel waterproofing system will be applied to the whole vault. No waterproofing layer is foreseen around an invert, wherever and whenever provided according to local geological conditions.

3.8.2 Drainage system

At the base of the vault, on both sides of the main tunnel and bypasses, HDPE slotted drainage pipes with an internal diameter equal to 200 mm will be provided and wrapped with filtering gravel 16/32 mm.

Drainage pipes allow groundwater to flow into flushing niches. Once in the niches, waters are collected by the seepage pipe (HDPE pipe connecting all the flushing niches, with an internal diameter equal to 300 mm).

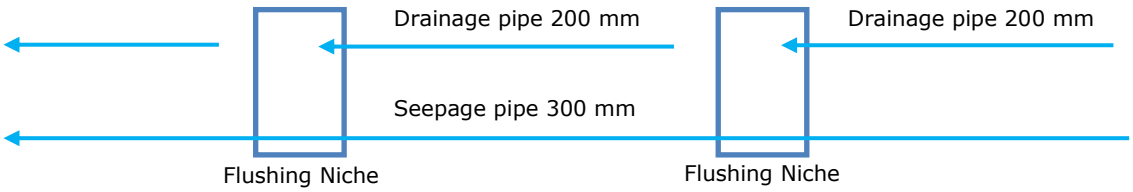


Figure 12: Typical groundwater drainage system

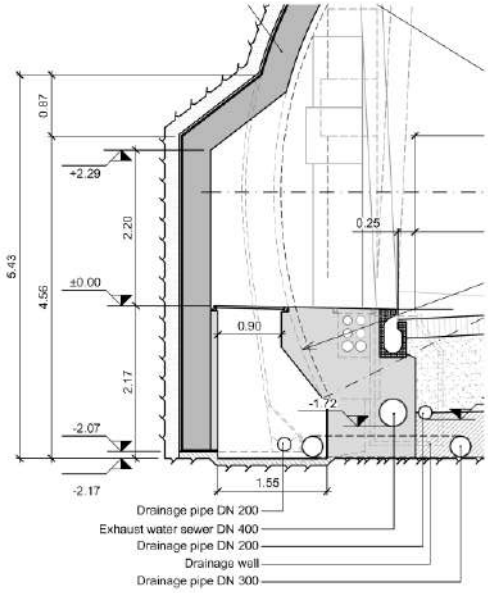
3.8.3 Flushing Niches

Flushing niches collect groundwaters and allow maintenance (regular flushing) of both drainage and seepage pipes.

Niches will be provided on both sides of the main tunnel, with a longitudinal step equal to 75 m and a minimum longitudinal length equal to 120 cm.

In the bypasses, two flushing shafts are foreseen at a distance of 75 m from the bypass end (river side).

For additional details see "Main tunnel layout" drawing D-A-C-D-002-C00.



3.8.4 Discharge at the portals

At the south portal, groundwaters coming from the drainage system will be discharged directly into the river. In the first drainage stretch at the north portal (between external shafts and the first flushing niche at km 2+005, see "main tunnel layout" D-A-C-D-002-C00), drainage pipelines shall be installed so that a longitudinal gradient can lead waters towards south.

3.9 Dirty and polluted water management

According to the so called "separate" water management system, dirty and polluted waters will be collected by a separate system and never mixed with the groundwater.

3.9.1 Sewage system

Dirty and polluted waters coming from in the inner tunnel space are:

- Carriageway waters which are carried inside the tunnel by vehicles in case of rain;
- Polluted liquids or fuel in case of accident or leaking;
- Firefighting waters in case of fire;
- Waters used during tunnel walls cleaning operations.

These kinds of water are collected by the linear drainage channel, thanks to the transversal gradient of the carriageway (see 3.6) and transported to the first chamber of the syphoned wells, every 50 m.

Some waters could also leak under the carriageway and seep through the filling gravel. They will be collected by a dedicated HDPE slotted drainage pipe with an internal diameter equal to 200 mm, connected to the first chamber of the siphoned wells.

3.9.2 Syphoned wells and water collector

A HDPE water collector pipe with an inner diameter equal to 400 mm connects all the syphoned wells and transports polluted waters through the tunnel to the south portal.

Every 50 m, special polymer concrete double chamber syphoned wells will be provided. They allow to avoid direct communication between the inner space of the tunnel and the main water collector and, hence, avoid propagation of fire liquids along the tunnel in case of accidents/fire.

Syphoned wells consist of two separate chambers, connected at the bottom by an opening into the separation wall, which is always under water:

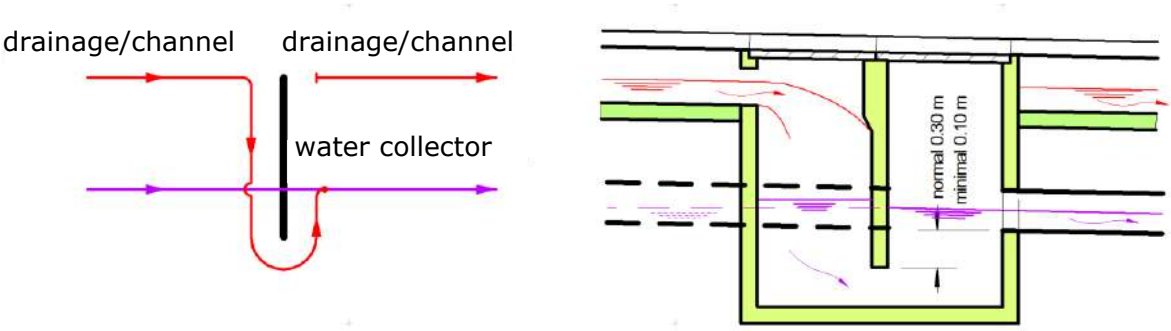


Figure 14: Syphoned wells functioning scheme according to ASTRA guidelines

- The first chamber (to the north) collects all the waters transported by the linear drainage channel and the drainage pipe under the carriageway. The main water collector does not communicate with the first chamber.
  - Pipes in: linear channel, carriageway drainage pipe;
  - Pipes out: none;
  - Pipes passing through: main water collector.
- The second chamber (to the south) collects waters transported by the main water collector, so that a minimum level of water is always present into the syphoned wells.
  - Pipes in: main water collector;
  - Pipes out: main water collector;
  - Pipes passing through: none.

3.9.3 Discharge at the portals

At the south portal, dirty waters will be discharged into a water basin, located outside the carriageway. A water basin volume, equal to 150 m^3, allows to collect waters and, whenever necessary, to avoid the direct discharge into the local sewage systems. In normal operation situation, waters coming from the tunnel water management system can be directly discharged into the local sewage net. In special cases, such as a fireor an accident inside the tunnel or duringtunnel washing operations, the basin volume shall be used to gather waters coming from:

- Firefighting (estimated 120 m^3 according to ASTRA guidelines) and accident liquids (estimated 50 m^3 according to ASTRA guidelines);
- Tunnel walls cleaning operations (estimated 100 m^3 according to ASTRA guidelines).

In these cases, the water basin connection to the local sewage system will be temporarily interrupted and gathered waters can be pumped out afterwards.

At the north portal, dirty waters will be discharged into a similar water basin, located outside the carriageway, with a reduced volume, equal to 50 m^3. It will be connected to the road water management system.

3.10 Fire management

3.10.1 Water supply system

A water supply system is foreseen in order to provide firefighting water in case of accident.

The main water supply pipe (ductile cast iron with PUR internal coating or similar), with an inner diameter equal to 200 mm, will be installed under the mountain side walkway and wrapped by sand. It will be always full of water under pressure.

Fire hydrants shall be located on both sides of the tunnel every 150 m.

Minimum service requirements at the hydrants are:

- Minimum dynamic pressure 3.5 bar
- Minimum hydrostatic pressure 6 bar
- Minimum water flow rate
  - 1 hydrant used 40 l/s

- 2 hydrants used at the same time 30 l/s each
- 3 hydrants used at the same time 25 l/s each

Hence, the minimum water flow rate in the water supply pipe shall be at least equal to 75 l/s.

Hydrants shall comply with the following minimum requirements (type Von Roll 5000S or similar):

- 1x Storz connector (75 mm);
- Stainless materials;
- Internal and external anticorrosive coating (epoxy layer or similar);
- Red colour finishing (RAL 3000).

3.10.2 Hydrant niches

Hydrants will be located ineach SOS niche and, on the opposite side, in a dedicated hydrant niche.

In combined SOS/hydrants niches, hydrants shall respect a minimum 40 cm distance from the niches' door.

A proper water discharge will be provided at the bottom of the 60 x 60 cm pit, right in front of the hydrants, by means of a HDPE 100 mm pipe, connected to the carriageway drainage pipe.

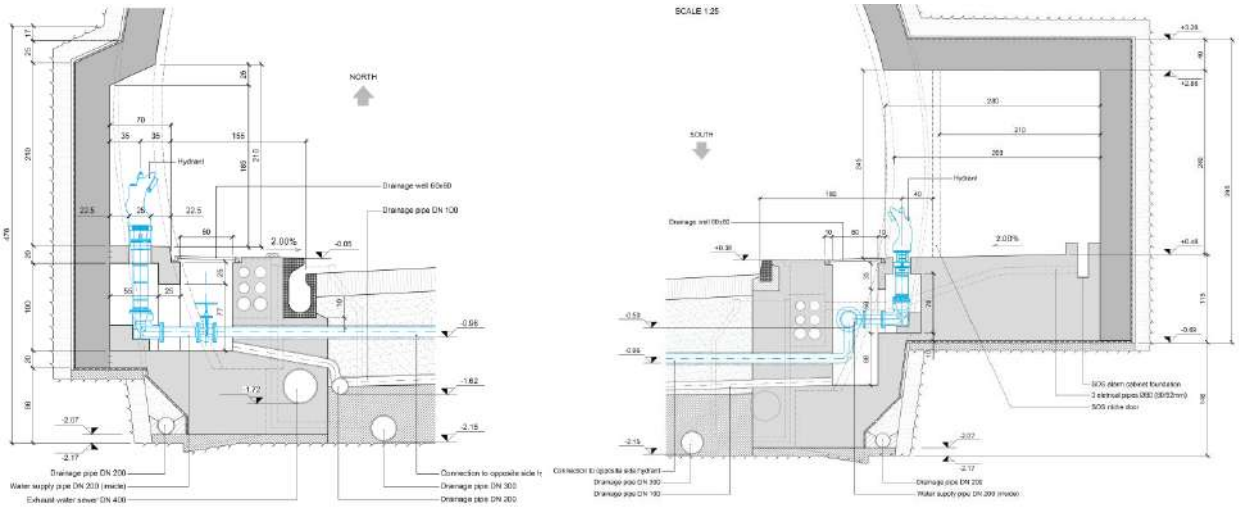


Figure 15: Hydrant niches and combined SOS/hydrant niches

3.10.3 Water supply reservoir

A 250 m^3water reservoir is foreseen at the underground level of the north technical building (see also the relevant chapter 4.3.2).Actually, 6 tanks of about 50 m^3 are foreseen in order to allow tanks maintenance, one by one in turn, without interrupting the availability of a minimum of 250 m^3 of water for the tunnel firefighting system.

Water withdrawal will be done at the river level (about -54 m down the portal level), in the existing "Tinaau" hydropower dam area, by means of two 100 mm pipelines (one is for safety in case of malfunctioning of the first one)and two alternating pumps (10.4 l/s).

The following actions must be taken by the Contractor:

- to design the most suitable withdrawal system and pipeline alignment, according to the local conditions and possibilities;
- to get all the necessary authorizations by all Authorities concerning the hydropower dam site and «Ramapithecus Park»;
- to provide measures such as signage and fencing, to prevent people from bathing in the withdrawal point area;
- to define how to access the withdrawal site for maintenance operations;
- to check the stability of the river bed and riverside as well as maximum and minimum water levels upstream and downstream of the dam;
- to adopt countermeasures to avoid clogging of the pipelines and to provide systems in order to allow sedimentation (such as a sedimentation/setting basin);

- to provide a water basin control and alarm system, with sensors that provide alarm to the tunnel control room in case of malfunctioning of the intake pumping system, or water levels in every tanks lower than expected or malfunctioning of the pumping station.

The following requirements must be then fulfilled at any time by the system:

- water volume 300 m^3 (min. 250 m^3 in case of one tank maintenance);
- maximum filling time 8 hours;
- water flow rate during filling 10.4 l/s;
- reservoir emptying time 1.1 hours (in case of the use of 3 hydrants – tot. 75 l/s).

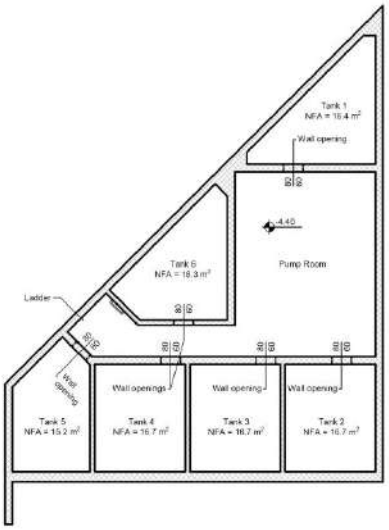


Figure 16: Water supply reservoir layout

3.10.4 Pumping station

The pumping room is located at the underground level of the technical building north, together with water reservoir tanks.

Pumping of water into the tunnel firefighting pipeline will be provided by at least 5 pumps (min. 20 l/s), working in parallel, to satisfy the following needs:

- Minimum dynamic pressure 3.5 bar
- Minimum hydrostatic pressure 6 bar
- Minimum water flow rate
  - 1 hydrant used 40 l/s
  - 2 hydrants used at the same time 30+30 l/s
  - 3 hydrants used at the same time 25+25+25 l/s

3.10.5 Pressure tests

The Contractor must check the firefighting system by means of suitable pressure tests according to EN 805, SVGW W4and local standards.

3.11 Tunnel ventilation

The tunnel ventilation system, by means of jet fans, smoke sensors and other specific devices, is described in the relevant annex of the E&M report. Couples of jet fans will be installed in the upper free space of the tunnel vault.

Bypasses will be nevertheless ventilated in order to maintain air overpressure along the escape routes in case of fire. In this case, a special enlarged section (called "Air Lock" section) will be provided in proximity of the bypass portals, on the rockshed side.The air lock section will be 5 m long and characterized by the following elements:

- Two slinding doors (see details in 3.4.2);

- 3 square openings 1m x 1m in the upper part of the separation walls, having a 35 cm minimum distance from the sliding door structure and the tunnel vault profile.

3.12 Standard design sections

According to the space requirements described in 3.3, the following standard design sections are provided:

- Typical cross section

  This section fulfils all the minimum requirements for the inner space.

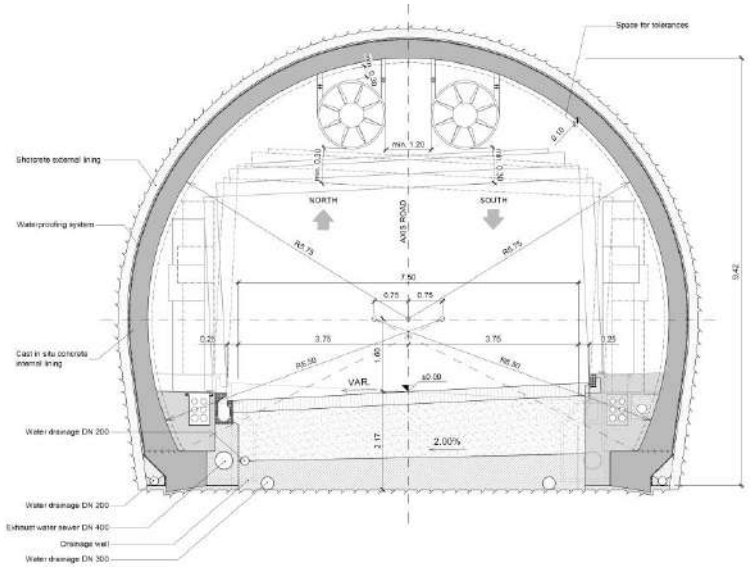


Figure 17: Main tunnel, typical cross section

- Widened typical cross section

  This section takes into account the widening requirements (60 cm) for visibility in the curved stretch of the tunnel.
  Basically, the geometry of the inner profile (arches, radii) is the same as that of the typical cross section, but a 60 cm straight segment at the vault key is added.

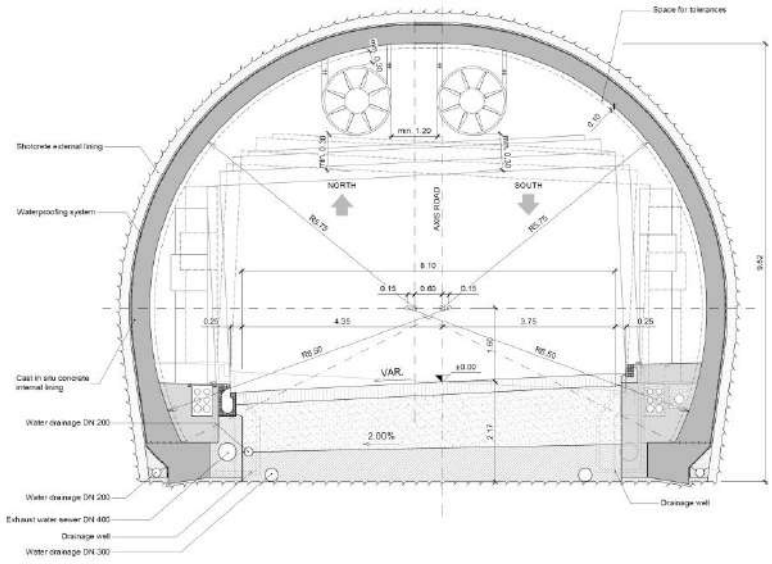


Figure 18: Main tunnel, widened typical cross section

- Lay by typical cross section

This section is representative of the lay-by bays in the central part of the tunnel. The geometry of the tunnel walls is equal to that of the typical cross section, whereas the vault radius is longer.

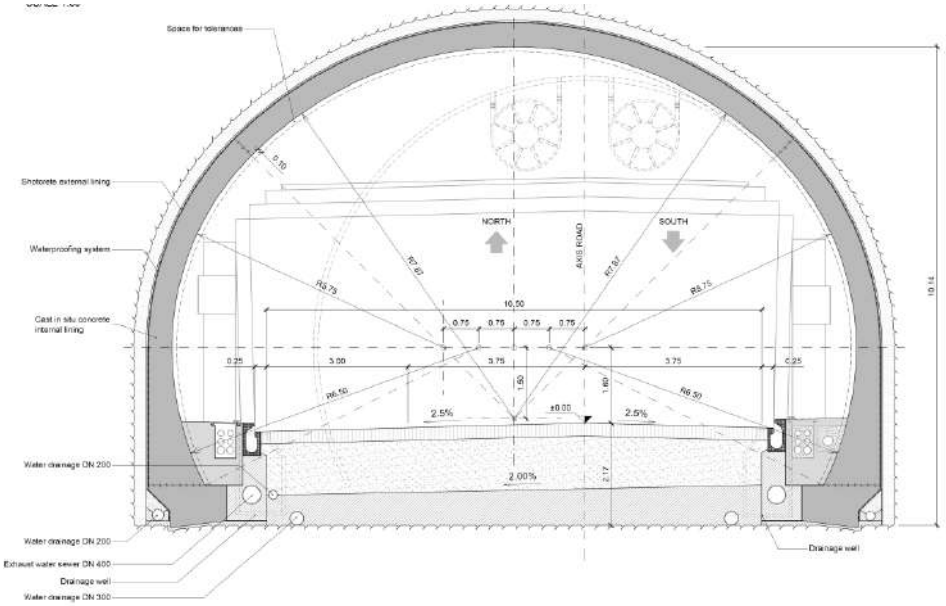


Figure 19: Main tunnel, lay by typical cross section

- Bypass typical cross section

  This section fulfils the minimum requirements for the inner space of the bypass. Moreover, it takes into account the necessary space for the sliding door frame.

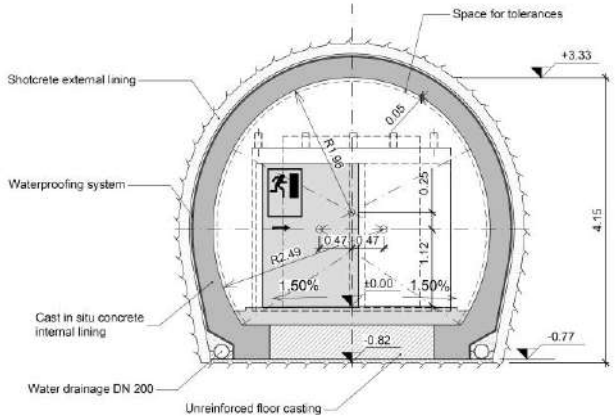


Figure 20: Bypass, typical cross section

- Bypass "air lock" cross section

  This section fulfils the minimum ventilation requirements for the inner space of the "air lock" section of the bypass. Moreover, it takes into account the necessary space for the sliding door frame, ventilation openings and command cabin.

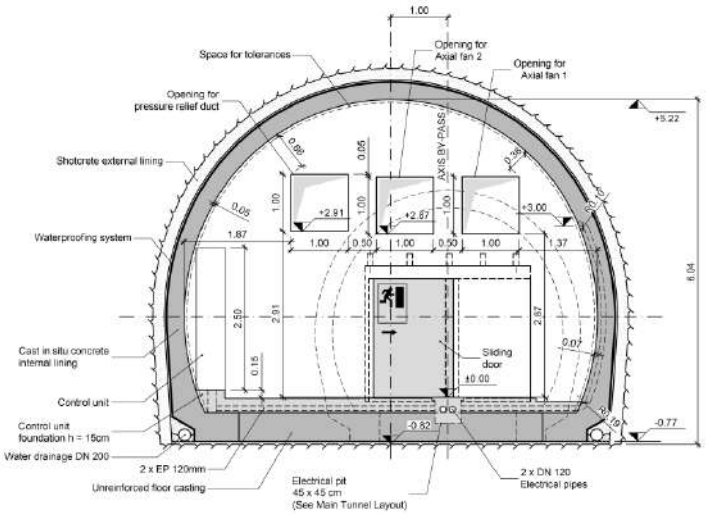


Figure 21: Bypass "Air Lock", typical cross section

3.13 Excavation and tunnel support

3.13.1 Excavation system

Considering the length of the tunnel, the foreseen geological conditions and the accessibility of the site, it is foreseen to excavate the tunnel by conventional tunnelling method. The use of a mechanized tunnelling method (i.e. using a TBM or similar) is considered not suitable mainly for two basic reasons: first of all, the length of the tunnel does not justify the cost for transport and supplying of a TBM; moreover the small available space at the portals makes complex the logistic during construction.

Conventional tunnelling consists of a cyclic execution process of repeated steps of excavation followed by the application of relevant primary support, which depends on existing ground/rock conditions and behaviour.

Considering predictable rock conditions in the present case, it is foreseen the use of drill and blast for most of the tunnel in compact rock, whereas ripper and hydraulic breaker are foreseen near the portals where weaker and weathered rock could be present. An experienced team of tunnel workers, assisted by special equipment, shall execute each individual cycle of tunnel construction.

By the use of special equipment and allowing access to the tunnel excavation face at almost any time, the conventional tunnelling method is very flexible in situations that require a change in the structural analysis and/or in the design of support measures. A standard set of equipment consists of the following items:

- Drilling jumbo: to drill holes for blasting (in medium to hard rock), rock bolting, water and pressure release;
- Road header or excavator, mainly where rock blasting is not possible (weak rock);
- Lifting platform allowing the miners to reach each part of the tunnel crown and face;
- Loader or excavator for loading excavated material onto dump trucks;
- Dump trucks for hauling excavated material;
- Set of shotcrete manipulators for application of wet shotcrete.

The assumed tunnel standard cross-section (about 110 m^2) is suitable to foresee a full face excavation: thanks to the high degree of mechanisation of the works and to the use of large, high performance equipment, full face excavation can be achieved even in difficult rock conditions, where face stability and support will be given paramount consideration.

3.13.2 Hazard scenarios and observational design approach

The recognition and the assessment of potential hazards as well as the planning of appropriate mitigation measures are fundamental to the design of underground structures. Hazards consist of events that have the potential to impact on matters relating to the project, which could give rise to consequences associated with health and safety, the environment, the design, the construction schedule and costs.

A preliminary evaluation of the geological-geotechnical scenario and relevant hazards have been identified and evaluated. The main expected hazards are (see also the geological and geomechanical profiles):

- stones falling from the crown;
- unstable blocks on the excavation contour;
- detachment of slabs;
- loosening of rock mass around the tunnel;
- plastic deformation of the rock mass;
- instability of the tunnel face;
- water income (effects on springs and surface waters).

The aforementioned hazards, individually or in combination, constitute possible hazard scenarios to be considered to define tunnel support measures.

Moreover, when tunnelling in a sedimentary rock, variable local rock conditions shall be expected and, hence, a flexible design and construction approach shall be adopted. Considering such expected conditions, the observational design approach is adopted, based on the concept to foresee, during design, different rock reinforcement and temporary support systems, to be applied along the tunnel depending on local rock behaviour measured during construction. Adopting the aforementioned design approach, the design shall include different fundamental instruments:

- based on geological investigation, the range of variability of rock mass characteristics shall be estimated and defined for each homogeneous section (from a geological point of view) along the tunnel;
- within the defined range of variability, a number of different hazard scenarios shall be identified;
- for each hazard scenario, the most suitable rock reinforcement and temporary support system shall be designed in order to guarantee safety and, in the meantime, optimize costs and construction time;
- A guideline that provides the range of rock conditions (for instance, described by well-known geological parameters such as GSI, RMR or Q) and of rock behaviour (for instance, described by level of deformation of the tunnel face or profile) for which each rock reinforcement and temporary support system is suitable;
- A geotechnical monitoring plan that define monitoring instruments to be installed and adopted during construction to assess local rock conditions and, hence, the applicability of the different support systems foreseen in the design;
- A longitudinal profile which provides, for each geologically homogeneous section, the foreseen alternative rock reinforcement and support systems and, for each of them, the probability of use, in order to obtain an estimation of construction time and costs.

The purpose of the primary/temporary support is to stabilize the underground excavation profile until the final lining is installed. Several elements are applied individually or in combination with different types of support, depending on the assessment of ground conditions.

According to the ground conditions, sub-horizontal drain pipes shall be installed at the tunnel face to avoid the risk of unexpected and sudden water inflow, in particular near the portals, where more fractured and weathered rock is expected.

3.13.3 Tunnel support class 0

Tunnel support class 0 is representative of the best geological rock mass conditions along the tunnel, where the main predictable hazard is the falling of stones from the vault.

The following supports are in sequence foreseen (every 3 m - advance shift):

- 5 cm C25/30 shotcrete layer (0/8 mm aggregates), reinforced with steel fibres;
- Steel wire mesh (steel grade B500 A or similar) ϕ 5mm/10x10 cm;
- Swellex rock bolts (Ftk ≥ 240 kN, L=4 m), if necessary;
- 5 cm C25/30 shotcrete layer (0/8 mm aggregates).

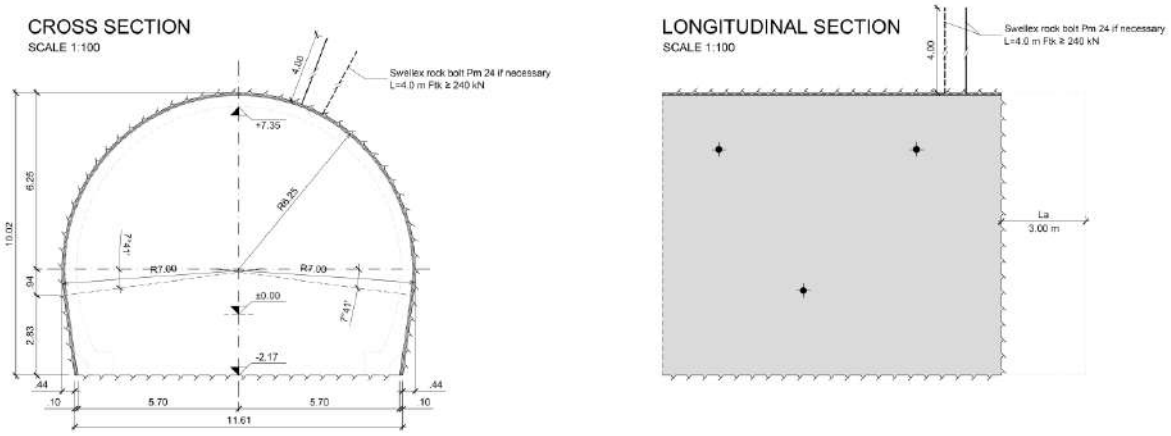


Figure 22: Tunnel support class 0, standard section

3.13.4 Tunnel support class 1

Tunnel support class 1 is foreseen to mitigate the following main hazards:

- stones falling from the crown;
- unstable blocks on the excavation contour;
- detachment of slabs.

The following supports are in sequence foreseen (every 2/3 m- advance shift, according to the encountered geological conditions) in standard/widened/bypass sections and every 2 m in lay-by bay section:

- 5 cm C25/30 shotcrete layer (0/8 mm aggregates), reinforced with steel fibres;
- Steel wire mesh (steel grade B500 A or similar) ϕ 5mm/10x10 cm;
- Swellex rock bolts:
  - Standard/Widened section: swellex rock bolts (Ftk ≥ 240 kN, L=4 m), with a 1.5 m (transversal) x 1.5/2.0 m (longitudinal) pattern (longitudinal step can be adapted according to the encountered geological conditions);
  - Bypass section: swellex rock bolts (Ftk ≥ 160kN, L=3 m), with a 1.5 m (transversal) x 2.0 m (longitudinal) pattern;
  - Lay-by Bay section: swellex rock bolts (Ftk ≥ 240 kN, L=5 m), with a 1.5 m (transversal) x 1.5 m (longitudinal) pattern;
- 10 cm C25/30 shotcrete layer (0/8 mm aggregates);
- Excavation face stabilization, by means of 5 cm C25/30 shotcrete layer (0/8 mm aggregates), reinforced with steel fibres.

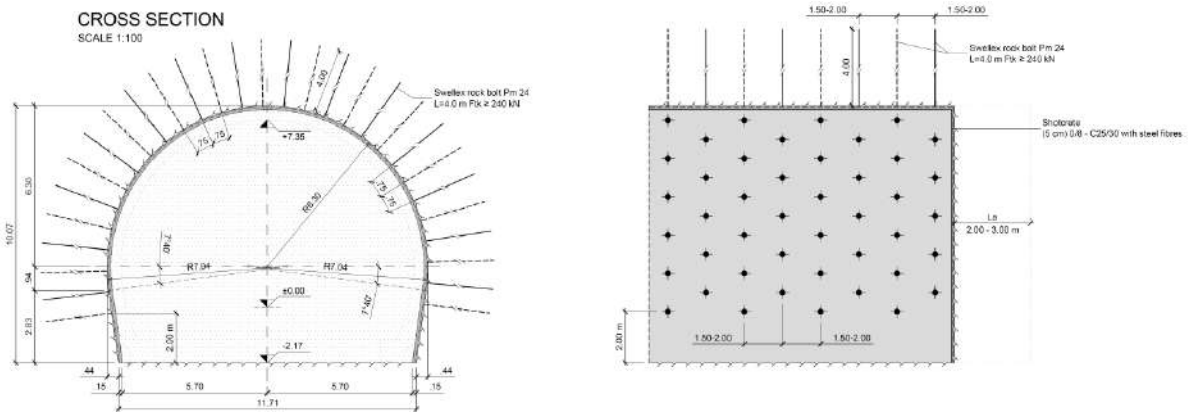


Figure 23: Tunnel support class 1, standard section

3.13.5 Tunnel support class 2

Tunnel support class 2 is foreseen to mitigate the following main hazards:

- stones falling from the crown;
- unstable blocks on the excavation contour;
- detachment of slabs;
- low to medium loosening of rock mass around the tunnel (GSI >45).

The following supports are in sequence foreseen (every 1.5/2 m - advance shift, according to the encountered geological conditions):

- 5 cm C25/30 shotcrete layer (0/8 mm aggregates), reinforced with steel fibres;
- Steel wire mesh (steel grade B500 A or similar) ϕ 5mm/10x10 cm;
- 10 cm C25/30 shotcrete layer (0/8 mm aggregates);
- Steel wire mesh (steel grade B500 A or similar) ϕ 5mm/10x10 cm;
- Cemented rock bolts:
  - Standard/widened/lay-by section: cemented rock bolts (Ftk ≥ 350 kN, L=7 m), with a 1.5 m (transversal) x 1.5 m (longitudinal) pattern;
  - Bypass section: cemented rock bolts (Ftk ≥ 250 kN, L=4.5 m), with a 1.5 m (transversal) x 1.5 m (longitudinal) pattern;
- 5 cm C25/30 shotcrete layer (0/8 mm aggregates);
- Excavation face stabilization, by means of 5/10 cm C25/30 shotcrete layer (0/8 mm aggregates), reinforced with steel fibres, and fiberglass or cemented anchors if necessary.

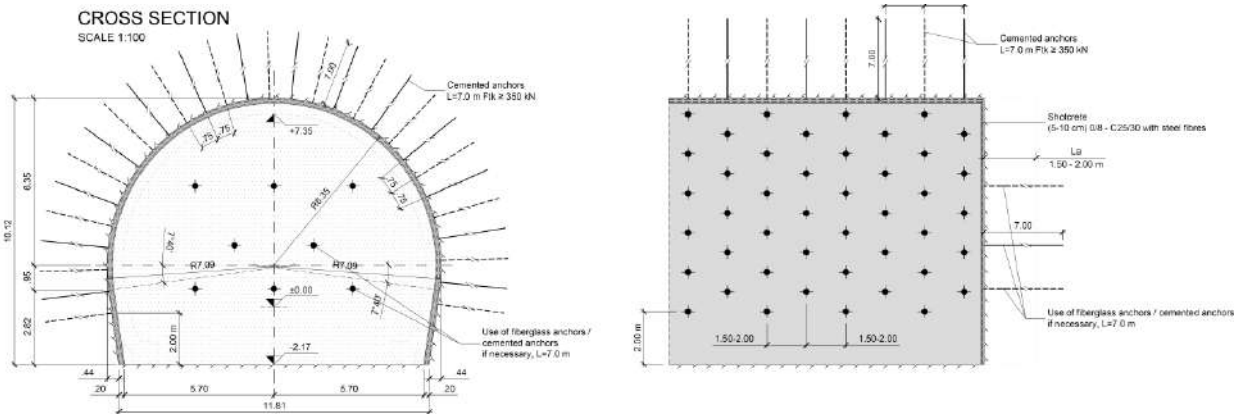


Figure 24: Tunnel support class 2, standard section

3.13.6 Tunnel support class 3

Tunnel support class 3 is foreseen to mitigate the following main hazards:

- stones falling from the crown;
- unstable blocks on the excavation contour;
- detachment of slabs;
- medium to high loosening of rock mass around the tunnel (GSI < 40).

The following supports are in sequence foreseen (every 1 m - advance shift):

- 5 cm C25/30 shotcrete layer (0/8 mm aggregates), reinforced with steel fibres;
- Steel wire mesh (steel grade B500 A or similar) ϕ 5mm/10x10 cm;
- Sub-horizontal spiles (forepoles) (Ftk ≥ 550 kN, L=3 m), with a 0.375 m (transversal) x 1.0 m (longitudinal) pattern, distributed at the vault with an angle of 120°. The bottom side of the forepoles (excavation side) lays on lattice girders;
- Lattice girders (longitudinal spacing 1.0 m):
  - Standard/widened section: lattice girders type 3G-70/26/34 or similar;
  - Lay-by bay section: lattice girders type 3G-130/20/30 or similar;
  - Bypass section: lattice girders type 3G-70/18/26 or similar;
- C25/30 shotcrete layer (0/8 mm aggregates);
  - Standard/widened section: 13 cm;
  - Lay-by bay section: 18 cm;
  - Bypass section: 11 cm;
- Steel wire mesh (steel grade B500 A or similar) ϕ 5mm/10x10 cm;
- C25/30 shotcrete layer (0/8 mm aggregates);

- Standard/widened section: 7 cm;
- Lay-by bay section: 7 cm;
- Bypass section: 4 cm;

- Excavation face stabilization, by means of 5/10 cm C25/30 shotcrete layer (0/8 mm aggregates), reinforced with steel fibres, and fiberglass or cemented anchors if necessary.

The primary lining foot shall have a thickness of at least 350 mm (standard/widened section) and 400 mm (lay-by section).

At the bottom of the tunnel walls of the standard/widened section, 1 m above the vaults' foot, cemented rock bolts (Ftk ≥ 350 kN, L=5 m), with a 1 m longitudinal spacing and a 250 x 250 x 20 mm steel anchor plate, will be provided to stabilize the tunnel paraments.

Whereas during spilesinstalltion water income is recorded or if water income is recorded at the tunnel face, at least n.2 slotted sub-horizontal drainage pipes at the tunnel face shall be installed, using slotted PVC pipes (or equivalent) with diameter 2", 15 m long, to be repeated every 10 m (advance length), till water income are nomore recorded. Drainage pipes shall be installed with 5° inclination upward, one on the left half and one at the right half of the tunnel face, starting at a height around 2/3 of the tunnel height.

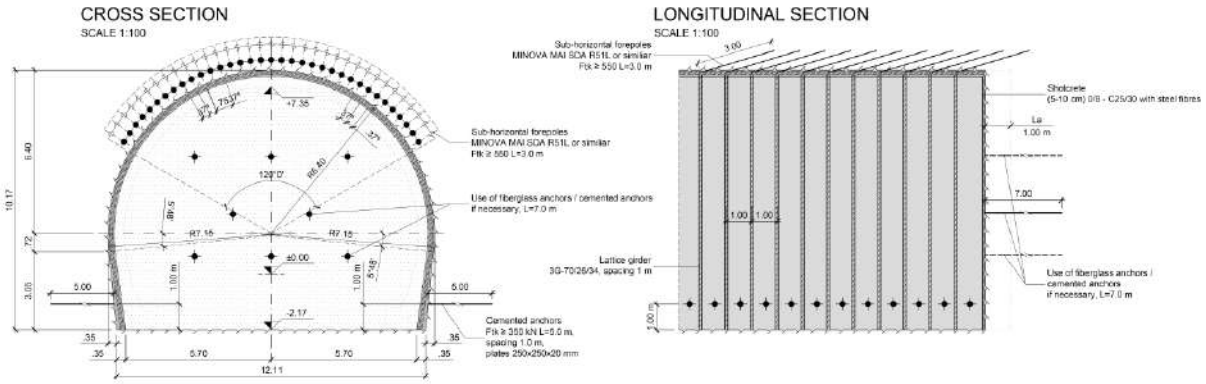


Figure 25: Tunnel support class 3, standard section

3.13.7 Tunnel support class 4

Tunnel support class 4 is foreseen to mitigate the following main hazards:

- stones falling from the crown;
- unstable blocks on the excavation contour;
- detachment of slabs;
- medium to high loosening of rock mass around the tunnel (GSI < 40) with low overburden (< 30 m), typically at the north and south portals;
- instability of the tunnel face.

The following supports are in sequence foreseen (every 1 m - advance shift):

- Execution of a steel tubes forepoling umbrella (steel grade S355) every 10 m (advance length). Diameter min. 114.3 mm, thickness min. 16 mm, drilling diameter min. 150 mm, transversal spacing 0.4 m, length 15 m, gradient 6% with reference to the tunnel axis;
- 5 cm C25/30 shotcrete layer (0/8 mm aggregates), reinforced with steel fibres;
- Steel wire mesh (steel grade B500 A or similar) ϕ 5mm/10x10 cm;
- HEB 180 steel ribs (steel grade S355) with a longitudinal spacing equal to 1.0 m;
- C25/30 shotcrete layer (0/8 mm aggregates): 18 cm;
- Steel wire mesh (steel grade B500 A or similar) ϕ 5mm/10x10 cm;
- C25/30 shotcrete layer (0/8 mm aggregates): 7 cm(wherever necessary, shotcrete completion by filling the gap between primary lining and final lining, before final lining and waterproofing execution);
- Excavation face stabilization, by means of 5/10 cm C25/30 shotcrete layer (0/8 mm aggregates), reinforced with steel fibres, and 18 fiberglass anchors (Ftk ≥ 800kN, drilling diameter min. 100 mm, length = 16 m, overlapping = 8m, execution every 8 m).

The primary lining foot shall have a thickness of at least 450 mm.

At the bottom of the tunnel walls of the standard section, 1 m above the vaults' foot, cemented rock bolts (Ftk ≥ 460 kN, L=5.5 m), with a 1 m longitudinal spacing and a 250 x 250 x 20 mm steel anchor plate, will be provided to stabilize the tunnel paraments.Whereas during drilling steel pipe of forepoling umbrella, water income is recorded, at least n.2 slotted sub-horizontal drainage pipes at the tunnel face shall be installed, using slotted PVC pipes (or equivalent) with diameter 2", 15 m long, to be repeated every 10 m (advance length), till water income are nomore recorded. Drainage pipes shall be installed with 5° inclination upward, one on the left half and one at the right half of the tunnel face, starting at a height around 2/3 of the tunnel height.

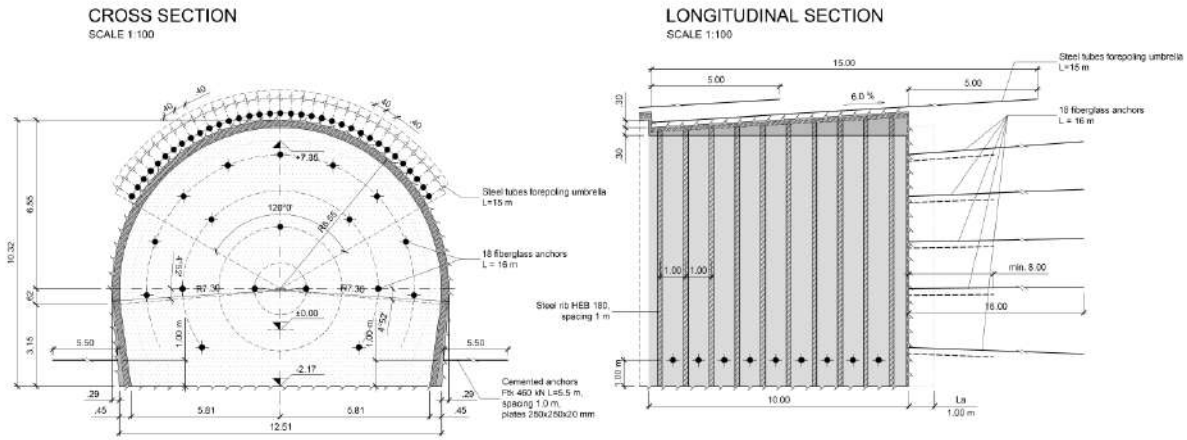


Figure 26: Tunnel support class 4, standard section

3.13.8 Tunnel support class 5

Tunnel support class 5 is foreseen to mitigate the following main hazards:

- stones falling from the crown;
- unstable blocks on the excavation contour;
- detachment of slabs;
- plastic deformation of the rock mass;
- instability of the tunnel face.

A tunnel invert is foreseen in order to face rock pressures due to the plasticization of the surrounding rock mass.

The following supports are in sequence foreseen (every 1 m - advance shift):

- Vault excavation and support

- 5 cm C25/30 shotcrete layer (0/8 mm aggregates), reinforced with steel fibres;
- Steel wire mesh (steel grade B500 A or similar) ϕ 5mm/10x10 cm;
- HEB 180 steel ribs (steel grade S355) with a longitudinal spacing equal to 1.0 m;
- C25/30 shotcrete layer (0/8 mm aggregates): 18 cm;
- Steel wire mesh (steel grade B500 A or similar) ϕ 5mm/10x10 cm;
- C25/30 shotcrete layer (0/8 mm aggregates): 12 cm;
- Stabilization/Reinforcement of both the excavation face and the tunnel contour, by means of 5/10 cm C25/30 shotcrete layer (0/8 mm aggregates), reinforced with steel fibres, and 60 fiberglass anchors (Ftk ≥800kN, drilling diameter min. 100 mm, length = 18 m, overlapping = 9 m, execution every 9 m).

- Invert excavation and support (distance from the tunnel excavation face = 2 m)

- 5 cm C25/30 shotcrete layer (0/8 mm aggregates), reinforced with steel fibres;
- Steel wire mesh (steel grade B500 A or similar) ϕ 5mm/10x10 cm;
- HEB 180 steel ribs (steel grade S355) with a longitudinal spacing equal to 1.0 m;
- C25/30 shotcrete layer (0/8 mm aggregates): 18 cm;
- Steel wire mesh (steel grade B500 A or similar) ϕ 5mm/10x10 cm;
- C25/30 shotcrete layer (0/8 mm aggregates): 12 cm.

Whereas during fiberglass anchor at the tunnel face, water income is recorded, at least n.2 slotted sub-horizontal drainage pipes at the tunnel face shall be installed, using slotted PVC pipes (or equivalent) with diameter 2", 15 m long, to be repeated every 10 m (advance length), till water income are nomore recorded. Drainage pipes shall be installed with 5° inclination upward, one on

the left half and one at the right half of the tunnel face, starting at a height around 2/3 of the tunnel height.

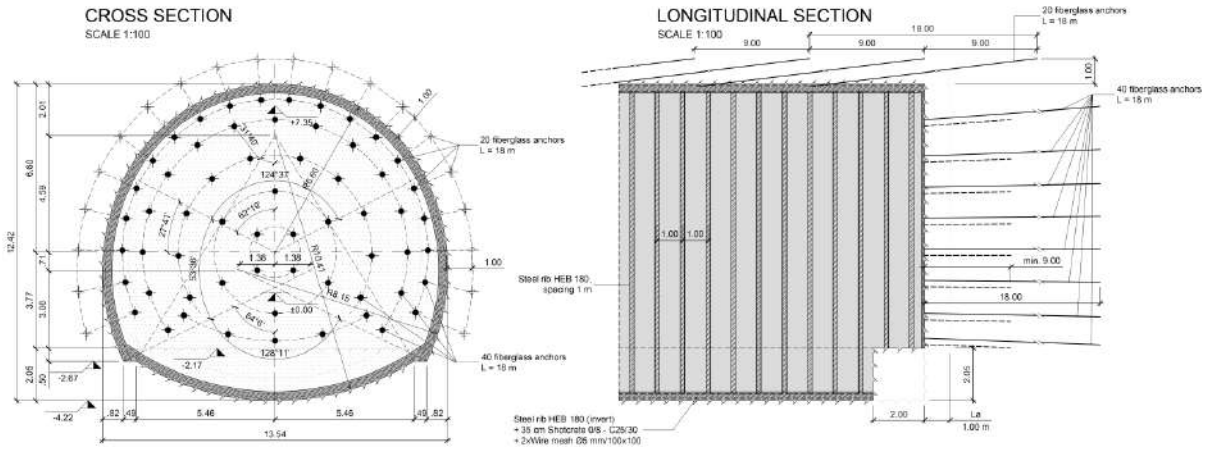
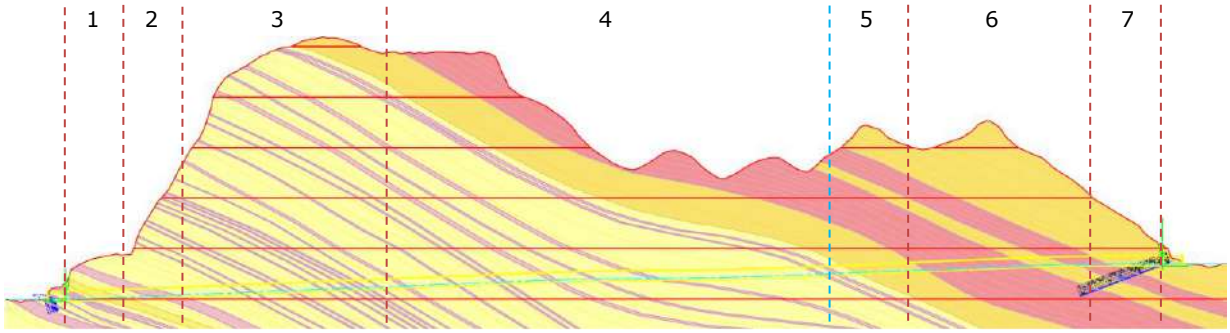


Figure 27: Tunnel support class 5, standard section

3.13.9 Classes distribution along the tunnel

In the geomechanicallongitudinal profile, suitable homogeneous sections have been identified, on the basis of expected geology and hazards (from 1 to 7 in Figure 28). Excavation support classes have been accordingly distributed along the tunnel.



	1	2	3	4+5	6	7
	km 0+925 - 0+982	km 0+982 - 1+036	km 1+036 - 1+256	km 1+256 - 1+765	km 1+765 - 1+941	km 1+941 - 2+012
CLASS 0	-	-	10%	20%	-	-
CLASS 1	-	-	30%	50%	-	-
CLASS 2	-	10%	40%	20%	10%	-
CLASS 3	20%	40%	20%	10%	20%	20%
CLASS 4	70%	-	-	-	-	70%
CLASS 5	10%	50%	-	-	70%	10%

Figure 28: Tunnel support classes distribution along the main tunnel

3.13.10 Classes distribution along the bypasses

As far as escape routes are concerned, excavation support classes have been distributed along the each bypass:

- Bypass 1 (south)

- 7 m portal section 100% Class 3
- Air lock section 100% Class 3
- Middle section 10% Class 0 / 30% Class 1 / 40% Class 2 / 20% Class 3

- 10 m connection section 100% Class 3

- Bypass 2 (intermediate)

- 7 m portal section 100% Class 3
- Air lock section 100% Class 3
- Middle section 20% Class 0 / 50% Class 1 / 20% Class 2 / 10% Class 3
- 10 m connection section 100% Class 3

- Bypass 3 (north)

- 7 m portal section 100% Class 3
- Air lock section 100% Class 3
- Middle section 10% Class 0 / 30% Class 1 / 40% Class 2 / 20% Class 3
- 10 m connection section 100% Class 3

3.13.11 Water income management and grouting

In any support class, whenever necessary based on water income during the systematic horizontal survey drilling to be done at the front face (see monitoring concept at 3.15), sub horizontal drainage pipes shall be used ahead of the excavation facein order to manage water income. Slotted drainage PVC pipes with a diameter of at least 100 mm or equivalent seystems shall be used. If necessary, they will be covered with a sleeve of geotextile (not woven) to prevent clogging. The length (min. 10 m) and the position of drainage pipes should be evaluated during advancement operations, according to local conditions.

When excavating upward (from south to North) a proper water collection system shall be realized in order to bring water at the portal and avoiding water stagnation near the tunnel face and at the foots or the temporary ling. When excavating downward (from North to South), a proper pumping system shall be also provided by the Contractor and continuously kept in service in order to avoid also risk of foin order to avoid tunnel flooding.

As during design survey, sudden water incomes were experienced during borehole coring, expecially during advancement from North, possible narrow sections with high water income are expected. In order to be able to face such local conditions without reducing too much the advancement rateand in order to reduce total water income during service of the tunnel, the Contractor shall be ready and demonstrate to be able to perform local intervention with chemical grouting, in order to locally reduce rock permeability around the tunnel and shall produce a concept to perform such additional grouting work. In the following picture, just as example, it is shown a concept of chemical grouting work aimed to reduce rock permeability around the tunnel.

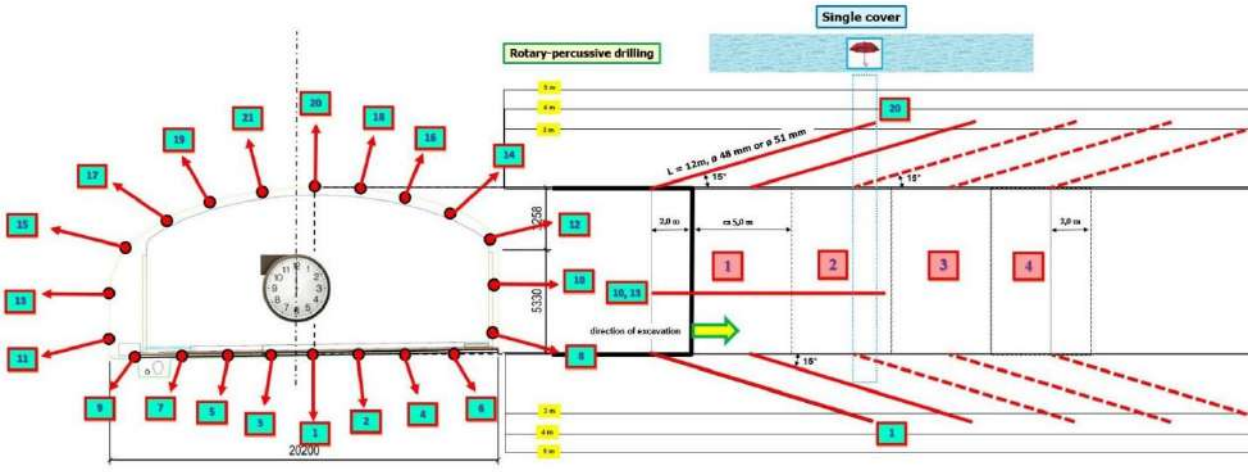


Figure 29: Example of chemical grouting work to reduce rock permeability around the tunnel

3.13.12 Anchors onsite tests

In order toverify that rock bolts and anchors meet the design requirements, suitable pull out tests shall be provided at least in the following situations:

- before tunnel excavation;
- during excavation, whenever a change in the geological formation is encountered;
- during excavation, whenever an unexpected geological formation is encountered.

In each homogeneous rock formation or ground condition, at least 3 pull out tests shall be provided for each designed anchor type (swellex rock bolts, cemented rock bolts, fiber glass elements). The design of the tests (location, pulling and contrast system, etc.) shall be provided by the Contractor according to Eurocodes. In the following, minimum requirements for the anchors resistance, in terms of characteristic friction between anchor and rock, are summarized according to the present design:

- Swellex rock bolts 80kN/m;
- Cemented rock bolts 94 kN/m.

Fiberglass reinforcements shall be verified by means of pull-out tests at a minimum test load equal to 760 kN.

3.13.13 False tunnel at the portals

In order to safely excavate the tunnel at the two portals, a false tunnel will be provided, at least 2 m long. The false tunnel will be made of shotcrete and reinforced with HEB 180 steel ribs and wire meshes (see relevant plan for details).

3.14 Expected rock mass parameters

In the following table, expected rock mass parameters are summarized. More details could be found in the geological report.

Rock mass parameters				TO (tunnel homogeneous section)									
				1 - Portal South		2	3	4	5	6	7 - Portal north	
				Sandstone	Mudstone						Sandstone	Mudstone
ROCK	RQD	min - max	[%]	0 - 100	65 - 80	50 - 100	50 - 100	50 -100	40 -100	0 - 100	0 - 100	65 - 80
	GSI	min - max	-	25 -85	25 - 60	30 - 80	40 - 80	40 - 80	30 - 80	30 - 80	30 - 80	25 - 60
	σc	min - max	[MPa]	14 - 51	5 - 35	5 -35	15 - 50	15 - 50	15 - 50	5 - 35	14 - 51	5 - 35
	Bulk density	min - max	[g/cm3]	2.37 - 2.66								
	Hoek-Brown	D		0.7								
		mi		13	7	7	7 - 13	7 - 13	7 - 13	7	13	7
		φ	[°]	38 - 57	21 - 46	19 - 40	30 - 47	33 - 49	29 - 51	18 - 38	38 - 57	21 - 46
		c	[kPa]	64 - 960	26 - 430	90 - 520	390 - 1360	310 - 1240	205 - 1160	105 - 560	70 - 810	26 - 430
		UCS	[MPa]	1.5 - 7	0.02 - 2.3	0.05 - 2.3	0.3 - 7	0.3 - 9.7	0.1 - 9.7	0.05 -2.3	0.12 - 5.8	0.02 - 2.3
		v		0.2	0.25	0.25	0.2	0.2	0.2	0.25	0.2	0.25
		E	[GPa]	0.8 - 20	0.34 - 11.5	0.6 - 11.5	2 - 20	2 - 20	1.12 - 20	0.6 - 11.5	1.02 - 18.2	0.34 - 11.5
Joints	fi	min - max	[°]	15.95 - 18.26								
	c	min - max	[kPa]	108 - 158								
Permeability k		min - max	[m/s]	1.9x10-3 - 2.5x10-4		<1.0x10-4	2.5x10-4 - 1.0x10-4	2.5x10-4 - 1.0x10-4	2.5x10-4 - 1.0x10-4	<1.0x10-4	1.9x10-3 - 2.5x10-4	

Table 2:Expected rock mass parameters

3.15 Tunnel monitoring

During excavation, deformation response of the surrounding rock mass and, hence, displacements of the primary lining shall be monitored during all the tunnel construction.

The monitoring phase begins when the excavation work starts and a proper monitoring system must be installed and activated as soon as the construction begins. Monitoring is aimed:

- to be able to verify design assumptions and to calibrate them during excavation (intensity and distribution of support measures);

- to check the conditions and response of the tunnel over time (long term behaviour).

An adequate tunnel monitoring program shall be provided by the Contractor. Hereby, the minimum requirements are summarised:

- continuous geological/geomechanical check of the excavation face during excavation and description of the lithology and discontinuities;
  - quick check in homogeneous or constant ground situations (at least every 10 m);
  - detailed check and descriptions in case of change of lithology and discontinuities;

- one horizontal drilling from the tunnel face, 30 m long, to be done every 20 m advancement and recording drilling parameters (so-called DAC-test), to be used to identify in advance rock quality changes;

- convergence measurements by means of mini prisms, fixed to the shotcrete primary lining right behind the excavation face (topographical monitoring section);

- topographical monitoring sections every 25 m;

- at least 5 mini prisms for each topographic section, located at the tunnel abutments, walls and vault key (see Figure 30).

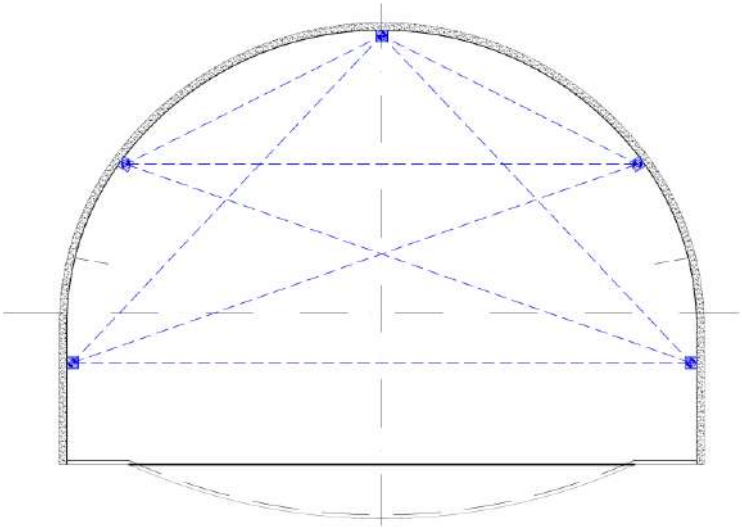


Figure 30: Example of convergence monitoring section

3.15.1 Frequency

Data acquisition frequency:

- daily, having a distance from the tunnel excavation face < 25 m;
- two times a week, having a distance from the tunnel excavation face > 25 m.

3.15.2 Thresholds

Convergence thresholds / Tunnel support Class 0-1-2-3:

- Expected maximum vertical displacement 6 mm - 10 mm (lay-by) - 1 mm (bypass);
- Alert threshold, vertical displacement 10 mm;
- Alarm threshold, vertical displacement 15 mm;

- Expected maximum horizontal displacement 2 mm;
- Alert threshold, horizontal displacement 5 mm;
- Alarm threshold, horizontal displacement 10 mm.

Convergence thresholds / Tunnel support Class 4:

- Expected maximum vertical displacement 8 mm;
- Alert threshold, vertical displacement 10 mm;
- Alarm threshold, vertical displacement 15 mm;

- Expected maximum horizontal displacement 2 mm;
- Alert threshold, horizontal displacement 5 mm;
- Alarm threshold, horizontal displacement 10 mm.

Convergence thresholds / Tunnel support Class 5:

- Expected maximum vertical displacement 8 mm;
- Alert threshold, vertical displacement 10 mm;
- Alarm threshold, vertical displacement 15 mm;

- Expected maximum horizontal displacement 6.5 mm;
- Alert threshold, horizontal displacement 10 mm;
- Alarm threshold, horizontal displacement 15 mm.

3.16 Inner lining

The lining concept to be applied shall be a double-shell lining, where the external lining shall support rock load during construction and inner lining loads in the long term; a proper waterproofing system is needed to guarantee serviceability of the tunnel (see 3.8.1).

The final lining shall be in plain or reinforced concrete, C30/37. A working Life of 50yearshas been foreseen.

In order to guarantee sufficient durability, the concrete shall be suitable for exposure classes XC4, XD1 and XF1, accordingly to EC2 and SIA 262; moreover shall be resistant to alkali-aggregates reaction.

A minimum 50 mm concrete cover must be guaranteed.

Before casting the inner lining, the waterproofing system shall be installed, having previously regularized the surface of temporary lining, in order to avoid the risk of damage of the waterproofing system (no steel element protruding from the shotcrete surface and no cavity/irregularities in the shotcrete surface that prevent the waterproofing membrane to fully rest on the shotcrete surface). Then, reinforcement, where foreseen, is installed by using a mobile scaffolding and adopting proper plastic element to guarantee a proper cover to reinforcement. Finally the concrete is poured usually in tunnel sections between 10 and 12 m long. No discontinuities on the waterproofing membrane are allowed, i.e. no structural elements through it that cause holes in it.

The following minimum design thicknessesare foreseen:

- Standard tunnel section

- Support Classes 0-1	unreinforced concrete	40 cm
- Support Classes 2-3	reinforced concrete	40 cm
- Support Classes 4-5	reinforced concrete	50 cm
- Invert (Class 5)	reinforced concrete	50 cm

- Widened tunnel section

- Support Classes 0-1	unreinforced concrete	40 cm
- Support Classes 2-3	reinforced concrete	40 cm

- Lay-by bay section

- Support Classes 0-1-2-3	reinforced concrete	50 cm

- Bypass section/Air Lock section

- Support Classes 0-1	unreinforced concrete	30 cm
- Support Classes 2-3	reinforced concrete	30 cm

3.17 Tunnel painting

Tunnel walls will be painted (Tosadur 2K coating or similar) with a RAL 9010 (white) colour up to +4.00 m above the walkways.

Before painting the walls, the following activities must be executed in order to adequately prepare the concrete surface (up to +4.00 m above the walkways):

- High pressure tunnel wall washing (min. 300 bar, pressure to be calibrated);
- Coating with a cement mortar base product 2-3 mm (tear strength >1.5 MPa, StoCrete TF or similar);
- Hydrophobic coating (SikaGard 706 Thixo or similar).

3.17.1 Painting: SOS Niches

In the SOS niches surrounding surface (1 m around the niche's profile), tunnel walls will be painted with a RAL 2004 (orange) colour (Tosadur 2K coating or similar, see Figure 31).

3.17.2 Painting: escape routes accesses (bypass)

In the escape route surrounding surface (3 m to the north and to the south of the bypass access profile and up to +4.00 m above the walkways), tunnel walls will be painted with a RAL 6029 (green) colour (Tosadur 2K coating or similar, see Figure 31).

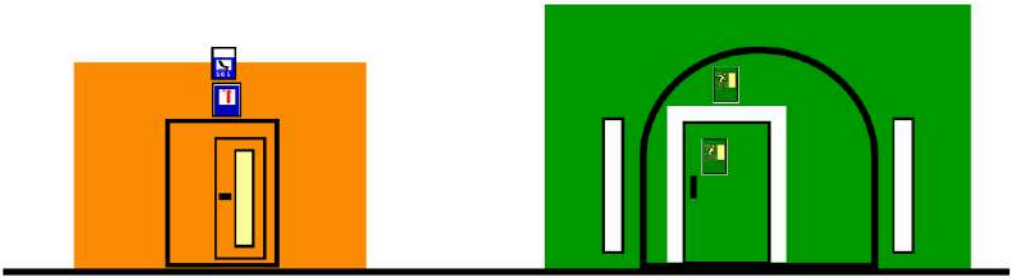


Figure 31: Typical painting patterns of SOS niches (left) and bypass accesses (right)

3.18 Summary of execution phases

In the following, general execution phases of the underground tunnel are described:

- Phase 0 – Tunnel Face support/pre-confinement

- Excavation face support by means of a shotcrete layer reinforced with steel fibres and fiberglass anchors/cemented anchors where necessary.
- Wherever foreseen, face reinforcement/pre-confinement by means of fiberglass anchors or fiberglass structural elements according to the design geometry and overlapping lengths.
- In tunnel support class 4, execution of a steel tubes forepoling umbrella at the excavation contour, according to design geometry and design overlapping length.
- Drilling and installation of drainage pipes will be provided if necessary.

- Phase 1 – Tunnel Advance

- Full face excavation with an advance length according to the applied tunnel support class.

- Phase 2 – Tunnel support

- Placing of a first fibre reinforced shotcrete layer on the tunnel excavation profile and, if necessary, on the excavation face.
- Placing of the first wire mesh steel reinforcement.
- Drilling and installation of radial rock bolts or sub horizontal forepoles.
- Where pertinent, placement of steel ribs/lattice girders according to the applied tunnel support class.
- After placing of steel ribs, connection of the ribs to each other by means of connecting steel bars.
- Placing of a second shotcrete layer and wire mesh according to the applied tunnel support class.
- Completion of the preliminary shotcrete lining. In tunnel support class 5, the last layer of shotcrete will be completed once the invert support is also executed.

- Phase 2b – Tunnel invert

- In tunnel support class 5, excavation of the invert at a 2 m distance from the excavation face.
- Preliminary lining of the invert by means of shotcrete, wire mesh and steel ribs.

- Connection of the invert steel ribs to the vault steel ribs and completion of the preliminary shotcrete lining.

- Phase 3 – Cast of the tunnel invert

- In tunnel support class 5, placement of the steel bars and cast of the concrete invert, having a maximum distance from the excavation face to be defined according to the monitoring results.

- Phase 4 – Waterproofing

- Placement of tunnel vault drainage pipes and filtering gravel package.
- Placement of the tunnel vault waterproofing system.

- Phase 5 – Cast of the final lining

- Cast of the tunnel final lining according to the design layout.

- Phase 6 – Carriageway, walkways and cable ducts

- Placement of cable ducts, shafts, drainages, pipes and hydrants.
- Cast of the walkways.
- Completion of the carriageway and niches.
- Technical installations (operating and safety equipment).

3.19 Operating and safety equipment

Accordingly to SIA 197/2, the following plants and equipment shall be designed and provided in order to guarantee proper operation of the tunnel and safety conditions:

- Lighting;
- Ventilation;
- Traffic management equipment (traffic signals and road markings);
- Surveillance system;
- Control system and communication network;

Moreover, the following is necessary for the operation of the above facilities:

- Energy supply;
- Cabling system;
- Auxiliary systems;
- Control room.

For additional details, see the relevant E&M technical report.

3.20 Construction phases

The construction of the tunnel is foreseen to be performed by the following main construction phases:

- Excavation of the main tunnel
- Excavation of the transversal tunnels;
- Construction of the tunnel lining;
- Construction of internal finishing
- Construction of technical buildings
- Installation of equipments.

Excavation of the main tunnel is foreseen to be performed by both portals, after excavation of the portal trenches itself; two tunnel advancement are performed in the mean time. During tunnel advancament from North to South, a pumping system shall be always made available at the tunnel face to avoid risk of tunnel flooring in case of sudden water income.

As during excavation of both portal trenches and first part of the tunnel from both sides, the road near the portals will be in srvice and the buildings near the portals will be operated (as weel as the temple near the South Portal), proper protection measures to avoid rock projection during excavation as well as proper mitigation measures to clearly separate the construction area from the road and pedestrian areas and reduce noise pollution shall be applied by the Contractor.

Excavation of the 3 transversal tunnels is foreseen one by one, after accomplishing main tunnel excavation and during tunnel linig construction. Excavation of transversal tunnels will be performed mainly from inside the tunnel in order to minimize disturbance to road traffic. Only last 7 m of excavation can be performed form the existing road, reducing the road width to one half and adopting intermediate traffic on the two dirction.

Tunnel lining construction is foreseen by use of only one movable formwork to be installed at the south portal and dismantled at the North Portal, moving from South to North; the formwork shall be able to cast the whole lining (except for the invert, where foreseen, and a small abutment as support) in one piece, in order to guarantee proper quality and finishing of the internal surface (i.e. continuous surface without longitudinal joints from the pedestrian pavement up to the crown. After casting, a proper protection of the hardening concrete shall be adopted in order to avoid thermal shock and to reduce shrinkage so to meet cracking requirmeents in accordance to relevant Eurocodes and design requirements: a proper concrete treatment protection concept shall be studied by the Contractor and presented to the Owner for acceptance.

Internal finishing will be installed and casted following inner lining at a proper distance to guarantee.

In parallel to tunnel lining construction, once excavation of the tunnel will be finished and, hence, installation areas at the portals shall be reduced, the technical buildings will be built at the two portals.

Once technical buildings shall be finished, equipments installation shall start from the buildings themselves and will continue in the tunnel once civil works will be completed.

4 CUT&COVER AND PORTALS

4.1 Excavation of north and south portals

The aim of this chapter is to provide an overview on the excavation works for the execution of the new road tunnel. The image below highlights North and South portal area:

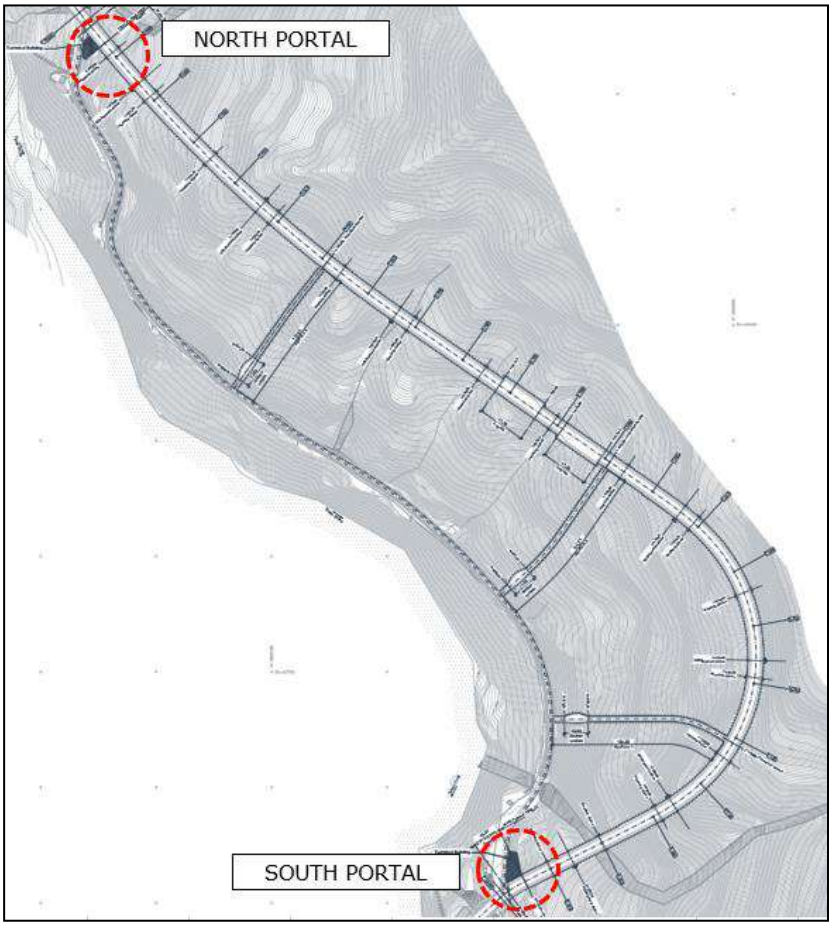


Figure 32 - General Tunnel Key plan

Figure 33 - North Portal Area

Figure 34 - South Portal Area

The proposed project of the Siddhababa tunnel road belongs to the rocks of the Siwaliks (Sub-Himalaya), Western Nepal. In Western Nepal, the rocks of the Siwaliks are subdivided into the Lower, Middle and Upper Siwaliks based on increasing grain size and lithological variation.

Figure 35 - Rock exposed on hill side

In general, soil parameters for each portal excavation design are reported below:

North Portal	γ [kN/m3]	φ'[°]	c' [kPa]	Poisson coeff. [-]	Elastic Modulus [GPa]
Sandstone_North_disturbance factor = 0.7	26	38	110	0.2	1.18
Sandstone_North_disturbance factor = 0.2	26	45	150	0.2	1.18

South Portal	γ [kN/m3]	φ'[°]	c' [kPa]	Poisson coeff. [-]	Elastic Modulus [GPa]
Sandstone_South_High Fracturated	26	38	110	0.2	1.18
Sandstone_South_disturbance factor = 0.7	26	41	125	0.2	1.55
Sandstone_South_disturbance factor = 0.2	26	47	165	0.2	1.55

4.1.1 Excavationprocess

Execution phases are reported below:

- **PHASE 1**

EXCAVATION UP TO -0.5 METERS BELOW FIRST LEVEL OF ROCK BOLTS;

- **PHASE 2**

PLACEMENT OF A LAYER OF SHOTCRETE REINFORCED WITH STEEL WIRE MESH;

- **PHASE 3**

EXECUTION OF THE FIRST LEVEL OF ROCK BOLTS;

- **PHASE 4**

EXECUTION OF THE DRAINAGES;

- **PHASE 5**

REPLICATION OF THE PREVIOUS STEPS UP TO THE FIRST LEVEL OF ANCHORS;

- **PHASE 6**

EXCAVATION UP TO -0.5 METERS BELOW ANCHORS, CAST OF THE RC BEAM AND EXECUTION OF THE ANCHORS.

4.1.1.1 Drilling

Drilling necessary disturbs the ground, methods should be chosen relative to the ground condition to cause either the minimum disturbance.

Holes for ground anchorages should be drilled to the position shown on the design drawings within a tolerance od +- 75mm.

For a specified alignment at entry point, the hole should be drilled to an angle of tolerance of +- 2.5°.

Tendons should be handled and protected prior to homing in such a manner as to avoid corrosion and physical damage.

To ensure proper central position and spacing of the tendon in the borehole, appropriate centralizer/spacer should be employed. Over the bond length, bar tendons should be centralized in the borehole to ensure a minimum grout cover to the tendon of 5 mm between centralizer location and 10mm at centralizer locations.

Centralizer are devices made of polyvinyl chloride (PVC) or other synthetic materials that are installed at various locations along the length of each bar to ensure that a minimum thickness of grout completely covers the nail bar. Centralizers shall be installed at regular intervals, typically not exceeding 2.5m, along the length of the nail

The stressing head and bearing plate should be assembly concentrically with the tendon within an accurancy of +-10mm and should be positioned not more than 5° form the tendon axis.

During the drilling operation, all changes in ground type should be recorded together with the notes on water levels encountered, drilling rates, flushing losses or stoppages.

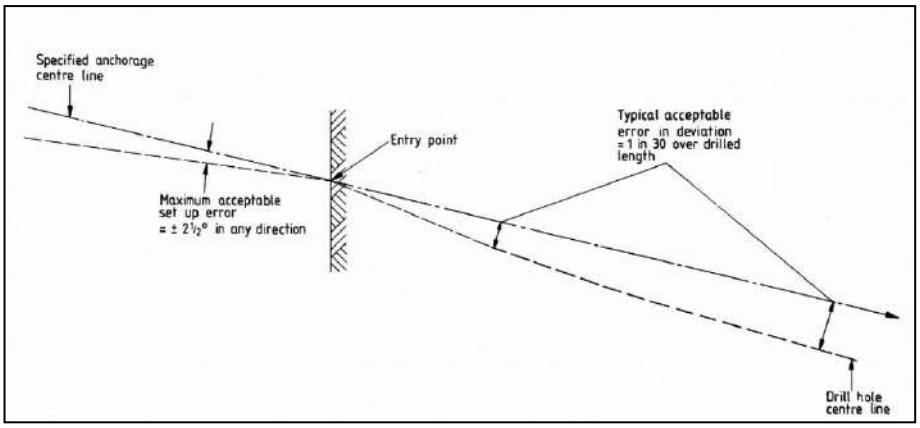


Figure 36 - Drill hole Deviation

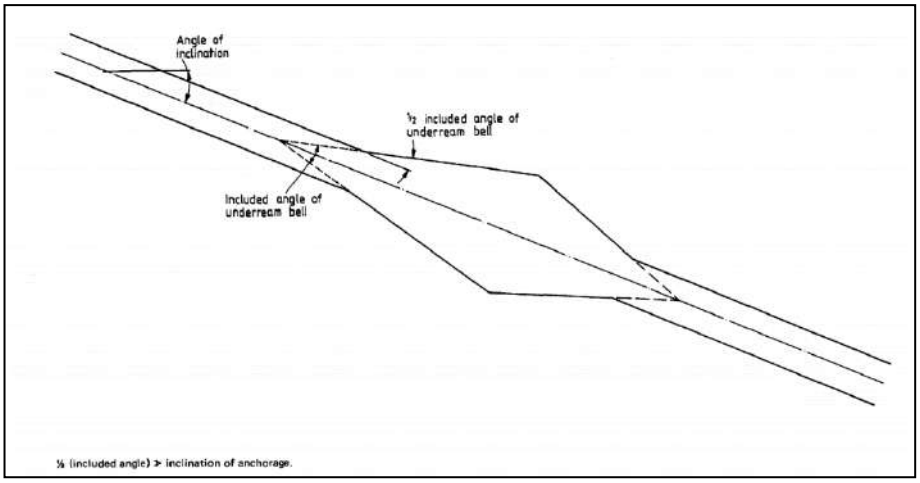


Figure 37 - Limiting Inclination for anchors

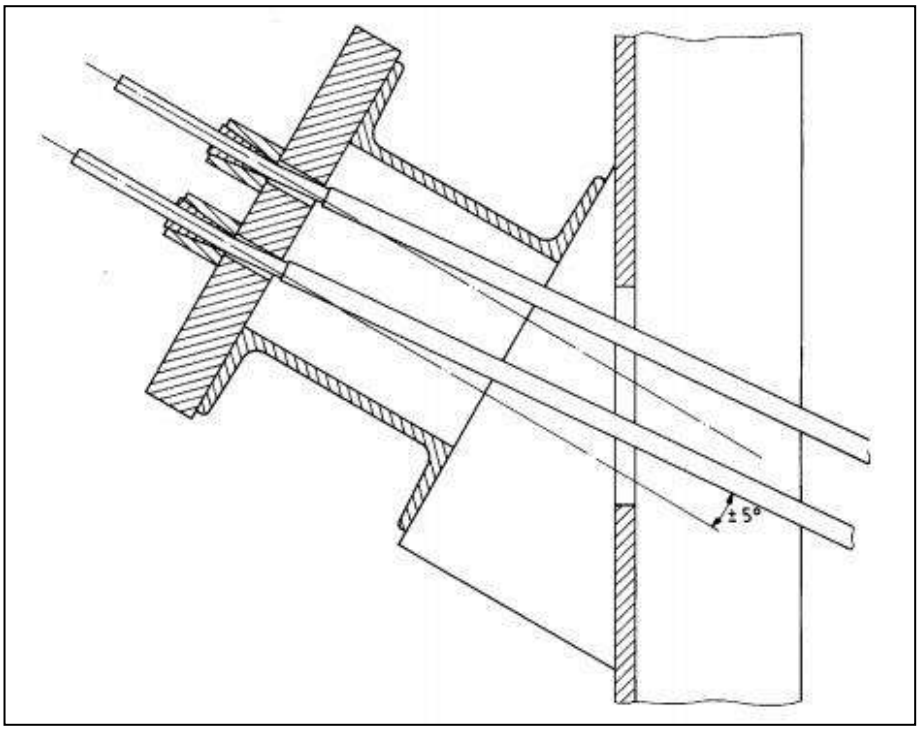


Figure 38 - Limiting angular tolerance at anchor head

4.1.1.2 Grouting

Grouting performs the following functions:

- To form the fixed anchors in order that the applied load may be transferred from the tendon to the surrounding ground;
- To increase the protection of the tendon against corrosion;

- To strengthen the ground immediately adjacent to fixed anchor in order to enhance anchorage capacity;
- To seal the ground immediately adjacent to the fixed anchor in order to limit loss of grout.

Each stage of injection should be performed in one continuous operation. At all time during injection, the end of the tremie pipe should remain submerged in grout.

For downward inclined holes, the grout should be injected through grout tubes into the lowest part of the hole.

Grout is commonly a neat cement grout and the injection pressure is equal to 20 kPa per meter depth of ground.

The cutting of the tendon after final grouting should be done by a disc-cutter.

4.1.1.3 Stressing

Stressing is required to fulfil the following two functions and the equipment and procedures should be designed accordingly:

- To tension the tendon and to anchor it as its secure load;
- To record the behaviour of the anchorage so that it can be compared with the behaviour of control anchorages.

For cementitious grouts, stressing should not commence until the primary grout forming the fixed anchors has attained a crushing strength of at least 30MPa, as verified from test on 100mm cubes.

No tendon part of temporary works should be stressed at any time beyond 80% of the characteristic strength. Corrosion protection

The design solution is defining a double corrosion protection (DCP), implying two physical barriers against corrosion. The purpose of the outer second barrier is to protect the inner barrier against the possibility of damage during tendon handling and placement.

Protection is achieved generally for free length of tendons by injection of solidifying fluids to enclose the tendon or by pre-applied coatings.

The bond length requires the same degree of protection as the free length. In addition the protective elements have all to be capable of transmitting high tendon stresses to the ground.

The essence of the anchor head protection is to provide an effective overlap with the free length protection, to protect the short exposed length of tendon below the plate and to isolate the short section of exposed tendon passing through the plate.

4.1.2 North portal excavation

Main relevant sections, highlighted in the key plan below, have been considered for the design of the north portal excavation:

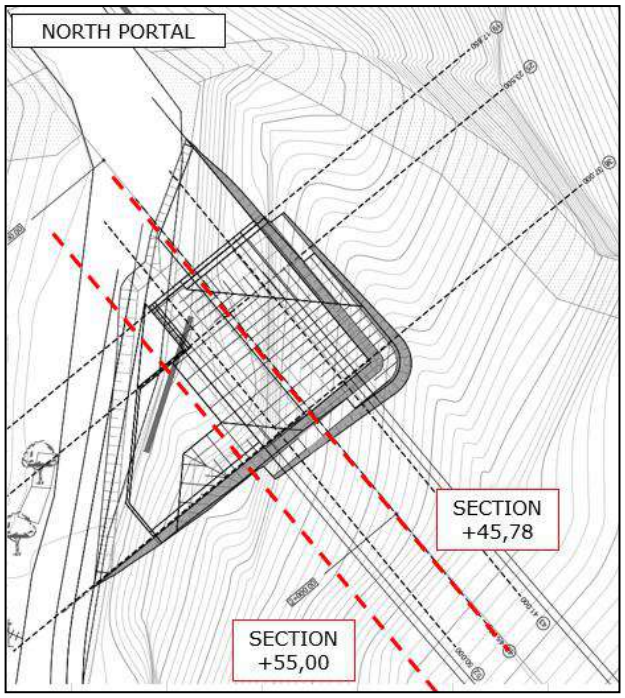


Figure 39 - Keyplan North Portal

Sections have been design according to UNI EN 1997 through Design Approach 1, considering both static and seismic load case. Refer to "Tunnel Calculation Report" for further details.

- Section +45.78, H excavation = 23m

  - ✓ Rockboltsdiam. 32mm, L=15m, spacing 2.0m(horiz) x 2.0m(vert.)
  - ✓ Rockboltsdiam. 43mm, L=15m, spacing 2.0m(horiz) x 2.0m(vert.)
  - ✓ Pre-tensioned anchorage; n strand =5, Ai =140mm^2, L free length= 10m, L grouted length= 10m, spacing 2.0m(horiz.), P0 =360kN
  - ✓ Shotcrete reinforced with wire steel mesh, th. 200mm, Φ12/14, mesh (150x150)mm

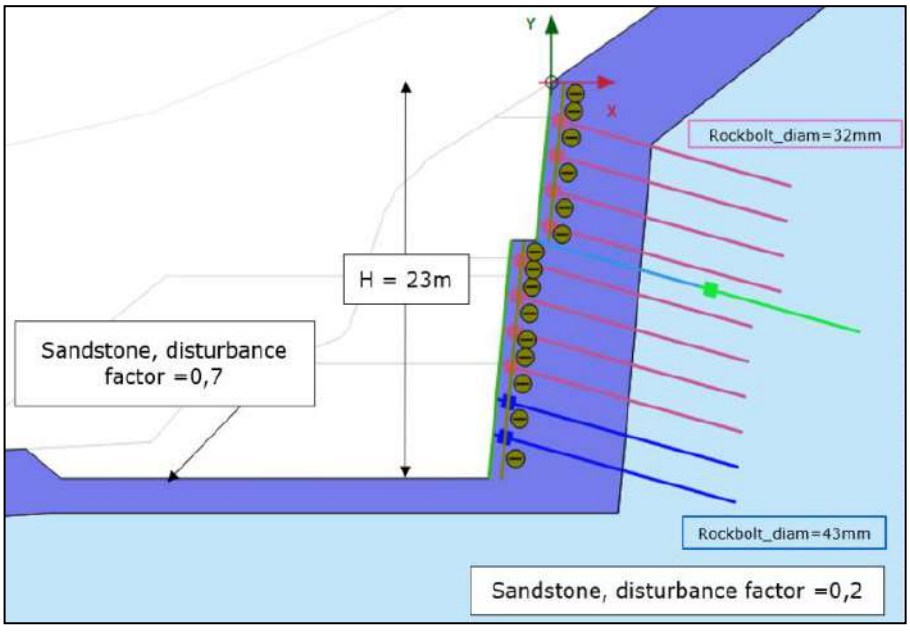


Figure 40 - Plaxis 2D Model Layout - North Section +45.78

- Section +55.00, H excavation = 20m

  - ✓ Rockboltsdiam. 32mm, L=15m, spacing 2.0m(horiz) x 2.0m(vert.)
  - ✓ Rockboltsdiam. 43mm, L=15m, spacing 2.0m(horiz) x 2.0m(vert.)
  - ✓ Pre-tensioned anchorage; n strand =5, Ai =140mm^2, L free length= 10m, L grouted length= 10m, spacing 2.0m(horiz.), P0 =360kN
  - ✓ Shotcrete reinforced with wire steel mesh, th. 200mm, Φ12/14, mesh (150x150)mm

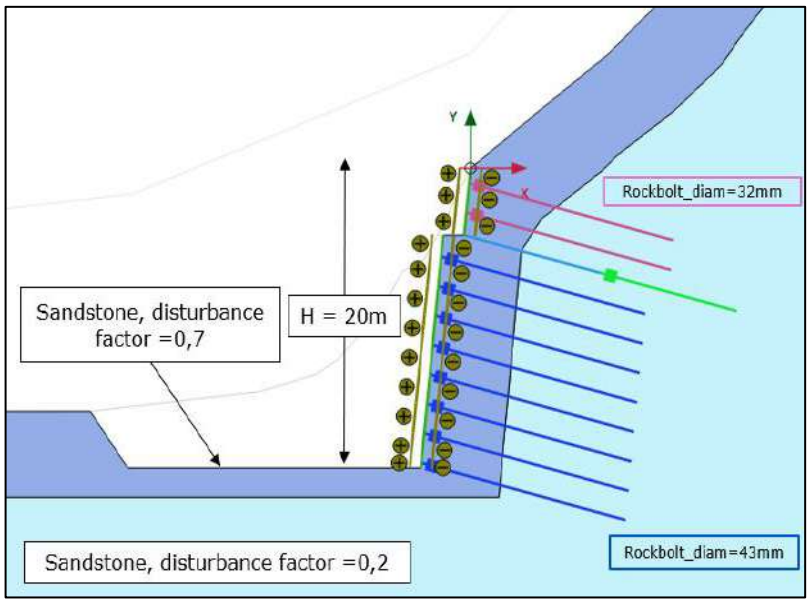


Figure 41 - Plaxis 2D Model Layout - North Section +55.00

4.1.3 South portal excavation

Main relevant sections, highlighted in the key plan below, have been considered for the design of the south portal excavation:

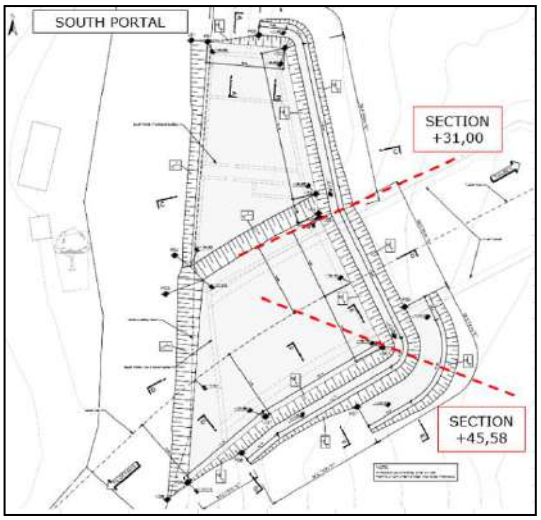


Figure 42 - Keyplan South Portal

Sections have been designed according to UNI EN 1997 through Design Approach 1, considering both static and seismic load case. Refer to "Tunnel Calculation Report" for further details.

- Section +45.58, H excavation = 35m
  - ✓ Rockboltsdiam. 32mm, L=15m, spacing 2.0m(horiz) x 2.0m(vert.)
  - ✓ Rockboltsdiam. 43mm, L=15m, spacing 2.0m(horiz) x 2.0m(vert.)
  - ✓ Pre-tensioned anchorage; n strand =5, Ai =140mm^2, L free length= 10m, L grouted length= 10m, spacing 2.0m(horiz.), P0 =360kN
  - ✓ Shotcrete reinforced with wire steel mesh, th. 200mm, Φ12, mesh (150x150)mm

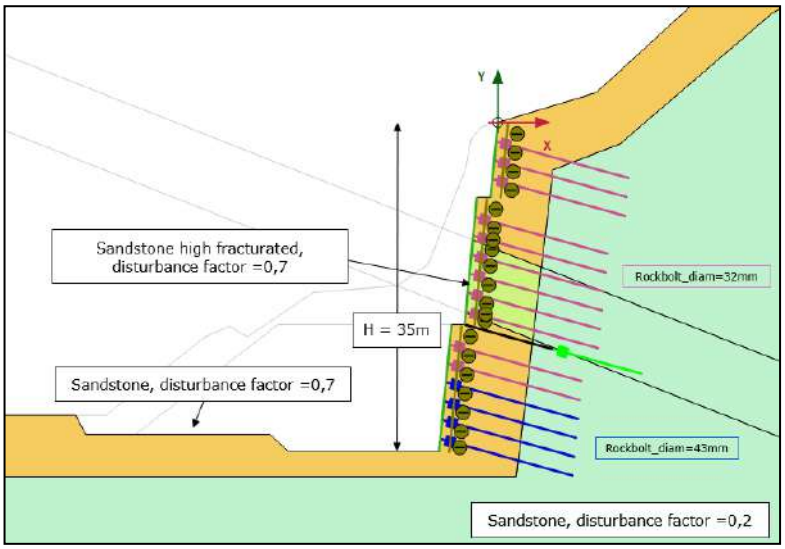


Figure 43 - Plaxis 2D - Model Layout - South Section +45.58

- Section +31.00, H excavation = 25m
  - ✓ Rockboltsdiam. 32mm, L=15m, spacing 2.0m(horiz) x 2.0m(vert.)
  - ✓ Pre-tensioned anchorage; n strand =5, Ai =140mm^2, L free length= 10m, L grouted length= 10m, spacing 2.0m(horiz.), P0 =360kN
  - ✓ Shotcrete reinforced with wire steel mesh, th. 200mm, Φ12, mesh (150x150)mm

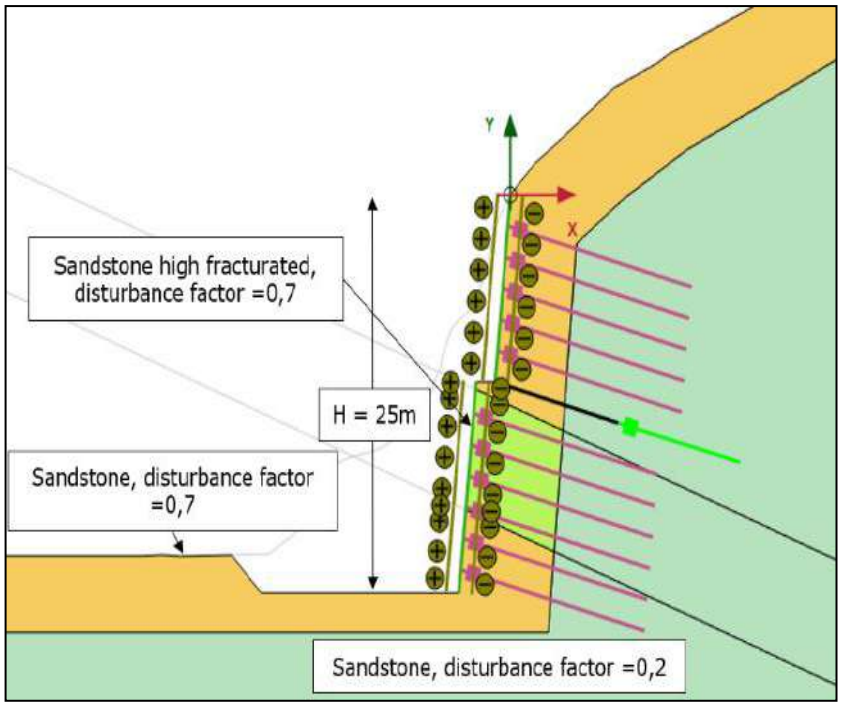


Figure 44 - Plaxis 2D - Model Layout - South Section +31.00

4.1.4 Excavationdetails

In the following figures, details related the permanent grouted rockbolts and to the pre-stressed anchors adopted for the stabilization of the excvations at the north and south portals are reported.

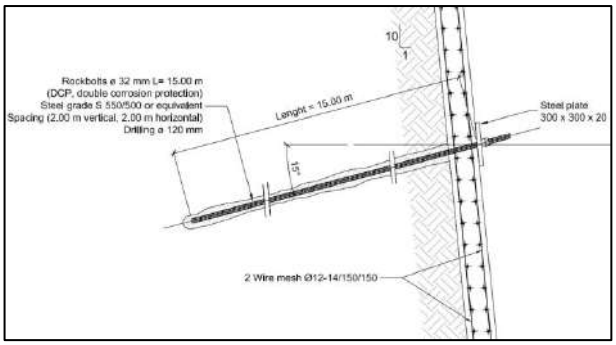


Figure 45 - Rockbolt Detail

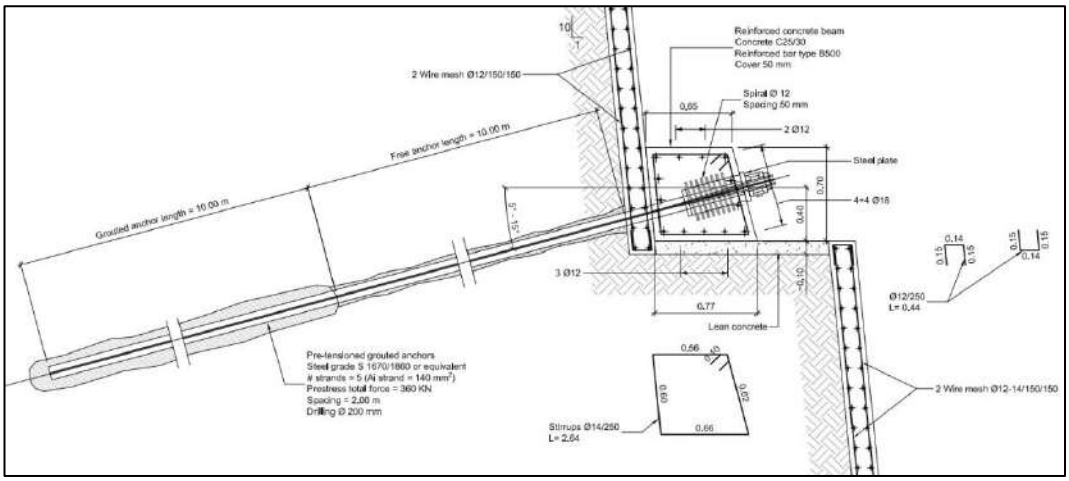


Figure 46 - Anchorage Detail

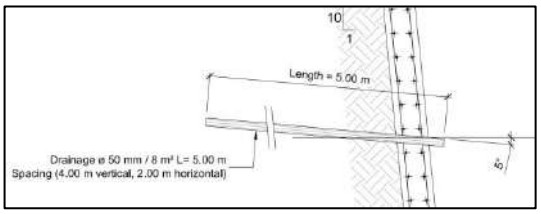


Figure 47 - Drainage Detail

4.1.5 Onsite tests

Field pull-out testing of nails shall be conducted to verify that the nail design loads can be carried without excessive movements and with an adequate safety factor for the service life of the structure, and to verify the adequacy of the contractor's drilling, installation, and grouting operations prior to and during construction of nails.

A representative sample of all rock bolts has to be subjected to acceptance tests, according to UNI EN 1997-1:

- Total number of rock bolts for each portal= 500
- Total number of rock bolts to be tested for each portal= 10

Test locations have to be chosen in order to guarantee an adequate sampling of rock condition in the project area.

In order to verify the design bond resistance value (q_S) , a pull-out test is prescribed to be executed to rock bolts sample of 5m length (3m bond length).

Considering a q_S base value for fractured rocks equal to 500 kPa, the diameter of the bar to be tested has been dimensioned limiting FS=1.25.

Test load:

P0 = 500kPa x 0.12m x ∏ x 3m = **565 kN**

Drlling diameter = 0.12m

Bond length = 3m

Bond resistance = 500 kPa

Bar diameter

D = √(4A / ∏) = 42.4 mm = **43mm**

A = 565000 N / 400 MPa = 1412.5 mm^2

fyk = 500 MPa /1.25= 400 MPa

The extraction of the bar at reaching the full load test, guarantees a respect of partial factor on materials as the qs value used in the modelling has been choose equal to 300KPa.

Once the pull-out test on rockbolts have been finalized, procedure for anchor tests has to be detailed based on results reached, considering 3 anchor samples for each tunnel portal, according to "*UNI EN ISO 22477-5:2018 - Geotechnical investigation and testing - Testing of geotechnical structures - Part 5: Testing of grouted anchors".*

Following completion of all on-site proving test the results should be available from the anchorage contractor in the form of a report before any working anchorage is installed.

4.1.6 Monitoring Plan

Failure of an anchorage may take three forms, namely breakage, relaxation of pre-stress or overtensioning above the design figure. The effect of each on the structure should be considered

Breakages will generally be due to corrosion or accidental mechanical damage and may occur at any point between the end of the fixed anchor and the anchor head.

Relaxation of tension may be due to several causes: the breakage of some of the wires in a tendon, movement of the fixed anchor or compression of the ground between the fixed anchor and the anchor head due to stress change.

Over tensioning may occur through the movement within rock formations or excavations.

Monitoring procedures should be designed to pinpoint the mode of failure and to determine the cause. It's recommended as the behaviour of anchorages (5% of working anchorages) can be safely by monitoring the behaviour of the structure as whole (by precision surveying of movements or by measurement of stress levels within the structure). In addition the malfunctioning of anchorages could endanger the structure and cause it to become an hazard to life.

As the anchorage will be part of a temporary work, rock bolts has to be monitored on design life base by installed monitoring sight:

- 6 topographical monitoring sections will be selected as the most representative for each portal area.
- 2 mini prisms, fixed to the shotcrete, will be place on each excavation height between berms.

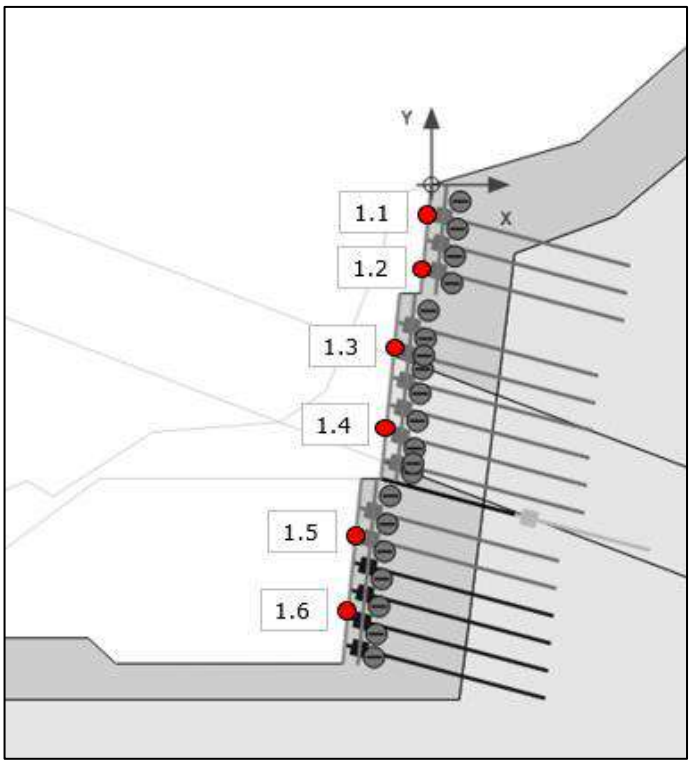


Figure 48 –Example of monitoring section

For detection of ground movements, procedure should be designed to record the pattern of the movements and should continue until they become negligible. In general test should initially be at short intervals of 3 months to 6 months, with later test at longer intervals depending on results.

4.2 Cut & Cover tunnel sections

At the portals, cut & cover sections of the tunnel will be executed after excavation of the portal trenches.

Each C&C section will be about 20 m long and the concrete lining will have a minimum concrete thickness equal to 70 cm. Waterproofing of the lining is described in chapter 3.8.1.

On one side, the C&C sections will be cast directly against the technical buildings.

The filling of the C&C sections, up to a maximum overburden of 9 m over the tunnel vault's key, will be provided by means of a suitable filling granular material, set stratum by stratum (max 50 cm) and compacted (minimum compaction modulus Me > 40 MN/m^2). Before starting filling above the tunnel, the adjacent building shall be finished, as it is part of the lateral supporting system of the tunnel.

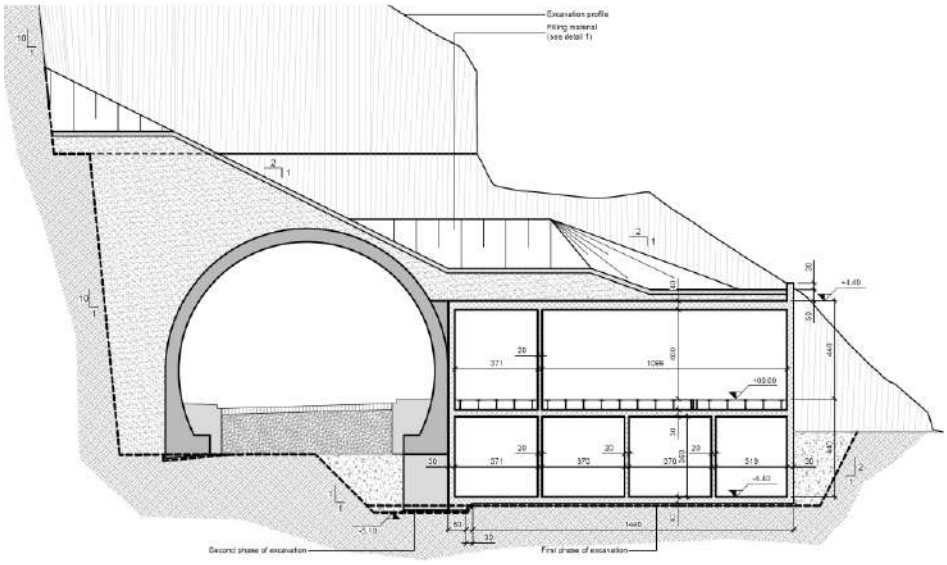


Figure 49: Cut & Cover section and interface with the technical building north

4.3 Technical buildings

At both the north and the south portal, technical buildings are necessary to accommodate operating and safety equipment, as well as maintenance rooms and living spaces for the tunnel personnel.

The filling of the technical buildings, with a minimum overburden equal to 50 cm will be provided by means of a suitable filling granular material, set stratum by stratum (max 50 cm) and compacted (minimum compaction modulus Me > 40 MN/m^2).

The Contractor is responsible for the design and dimensioning of the heating, ventilation and air conditioning plant of the buildings, according to the functional layout described below and relevant Nepalese laws. Moreover he is responsible for the design of all holes, cable shafts, pipe crossings, sanitary fitting, furnishing, fire emergency and extinguishing devices (according to Nepalese standards), lighting etc.

Additional requirements can be found in the E&M technical report.

4.3.1 Technical building south

The technical building at the south portal will accommodate the following rooms and equipment as a minimum requirement (additional details can be found in the E&M technical report):

- Ground floor

- Medium voltageroom (MVR), min. 35 m^2
  - direct access from the outside;
  - separation wall between MVR and other spaces;
  - reinforced concrete floor and crawl space for cables;
  - electrical pipelines connection to an external cable pit, outside the building, for electrical pipelines coming from the tunnel;
  - connection to an external cable pit, outside the building, for medium voltage cable lines (see E&M technical report).
- Low voltage room (LVR) , min. 65 m^2

- direct access from the outside;
- floating technical floor, min. height 50 cm, load capacity ≥15 kN/m^2 (other requirements according to ASTRA guidelines 23 001-11870);
- connection to an external cable pit, outside the building.

- Garage/Storage/Workshop, min. 100 m^2
  - direct access from the outside of a maintenance vehicle*;
  - water supply pointinside the room;
  - water supply point outside the room (outside the building);

  * a suitable space to park the maintenance vehicle directly outside the building must be reserved and fenced.
- Main entrance and stairs.
- Expected minimum heating development by electrical equipment 70 kW.

- First floor

- Electromechanical room, min. 70 m^2
  - trap door on the floor 1.5 m x 1.5 m;
  - 1 ton hoist for technical equipment lifting.
- HVAC (heating, ventilation and air conditioning) room, min. 30 m^2.
- Living spaces for tunnel personnel
  - Kitchen and dining room, min. 20 m^2.
  - Office, min. 20 m^2.
  - Meeting room, min. 15 m^2.
  - Control room, min. 35 m^2.
  - WC room, min. 9 m^2.
  - Corridor and stairs.

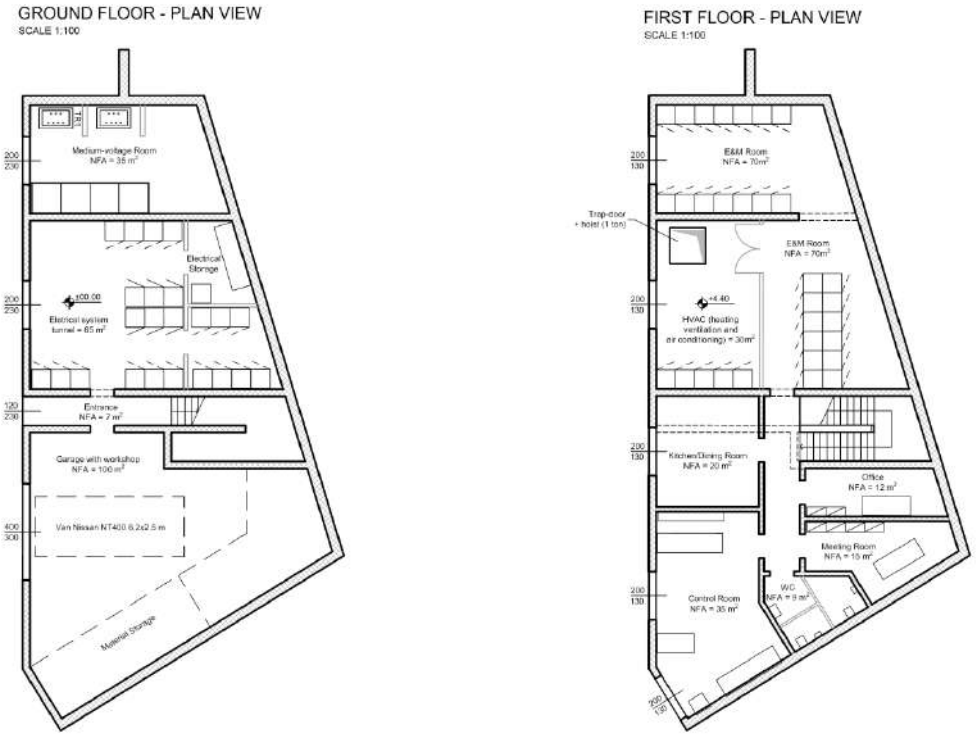


Figure 50: Technical building south, functional layout

4.3.2 Technical building north

The technical building at the south portal will accommodate the following rooms and equipment as a minimum requirement (additional details can be found in the E&M technical report):

- Ground floor

- Medium voltageroom (MVR), min. 35 m^2
  - direct access from the outside;
  - separation wall between MVR and other spaces;
  - reinforced concrete floor and crawl space for cables;

- 2x HDPE DN 120 electrical pipes connection to the cable shaft in the tunnel walkway adjacent to the building.

- Low voltage room (LVR) , min. 50 m^2
  - floating technical floor, min. height 50 cm, load capacity ≥15 kN/m^2 (other requirements according to ASTRA guidelines 23 001-11870);
  - 10x HDPE DN 120 electrical pipes connection to the cable shaft in the tunnel walkway adjacent to the building.
- Electrical storage room, min. 10 m^2.
- Warehouse, min. 15 m^2.
- Main entrance and trap door on the floor, including steel ladder to access underground floor and 1 ton hoist for technical equipment lifting.
- HVAC (heating, ventilation and air conditioning) room, min. 20 m^2.
- Expected minimum heating development by electrical equipment 45 kW.

- Underground floor

- Water supply reservoir
  - Pump room to accommodate 5x min. 20 l/s (min. power 22 kW) pumps, working in parallel and min. 2x 10.4 l/s (min. power 12 kW) alternating pumps.
  - 6x 50 m^3 water tanks with wall openings for inspection (80x60 cm), located at a distance of 20 cm from the ceiling.

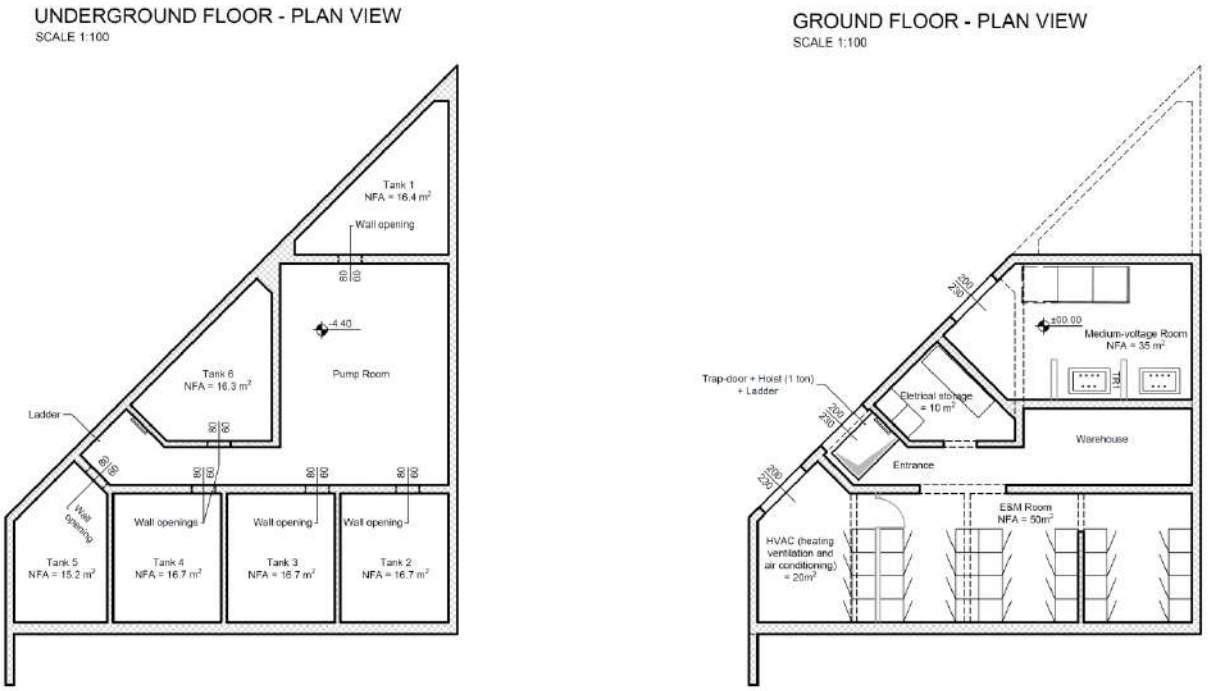


Figure 51: Technical building north, functional layout

4.4 Bypass portals

4.4.1 Excavation

The bypass portals will be executed by means of a limited excavation of the natural rocky slope along the existing road. Before excavation begins, preliminary safety measures shall be provided by means of shotcrete and cemented anchors on the surrounding rock of the bypass excavation contour. The following phases describe the construction sequence and technical requirements:

- Phase 0 – Scaling of unstable stones at least 5 m above the bypass excavation contour;

- Phase 1 – Preliminarysafetymeasures

- Safety measures shall be provided on a slope surface measuring at least 5 m above and on each side of the bypass excavation contour;

- Execution of a 15 cm C25/30 shotcrete layer (0/8 mm aggregates), reinforced with a steel wire mesh (steel grade B500 A or similar) ϕ 5mm/10x10 cm;
- Cemented rock bolts (Gewi 20 mm or similar, B500 B steel grade), with a 2 x 2 m pattern, 4/5 m long, having a drilling diameter > 100 mm.

- Phase 2 – Bypass class 3 sub-horizontal forepoles execution (first forepoles umbrella).

- Phase 3 – Bypass excavation and supports according to the foreseen tunnel support classes and their distribution along the bypass axis.

4.4.2 Connection to rockshed structure

After waterproofing and casting of the inner lining of the bypass, the connection to the rockshed will be provided by casting a box shape concrete structure, having a minimum thickness of 60 cm.

Waterproofing layers of rockshed and bypass shall be welded together.

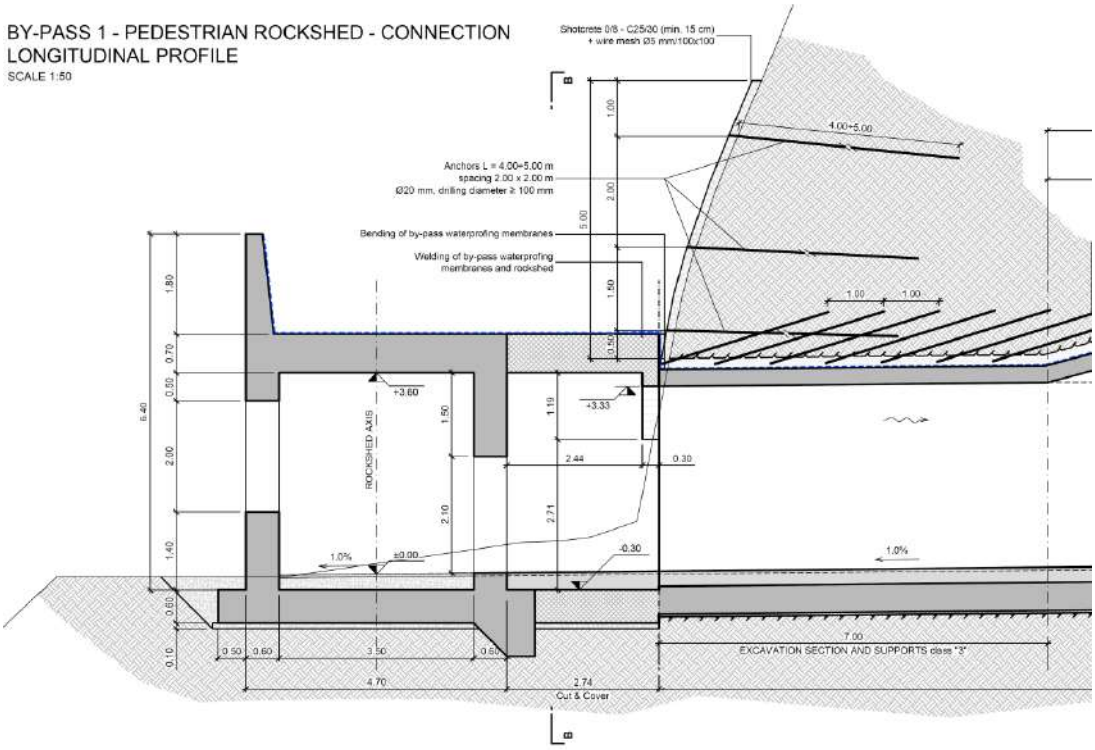


Figure 52: Typical bypass portal and connection to rockshed

ANNEX C: EXPLOITATION AND SAFETY EQUIPMENT - TECHNICAL REPORT AND DESIGN BASIS

Project Specific Section

ROCKFALL PROTECTION ALONG SIDDHABABA SECTION OF SIDDHARTHA HIGHWAY
Ch. 28+200 km – Ch. 30+600 km

Table of contents

1 Tunnel data

The 1130 m long Siddhababa Tunnel is located on the H10 road at the foothills of the Himalaya about 30 km north of the Nepali-Indian boarder. It lies in a valley with an approximate north-south orientation and is planned to bypass an area prone to landslides.

The tunnel opening is forecasted for 2023 (design year).

The tunnel:

• will be operated with bidirectional traffic with one lane in each direction,

• is 1’130 m long,

• rises from the southern portal to the northern portal with about 35 m,

• provides 3 bypass tunnels (escape tunnels) towards a parallel road

• is located approx. 210 m above sea level.

The lengths of the bypass tunnels are about 155 m, 129 m and 125 m.

Emergency exits inside the tunnel are provided every 300 m, which means that an emergency exit is 245 m from the southern portal and another 285 m from the northern portal.

The Siddhababa tunnel has to be designed for forecasted traffic for the following years:

− Design year (i.e. tunnel opening year): 2023

− Design year + 20 years: 2043

It was informed by the Customer that the yearly traffic increase of 7% is not to be applied to this project.

According to traffic counts, following data was provided by the Customer:

− Average Annual Daily Traffic (AADT) for both traffic directions: 12’444

− Thereof:

Heavy goods vehicles (trucks, busses, utility vehicles, tractor): 1’474

Passenger cars (car/taxi/motorised three, rickshaw, bullock): 1’886

Motor cycles: 9’084

2 Framework conditions and assumptions of the designer

1) In this project the use of Swiss standards and directives of the Swiss Federal road administration (FEDRO) has been assumed concerning the characteristics of the tunnel facilities in relation to safety and operation.

   In the executive project, in the fabrication of the systems as well as in their installation and commissioning, the general contractor must refer, in order: to the Nepalese laws, to Nepalese and international standards, to directives (Richtlinie) and technical specifications (technische Merkblätter) of the Swiss Federal Road Administration (FEDRO).

2) For electrical installations of buildings, as for low voltage electrical distribution, a generic solution has been defined; in the executive phase the general contractor will have to consider the application of the Nepalese regulations, where present, in this specific field.

3) The project contains the description of the technical solution to be implemented regarding the operating and safety systems; the detail-degree of the description has been harmonized with the project phase and with the procedural situation (choice of a general contractor), therefore no details are provided where it is not considered essential for the outcome of the works. It was therefore assumed that the executive details will be defined with the general contractor, by the client or by a representative of the same, during the execution phase of the project.

4) The installations are designed to be serviced at least once a year by specialized personnel (of the client, of the future manager of the tunnel or of the general contractor). The correct maintenance frequency however depends on the characteristics of the individual installation and will be defined by the supplier (general contractor).

   The operation of the installations is strictly related to a correct and exhaustive periodic maintenance; the lack of adequate maintenance affects the operation of the plants and, ultimately, the safety of tunnel users.

5) The project assumes that tunnel users comply with traffic regulations, such as compliance with speed limits and signage and in particular compliance with the overtaking and stop prohibitions in tunnel. Likewise, the systems have not been designed to withstand shock or impact forces caused by loads projecting beyond the permitted vehicle-shape in tunnel.

6) The systems designed ensure automatic routines to guarantee the safety of the tunnel users. Nevertheless, the project assumes that the gallery is monitored and managed continuously (7 days a week, 24 hours a day) by at least two operators in the control room in the technical building at the south portal of the tunnel. In fact, in case of an event such as a fire in tunnel, only operators present on site and trained, can ensure adequate treatment of emergencies. It has been assumed that these operators will interface with the rescue services, such as the police, firefighters and rescuers, for the operational management of the events.

7) The project assumes that a regulation will be created by the tunnel manager that specifies the minimum operating conditions of the plants under which the tunnel can remain open and therefore, consequently, in correspondence with which plant faults the tunnel must be closed. Operation of the tunnel in the absence of adequate operating conditions of the plants (eg lack of ventilation, lack of fire detection, lack of electricity supply, and similar) exposes users to risk, can favour the occurrence of accidents and prevents the possibility of saving users.

8) The project for the signage system (arrangement of traffic signs, their images, distances, etc.) must be submitted by the client to the competent Nepalese authorities (ministries, police, etc.) for examination and approval before the tunnel is put into operation. In order to avoid late modifications, it would be desirable to obtain this approval before the procurement phase or, at the latest, before the start of the manufacture of the signs and their installation. Without the approval of the signage by the competent authorities, the tunnel shall not be put into service.

9) In the rest of the document indications will be provided on the constitution of the individual elements of the exploitation and safety systems and their housing. However, a general principle is given here, which also applies where details are not provided in this document: all the elements forming the exploitation and safety systems must be installed in cabinets or enclosures that allow protection against rain, dust,

humidity, solar radiation, aggressive atmosphere, etc. Exceptions to this principle are the elements which, due to the function they perform, must be in direct contact with the field (traffic signs, sensors, cables, lamps, etc.).

10) As for the tunnel ventilation, the project contains a mere dimensioning of jet-fans and sensors. It is task of the contractor to define, in the final design phase of the system, the functioning (algorithms) of the ventilation in the normal case (sanitary ventilation) and in the event of a fire (operation of the system in the various fire scenarios in the tunnel). The definition of these algorithms is essential for the safety of tunnel users in the event of a fire.

    Once the ventilation system has been defined and installed, the Customer (or the contractor) must provide for real operational tests, even simulating the event of a fire, involving the emergency services such as fire brigades, police, rescuers, etc.

11) Since it is not possible to have redundant medium voltage power supply, that is coming from two different networks, the loss of this power entails the immediate inability of the tunnel due to the lack of ventilation in case of fire. For this reason, uninterruptable power supplies with batteries have been foreseen to guarantee one hour of operation of the systems (excluding ventilation). This time lapse serves to close the tunnel, which cannot remain open in case of lack of ventilation.

12) In the event of a fire, the tunnel is closed and the traffic piles-up along the road leading to it. Part of the traffic could attempt to reverse using lay-bys along the road. All these conditions make it difficult for rescuers to access the tunnel.

    For this reason, the client will have to check with the emergency services (police, fire brigade) the conditions of viability of the access road, and the related times, in correspondence with the closure of the tunnel in case of fire. If the arrival times of the rescuers are not compatible with the rescue of persons in the tunnel, rescue stations closest to the tunnel should be provided.

    It is also advisable to provide landing places for rescue helicopters at the tunnel portals.

13) Due to the high power-requirement, no reserves were included in the calculation. In the execution phase, and in the phase of agreements with the electricity supplier, the client must evaluate, and have included in the project, the largest possible reserve power margin (desired 30%) compatible with the conditions of the network and the supply.

14) The cellular telephone system is not part of the installations covered by this project. It is in fact to be considered as an extension of the systems of the mobile telephony signal provider, and must be designed, supplied, installed and maintained by him.

    Nevertheless, in view of the importance of such a system both for the users of the tunnel and for the rescue forces, a separate room is provided for the installation of the necessary equipment. The external antennas for the collection of the external signal and the internal antennas for the broadcasting of the signal in tunnel and buildings will be installed by the provider of the mobile telephony.

    This equipment will be powered by the low voltage distribution of the tunnel in the technical rooms, through a connection to reserve switches. Electricity consumption, as well as the space used, should be the subject of a specific agreement between the tunnel owner and the mobile phone provider.

    The mobile phone signal broadcasting system is of great importance for the safety of tunnel users. However, it is also very important during the excavation and construction phases of the tunnel; therefore, it is recommended to start early with the stipulation of agreements with the mobile telephony provider, to ensure good coverage already from the early stages of work.

15) The radio signal transmission system in the tunnel is also an important means of communication for rescuers in the event of an incident, and for maintenance personnel in the performance of their routine duties. The frequencies used in Switzerland were taken into account in the planning.

    Before commissioning, they must be checked with the emergency services (fire brigade, ambulance, police, etc.) and adapted to the frequencies used in Nepal.

16) The closure of the tunnel in case of danger (accident, fire) is a critical event and must be well understood by road users.

    In Nepal Road Standard 2070, no indication was found of the transition times for traffic lights (changeover to red, stop of the traffic-flow). Therefore, two transition tables corresponding to Swiss

regulations were suggested. It is imperative for the implementation phase that the general-contractor checks again with the competent authorities what the image transitions (switching from off/green to red and vice versa) of the traffic lights should be in order for the tunnel closure event to be clearly and unmistakably understood by road users.

17) A **60-month maintenance and warranty period** provided by the plant supplier was included in the costs estimate. In fact, experience shows that, given the complexity of the systems, a similar duration allows to eliminate defects left hidden at the time of testing.

18) Because of the complexity of the plants, it is strongly recommended that the client defines a group of people already by the project phase, who will then join the general contractor in the executive phase. These people will be the future managers and maintenance people of the plants of the tunnel, and the future control room operators. In this way it will be possible to ensure the transmission of know-how concerning the plants and their operation.

3 General concepts and requirements

3.1 Directives and norms considered

Main directives partially considered in the design of the operating and safety systems are the directives of the Swiss Federal road administration[1] (FEDRO):

- FEDRO 13001 Lüftung der Strassentunnel (2008 V2.03)
- FEDRO 13002 Lüftung der Sicherheitsstollen von Strassentunneln (2008 V1.06)
- FEDRO 13004 Branddetektion in Strassentunneln (2007 V2.10)
- FEDRO 13005 Videoanlagen (2012 V1.01)
- FEDRO 13006 Funksysteme in Strassentunneln (2018 V5.00)
- FEDRO 13010 Signalisation der Sicherheitseinrichtungen in Strassentunneln (2011 V2.06)
- FEDRO 13011 Türen und Tore in Strassentunneln (2009 V1.05)
- FEDRO 13015 Beleuchtungsanlagen (2017 V1.11)

The body of technical prescriptions[2] of FEDRO was also considered, even partially in this case.

3.2 Technical and market factors

Operational safety and product quality:

- Choice of devices that guarantee the longest possible service life;
- Additional measures to enable maintenance to be carried out quickly and safely;
- Execution of installations that allow fire resistance where necessary and no-flame propagation, reduced emission of smoke free from corrosive gases.

Uniformity of solutions:

- Simplify and reduce the variety of spare equipment and materials in order to reduce maintenance costs.

Known technologies:

- Use of equipment, control systems and installation technologies, known and already applied with success in other similar projects
- The equipment must be easily replaceable with same or with similar and compatible

products. Availability of spare parts:

- As general rule, chosen products must guarantee the availability of spare parts for a period of at least 10 years.

Presence in Nepal:

- It should be preferred the choice of products with representation (integrators, suppliers, service centres, etc.) in Nepal, if present.

3.3 Choice of materials

As a rule, all the materials chosen must be suitable for the place of installation foreseen for them, especially for the equipment installed in the tunnel (corrosive atmosphere, presence of pollutants).

In the rest of the document specific indications will be given for particular cases.

[1] https://www.astra.admin.ch/astra/de/home/fachleute/dokumente-nationalstrassen/standards/betriebs-sicherheitsausruestungen.html

[2] https://www.astra.admin.ch/astra/de/home/fachleute/dokumente-nationalstrassen/fachdokumente/fachunterstuetzung/fachhandbuch-betriebs-sicherheitsausruestungen.html

3.4 Risk assessment

List of risks related to the project (delays, installation difficulties, etc.).

For each risk, an evaluation is attributed as a product between the probability of its occurrence (from 1 = low to 3 = high) and the size of the damage related to its occurrence (from 1 = low to 3 = high). Where possible, the measures to be taken to address the risk and the responsibilities for them are indicated.

Risk	Probability P	Impact I	Value P x I	Measure	Responsibility (risk owner)
Costs and delays due to project changes while work in progress	2	2	4	Clear definition of functional requirements. Continuous evaluation of ongoing works.	Designer. Direction of works representative of the client.
Budget overrun	1	3	3	Constant cost control	Direction of works representative of the client.
Poor quality of work due to pressure on deadlines (construction duration)	1	3	3	Introduction of contingencies in time estimates. Precise planning of the construction phases.	Designer. Direction of works representative of the client; General contractor
Plants not working as expected after commissioning.	1	3	3	Continuous control of installations during construction phases.	Direction of works representative of the client.

Table 1: Risk assessment

3.5 Environmental conditions

In the technical rooms the temperature is controlled by the HVAC system and no special precautions are required.

For open-air and tunnel installations, a temperature range of 0 ° C to 50 ° C must be considered, with the possibility of condensation forming.

In the case of equipment installed in open-air cabinets, the place of installation must be carefully considered: in the presence of particularly strong exposure to the sun, measures such as forced ventilation and the installation of tropical roofs must be taken.

All the components chosen must be suitable for the place of installation and guarantee a life expectancy, in the installation conditions, of more than 25 years.

3.6 Coding system

A code and labelling system must be adopted that shows the code of every element that must be maintained or that can be a source of data (alarm, measurement, video, voice) or recipient of data (commands).

The system must be based on these principles:

- all the cables must have, on their two ends, a label that identifies the plant they belong to, the point where the end of the label is located and where the other end is installed
- all the elements installed outside of the cabinets must be codified with a code that shows the place of installation, the plant to which it belongs and the identifier of the element itself
- all the elements installed inside cabinets must be labelled according to the identifier that has the same element in the wiring diagrams of the cabinet

- all the visualizations of an element at the level of the tunnel control system (element view, alarm line, etc.) must show the coding of the element itself.

This coding system is necessary to facilitate the understanding of the origin of an alarm or fault and allow a quick treatment of the same by the maintenance staff.

4 Description of the planned measures

4.1 Energy supply

4.1.1 Medium voltage supply

The project starts from the assumption, confirmed by the client, of being able to have a medium voltage power supply (11 kV) by the tunnel portals in the technical buildings (in separate rooms, exclusively reserved for medium voltage).

The medium voltage will be taken from the electricity company to the technical room at the south portal of the tunnel; here it will be transformed into low voltage. Furthermore, starting from this technical room, the electric company will also carry the medium voltage to the technical room at the north portal of the tunnel, using a medium voltage cable laid inside the tunnel in a special duct reserved for it. At the northern location its transformation into low voltage will take place.

The power supply is guaranteed by the local electricity company by connection to the 11 KV transmission line from Hotel Avenue, near Butwal-Palpa area.

Once the requirements of the electricity company are defined, civil works can be evaluated in this project to create an underground conduit where cables can be pulled by the electricity supplier from the last pylon of the medium voltage supply line to the well outside the technical building by the south portal of the tunnel. The division of costs and responsibilities for these works requires an agreement between the client and the electricity supply company.

It is so assumed in the present project that the electricity supply company makes available, in separate rooms in the buildings at the tunnel portals, the power required for the medium voltage tunnel inside specific supply cabinets with the related switches and transformers from medium voltage to low voltage 400 V.

The interface, and supply boundary, is in this way located at the low voltage terminals of the transformers (from the low voltage terminal onwards starts the scope of the present project; medium voltage cables and transformers are excluded from the scope of this project). The costs for the construction of the medium voltage distribution plant are not considered in this project.

This type of interface is foreseen to guarantee the standardization and compatibility of the elements (switches, transformers and cables) installed with those provided by the electricity supplier.

The electrical power of the plants will be supplied by the local electricity company and will be delivered in low voltage at 400V-50Hz for a maximum committed power of 755 kW.

Considering also that the electrical company clearly states that the supply cannot be guaranteed in case of failure of the national network and that there is no redundancy of power supply, the tunnel must be closed for safety reasons during the blackout. The tunnel installations will be designed in such a way as to be energy self-sufficient for enough time (starting from the blackout) to close and empty the tunnel (UPS, uninterruptable power supply network).

The contractor, during the detailed design phase, will plan the low voltage power supply system and connections according to Nepalese standards.

The medium-voltage system requires the Electricity Company to make available to the tunnel control system only the status of the main switches of the medium-voltage supply in the technical rooms and the measurements of the energy consumed for statistical as well as for billing purposes.

4.1.2 Low voltage supply

The power supply of the tunnel equipment will be divided between the two technical rooms near the entrances (north and south) in order to reduce the quantity and cross-section of electrical cables passing through the tunnel.

Each power switch shall be equipped with auxiliary contacts to signal the failure of the switch to the control system via relay contacts.

Each switch must be designed in order to guaranty the over-current discrimination in case of a fault in one point of the installation.

All cables in the tunnel will be routed in the cable ducts positioned in the vault and/or in the cable tracks positioned on the sides of the carriageway. In the technical rooms the cables will be housed in cable ducts located under the floor and reach the electrical cabinets from below. The cables shall be dimensioned in accordance with the laws, standards and ordinances on electricity in force in Nepal.

Cables are also dimensioned on the basis of the maximum permissible voltage drop in the line and coordinated with the line protections on the basis of the minimum short-circuit current at the end of the line.

Cables must be halogen-free, without emission of toxic or corrosive gases, with a reduced emission of non-flammable and self-extinguishing fumes.

Cables installed outdoors must be UV resistant, temperature resistant up to the extreme limits of use in the location, and weatherproof.

Cables for the stand-by electrical network distribution (UPS) are provided with a function stand-by network of 180 minutes, while electric cables for the normal network distribution are provided with a function stand-by network of 5 minutes.

4.1.3 Uninterruptible power supply

The 400/230 V - 50 Hz uninterruptible power supply will be composed of static uninterruptible power supplies (UPS) installed in the technical rooms by south and north portals. UPS will be powered by the normal network.

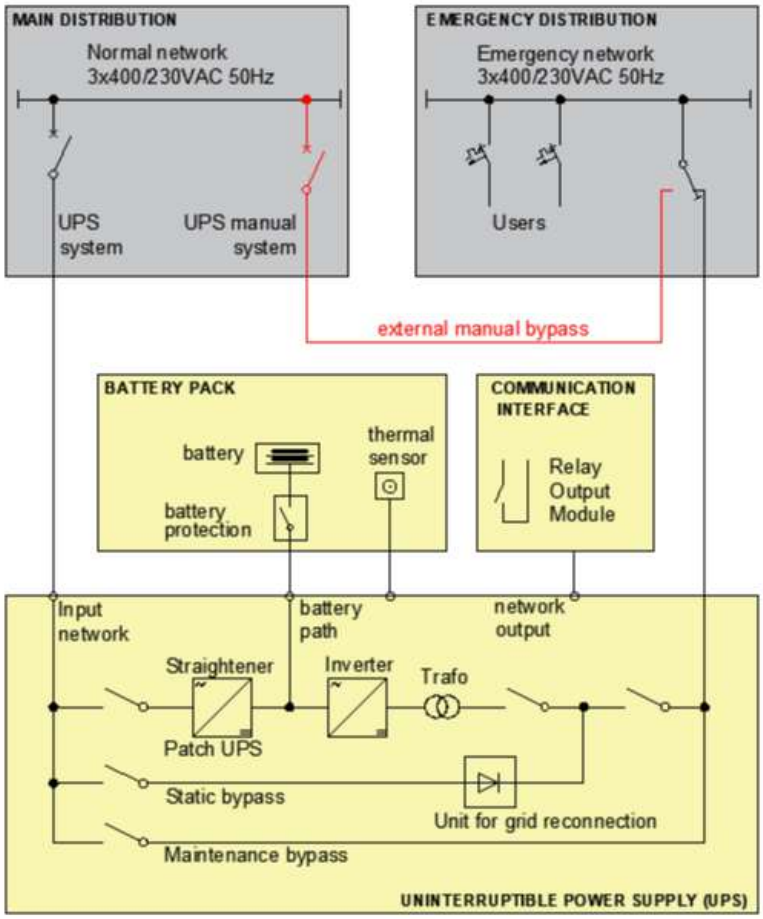
UPS are designed with a set of batteries so that they can power the systems for at least 60 minutes in the event of a loss of normal power. In the event of a normal power failure, the system automatically switches to battery operation.

During UPS maintenance operation, a manual external by-pass will transfer the load from the uninterruptible power supply to the normal power supply.

Supervision of the normal network is via digital network analysers installed in the main cabinets. The supervision of the uninterrupted network is entrusted by the uninterruptible power supply units. All the necessary network parameters shall be transmitted to the tunnel control system via a standard communication protocol.

The uninterruptible power supply will be dimensioned to completely supply the following plants, plus a safety margin of 40%:

- Emergency lighting
- Fire emergency lighting
- Optical guides
- Signage
- Fire detection system
- Radio broadcasting
- Cellular phone network
- Video-surveillance
- Communication network
- Tunnel control system
- Emergency telephone cabinets.



Picture 1: Scheme UPS connections

Picture 2: Batteries and UPS

4.1.4 Estimated electrical powers

The following table shows the electrical powers absorbed from the normal network

Installation	Power input [KW]
Lighting	40
Ventilation	55-530
Signage	1
Tunnel fire detection system	1
Videosurveillance system	3
Communication network	1.5
Tunnel control system	5
Radio diffusion in tunnel	1
Emergency telephone system	0.5
Electrical and lighting system in buildings	12
HVAC system in buildings	10-35
Pumping station	37-125
TOTAL POWER WITHOUT RESERVE	**166 min.** **755 max.**

Table 2: Electrical powers normal network

The low-voltage distribution plant is dimensioned with a coincidence factor of 1.

The following table shows the electrical powers absorbed from the stand-by network

Installation	Power input [KW]
Lighting	10
Signage	1
Tunnel fire detection system	1
Videosurveillance system	3
Communication network	1.5
Tunnel control system	5
Radio diffusion in tunnel	1
Emergency telephone system	0.5
Electrical and lighting system in buildings	3
TOTAL POWER WITHOUT RESERVE	**26**

Table 3: Electrical powers stand-by network

Depending on the loads supplied by the stand-by network, two 40KVA uninterruptible power supply is to be foreseen (one for the north and one for the south technical room). The final dimensioning of the plant will be the responsibility of the contracting company.

4.2 Lighting

4.2.1 General structure of the lighting plant

The lighting system consists of the following sub-systems:

- Crossing lighting: is a band of lamps hung at the vault of the tunnel, with the aim of maintaining the luminance level required inside the tunnel not less than (Nepal Road Standard 2070):
  - 30 lux at night
  - 400-750 lux during day time near the portals and 30 lux at the middle of the tunnel

  The arrangement of the lamps should be so that the carriageway is lit on its entire width (lanes, runway, banquet) and the side walls to a height of 2 m. Above 2 m, no lighting is required except under special circumstances. The cross lighting is installed along the entire length of the tunnel. One lamp in four is connected to the UPS network and provides emergency lighting for 60 minutes in the event of a loss of normal power.

- Reinforcement lighting: these are two bands of lamps, placed by the entrances to the tunnel and having the purpose of connecting the luminance level outside the tunnel with the internal one. A further objective of this subsystem is to avoid the "black hole" effect to motorists entering the tunnel. The length of the tunnel section with the presence of reinforcement lighting depends on the lighting engineering calculations which must be performed by the contractor. The arrangement of the lamps must be such that they only illuminate the road. The adaptation light is installed at the entrances of the tunnels.

- Fire emergency lighting: a set of lamps placed along the tunnel, with the aim of guiding, in the event of a fire, people fleeing vehicles to emergency exits. Every 50 m an element of emergency lighting is provided on the side of the emergency exits. The lights of the emergency lighting are mounted at a height of approx. 0.5 m above the banquet.

- LED optical guide: the optical guide consists of point-sources. The marking points of the optical guide are attached to the left and right of the road along the banquets in the curb or near the road. The optical guide is installed along the entire length of the tunnel. The markings should be visible from both directions of travel.

- Emergency exit lighting: consists of green side lamps and integrated LED flash lights. This sub-system signals the presence of emergency exits to motorists in the event of an event.

- Escape route (or egress route) lighting: it consists of a band of lamps hanging from the tunnels that lead from the tunnel to the external road.

- Street lighting: it is the lighting outside the gallery, composed of street lamps.

- Lighting by rock-shed: it is the lighting of the street inside the rock-shed.

Picture 4: Example of tunnel lighting equipment

4.2.2 Control system and sensors

The lighting control system is part of the tunnel control system (see chapter 4.6.2).

Only specific functions concerning lighting, which must be carried out in the tunnel control system, are described here.

The tunnel control system must show to the operators the alarms (faults) as well as the status of the lighting system.

The following operating logic is provided for each sub-installation:

Cross-lighting

- light intensity shall be regulated on 4 levels: emergency (25%), night (50%), day (75%), maximum lighting (100%);
- external luminance probes allow the automatic adjustment of the 4 levels;
- day/night change must take place through a threshold value managed with data from the external luminance probes. In the event of a fault of a probe, the day/night change can be managed by means of the other probe. In the event of a fault of two probes, the day/night change can be managed by means of the ephemeris of the tunnel location.

Reinforcement-lighting

- light intensity is regulated on 4 levels
- external luminance probes allow the automatic adjustment of the 4 levels;
- day/night change must take place through a threshold value managed with data from the external luminance probes. In the event of a fault of a probe, the day/night change can be managed by means of the other probe. In the event of a fault of two probes, the day/night change can be managed by means of the ephemeris of the tunnel location.

Fire emergency lighting

- switched off under normal conditions;
- lit in case of fire.

Optical guide

- light intensity is regulated on 3 levels, night (25%), day (75%), event (100%);

Other

- emergency exit light shall be always on;
- light bands and flashes: bands always on, flashes on in case of fire;
- one in four lamps in the escape route lighting are always on.

Luminance probes are powered by the normal network and are installed about 70 m from the respective north and south portals. The exact positioning must be defined by the general contractor based on careful inspections. The luminance measurement of each portal is transmitted to the tunnel control system via an analogue signals or field-bus.

Before the final design of the lighting system by the contractor, the characteristic luminance values must be measured on site at the tunnel portals, on the basis of which to carry out the lighting engineering dimensioning of the system.

4.2.3 Crossing lighting

For the crossing lighting, the use of LED technology is mandatory. This technology is now very widespread in the world, allows to have an excellent light output/power ratio (very low power consumption), has an excellent performance over time and has a very long life-span. The lamps are

fixed to the gallery vault by means of two brackets. Through this system it is possible to modify the position of the lamp on the vertical axis, on the transversal axis and the rotation on the longitudinal axis. Horizontal brackets are also applied to the vertical brackets, allowing the installation of a channel for the laying of power and control cables.

Lamps and power supply

The lamps are divided into four groups: North, North Emergency, South and South Emergency and have a distance between each lamp of about 12m. One lamp every four is connected to the stand-by network. This solution allows these lighting values to be achieved:

lighting	level of brightness
Max	100%
Daytime	75%
Night	50%
Emergency	25%

The dorsal power cable of each group starts from the adjacent central unit and ends in the junction box adjacent to the first lamp, after which there is a cable that connects all the other lamps in the group. For each lamp the phases (F1-F2-F3) will be alternated in order to share the load. The cables will be laid on the cable duct. The junction box terminals is used to supply the lamps. The branch cable is flexible. Each lamp has a single-phase power supply and must provide for its adjustment and control (e.g. using DALI). Cable characteristics

For the normal network, cables with 5-minute isolation must be used, while for the stand-by network, cables with 180-minute isolation and 30-minute functionality must be used. All fire-resistant cables will have "B2ca-s1a, d1, d1, a1" characteristics according to European standard EN 50575 - CPR EU 305/2011.

The general contractor is responsible for checking and laying cables that guarantee the required operation.

Lamp features:

- technology LED;
- a lifespan of at least 80,000 hours;
- bright colour = 4’500K;
- Minimum luminous efficiency: 100lm/W;
- a failure of the illuminating cover must not lead to the replacement of the complete lamp;
- IP65
- corrosion-resistant stainless-steel housing.

The lamps are fixed to the gallery vault by means of two brackets (mounting system). The minimum characteristics:

- bracket with vertical upright with adequate length and with the possibility of fixing brackets for the cable duct and fixing plates at a time. The plates allow the adjustment of the inclination to allow the adaptation to any surface.
- horizontal brackets for fixing the cable duct and in stainless steel;
- each fixing point is protected against self-loosening;
- each mounting system is calculated for a load capacity corresponding to a static load of at least 1kN (100 kg per lamp);
- each mounting system allows easy adaptation to the irregularities and inclination of the supporting surface (reinforced concrete);
- all metal elements are sandblasted;
- for the separation of the different materials, in particular of the supports with the lamps, there are Teflon washers with knurled edges that guarantee electrochemical insulation of different metals, also preventing the lamp from moving;
- the material of all the components, including the bolts, and metal bushings for fixing the supports, must be adequate for installation in tunnel.

Electric power estimation

Power supply from technical room north:

- Lighting circuit F1 = 1.5 KW (cosphi =0.9)

- Lighting circuit F2 = 1.5 KW (cosphi =0.9)
- Lighting circuit F3 = 1.5 KW (cosphi =0.9)

Total = 4.5 KW

Power supply from technical room south:

- Lighting circuit F1 = 1.5 KW (cosphi =0.9)
- Lighting circuit F2 = 1.5 KW (cosphi =0.9)
- Lighting circuit F3 = 1.5 KW (cosphi =0.9)

Total = 4.5 KW

Power supply from technical room north, UPS:

- Lighting circuit F1 = 0.5 KW (cosphi =0.9)
- Lighting circuit F2 = 0.5 KW (cosphi =0.9)
- Lighting circuit F3 = 0.5 KW (cosphi =0.9)

Total = 1.5 KW

Power supply from technical room south, UPS:

- Lighting circuit F1 = 0.5 KW (cosphi =0.9)
- Lighting circuit F2 = 0.5 KW (cosphi =0.9)
- Lighting circuit F3 = 0.5 KW (cosphi =0.9)

Total = 1.5 KW

4.2.4 Reinforcement lighting

The use of LED technology is mandatory for the implementation of reinforcement lighting. This technology is now very widespread in the world, allows to have an excellent light output/power ratio (very low power consumption), has an excellent performance over time and has a very long-life span. The lamps are fixed on the side tunnel walls by means of two brackets. Through this system it is possible to modify the position of the lamp on the vertical axis, on the transversal axis and the rotation on the longitudinal axis.

Lamps and power supply

The lamps are divided into two groups: North and South and have a distance of about 2m between each other. Reinforcement lighting and is provided for about the first 100m from the entrance of the two portals. The precise lenght of the stretch with reinforcement lighting will be defined in the executive design by the contractor based on lighting engineering calculations.

The dorsal power cable of each group starts from the adjacent central unit and ends in the junction box adjacent to the first lamp, after which there is a cable that connects all the other lamps in the group. For each lamp the phases (F1-F2-F3) will be alternated in order to share the load. The cables will be laid on the cable duct. The junction box terminals is used to supply the lamps. The branch cable is flexible. Each lamp has a single-phase power supply and must provide for its adjustment and control (e.g. DALI).

Cable characteristics

For the normal network, cables with 5-minute isolation must be used, while for the stand-by network, cables with 180-minute isolation and 30-minute functionality must be used. All fire-resistant cables will have "B2ca-s1a, d1, d1, a1" characteristics according to European standard EN 50575 - CPR EU 305/2011. The contractor is responsible for checking and laying cables that guarantee the required operation.

Lamp features:

- technology LED;
- lifespan of at least 80,000 hours;
- bright colour = 4’500K;
- minimum luminous efficiency: 100lm/W;
- a failure of the illuminating cover must not lead to the replacement of the complete lamp;
- IP65 protection degree
- corrosion-resistant stainless-steel housing.

The lamps are fixed on the side tunnel walls by means of two brackets (mounting system). The minimum characteristics are:

- bracket with vertical upright with adequate length and with the possibility of fixing brackets for the cable duct and fixing plates at a time. The plates allow the adjustment of the inclination to allow the adaptation to any surface.

- each fixing point is protected against self-loosening;
- each mounting system is calculated for a load capacity corresponding to a static load of at least 1kN (100 kg per lamp);
- each mounting system allows easy adaptation to the irregularities and inclination of the supporting surface (reinforced concrete);
- all metal elements are sandblasted;
- for the separation of the different materials, in particular of the supports with the lamps, there are Teflon washers with knurled edges that guarantee electrochemical insulation, also preventing the lamp from moving;
- the material of all the components, including the bolts, and metal bushings for fixing the supports, must be adequate for installation in tunnel.

- Lighting circuit F1 = 3 KW (cosphi =0.9) ○ Lighting circuit F2 = 3 KW (cosphi =0.9) ○ Lighting circuit F3 = 3 KW (cosphi =0.9)

Total = 9 KW

Power supply from technical room south:

- Lighting circuit F1 = 3 KW (cosphi =0.9) ○ Lighting circuit F2 = 3 KW (cosphi =0.9) ○ Lighting circuit F3 = 3 KW (cosphi =0.9)

Totale = 9 KW

4.2.5 Fire emergency lighting

Emergency lighting is necessary to guide road users in the event of a strong presence of smoke (due to a fire) that significantly reduces visibility. The lamps of the fire emergency lighting are placed on the northbound lane where the emergency exits are provided. The power supply is divided into two groups, one starting from the north technical room and one starting from the south technical room. Each lamp has a junction box (IP65 and E30). From the junction box to the lamp there is a power cable (fire resistant for 180 minutes and having characteristics “B2ca-s1a, d1, a1” according to European standard EN 50575 - CPR EU 305/2011). The branch in the box must be provided by dividing the load over the three phases. Here is an example of fire emergency lighting:

Picture 3: Example of fire emergency lighting

Lamp features:

- LED technology;
- instantaneous power on with 100% power; ○ Luminous flux >1'000 lm;
- a failure of the illuminating cover must not lead to the replacement of the complete lamp;

- pipes (against flame propagation) are to be installed on the side wall from the cable duct to the lamp to protect the connection cable.
- the visible luminous surface must not exceed 50 cm^2; ○ resistant to heat, splashes and dirt;
- lighting bodies are laid every 50 m and at a height of 50 cm from the banquet;
- the material of all the components, including the bolts, and metal bushings for fixing the supports, must be adequate for installation in tunnel.

4.2.6 Optical guide

LED modules will be installed to mark the direction of travel for road users. The installation is planned on both sides of the pavements. For about the first 100m at the entrance to the tunnel in both directions, where the reinforcement lighting is present, the distance between the modules will be 25m, while in the remaining part of the tunnel it will be 50m. Each side of the tunnel must have its own supply line and will be controlled by a control unit installed in the technical room north. The edge of the pavement must be provided with a groove milled to allow the laying of power cables. The milling for the laying of the power cable must be 1cm wide and at least 3cm deep. After laying the cable and connecting it to the modules, a protective sleeve covering the groove must be laid.
Here is an example of LED optical guide:

Picture 4: Example of LED optical guide

Module features:

- LED technology;
- IP68 protection degree;
- Life-span of at least 100,000 hours; ○ bright color = 4'500K;
- luminous intensities ≥ 25 cd and ≤ 100cd (maximum);
- a failure of the illuminating cover shall not lead to the replacement of the complete lamp; ○ driveway resistance 5 tons.

4.2.7 Emergency exits lighting

Two green light bands shall be installed by each emergency exit to mark the entrance to the escape route in the event of fire/emergency. A lamp shall also be installed above the door. The lamps are composed of a vertical green bar on the whole height and 3 flashing LED lamps distributed on each side. The green bars must always remain on; in case of an event the LED lamps on the sides must flash to draw the attention of road users and signal the escape route despite the presence of smoke. The lamps are connected to the UPS network.
Here is an example of standard illumination of an emergency exit:

Picture 5: example of illumination of emergency exits

LED lamp features:

- LED technology;
- life span of at least 80,000 hours; ○ Bright colour = 4'500K;
- A failure of the luminaire shall not lead to the replacement of the complete lamp; ○ IP65 protection degree;
- corrosion-resistant stainless steel-housing;
- pipes (against flame propagation) are to be installed on the side wall from the cable duct to the lamp;
- fire resistant cable and having characteristics “B2ca-s1a, d1, a1” according to European standard EN 50575 - CPR EU 305/2011, cable from the backbone for each luminaire.

Mounting system of the lamp above the exit:

The minimum characteristics are:

- slots for direct wall mounting.
- each fixing point is protected against self-loosening;
- each mounting system is calculated for a load capacity corresponding to a static load of at least 1kN (100 kg per lamp);
- all metal elements are sandblasted;
- for the separation of the different materials, in particular of the supports with the lamps, there are teflon washers with knurled edges that guarantee electrochemical insulation, also preventing the lamp from moving;
- the material of all the components, including the bolts, and metal bushings for fixing the supports, must be adequate for installation in tunnel.

Green bands and LED flashes features:

Lamp features:

- LED technology;
- Service life of at least 80,000 hours; ○ Bright colour = 4'500K;
- A failure of the luminaire shall not result in the replacement of the complete lamp;
- IP65 protection degree;
- corrosion-resistant stainless-steel housing, RAL 6035;
- the middle of the luminous bands is foreseen at 1 m from the sidewalk, vertically mounted; ○ Plexi-glass of the vertical band, opaque and green in colour;

- pipes (against the propagation of the flame) are installed on the side wall from the cable duct to the lighting cover;
- cable deriving from the backbone fire resistant cable and having characteristics “B2ca-s1a, d1, a1” according to European standard EN 50575 - CPR EU 305/2011, for each lamp.

Mounting system and fixing of light bands and flashes:

- slots for direct wall mounting.
- each fixing point is protected against self-loosening;
- each mounting system is calculated for a load capacity corresponding to a static load of at least 1kN (100 kg per lamp);
- all metal elements are sandblasted;
- for the separation of the different materials, in particular of the supports with the lamps, there are Teflon washers with knurled edges that guarantee electrochemical insulation, also preventing the lamp from moving;
- the material of all the components, including the bolts, and metal bushings for fixing the supports, must be adequate for installation in tunnel.

4.2.8 Lighting of escape routes

Escape routes shall be illuminated. The lighting consists of internal lights along the entire length of the escape route and external lights by the entrance and the light bands and flashes at the entrance. Each escape route is provided with a normal power supply line and an emergency (UPS) power supply line. The connection is made from the nearest technical room. For each cable there is an IP65 junction box (in the case of the emergency power cable also E30) which must allow the junction of at least 4 connections. The junction boxes will be positioned on the side wall of the tunnel, above the cable duct. The following lamps are connected to the normal network:

- internal lamps (2 every 3)
- internal lamps (1 every 3);
- external lamp above the entrance;

Interior lighting

The escape routes are to be illuminated along their entire length by means of lamps with LED technology. The lamps are connected to both the normal and stand-by networks. The lighting of each cross passageway is designed to achieve an average brightness of 20 lux in the central area of the escape route, measured at a height of 80 cm above the ground and a minimum of 1 lux in every other place.

Lamps connected to the stand-by network provide an average brightness of 1 lux in the central zone of the escape routes, measured at a height directly on the ground. The lamps are automatically switched on after the tunnel door has been opened.

Lamp features:

- LED technology;
- life span of at least 80,000 hours; o bright colour = 4'500K;
- a failure of the illuminating cover must not lead to the replacement of the complete lamp; o IP65 protection degree;
- corrosion-resistant stainless-steel housing;
- pipes (against flame propagation) are to be installed on the side wall from the cable duct to the lighting cover;
- cable derived cable deriving from the backbone fire resistant cable and having characteristics “B2ca-s1a, d1, a1” according to European standard EN 50575 - CPR EU 305/2011, for each lamp.

Mounting and fixing system:

The lamps are fixed to the escape route by means of two brackets (mounting system). The minimum characteristics are:

- bracket with vertical upright with appropriate length and with the possibility of fixing brackets for the cable duct and fixing plates at a time. The plates allow the adjustment of the inclination to

allow the adaptation to any surface.

- horizontal brackets for fixing the cable duct and in stainless steel;
- each fixing point is protected against self-loosening;
- each mounting system is calculated for a load capacity corresponding to a static load of at least 1kN (100 kg per lamp);
- each mounting system allows easy adaptation to irregularities and to the inclination of the supporting surface (reinforced concrete);
- all metal elements are sandblasted;
- for the separation of the different materials, in particular of the supports with the lamps, there are Teflon washers with knurled edges that guarantee electrochemical insulation, also preventing the lamp from moving;
- the material of all the components, including the bolts, and metal bushings for fixing the supports, must be adequate for installation in tunnel.

Electric power estimation

The estimate of the total power absorbed by the total normal network of luminaires (power supply from technical room north/south):

- Lighting circuit F1 = 1.5 KW (cosphi =0.9)
- Lighting circuit F2 = 1.5 KW (cosphi =0.9)
- Lighting circuit F3 = 1.5 KW (cosphi =0.9)

Total = 4.5 KW

4.2.9 Street lighting

At the north portal and at the south portal, 6 luminaires will be installed, 3 on each side. The power supply is provided by the nearest technical room with cable type FE05C 5x10mmq through a series connection. Electric power estimation

The estimate of the total power absorbed by the total normal network of luminaires (power supply from technical room north/south):

- Lighting circuit 1= 1 KW (cosphi =0.9)
- Lighting circuit 2 = 1 KW (cosphi =0.9)

Total = 2 KW

4.2.10 Lighting by rock-shed

The pedestrian walkway will be illuminated along its entire length by means of luminaires with LED technology lamps. The luminaires will be connected both to the normal electrical network and to the stand-by electrical network. The lighting is designed to reach an average brightness of 20 lux in the central area, measured at a height of 80 cm above the ground according to the international directive on street lighting. The luminaires connected to the stand-by electrical network provide an average brightness of 1 lux in the central zone of the route, measured at a height directly on the ground. The lamps are automatically switched on in the evening by means of a twilight sensor.

Lamp characteristics:

- LED technology;
- service life of at least 80,000 hours;
- bright colour = 4'500K;
- a failure of the illuminating cover must not result in the replacement of the complete lamp.

Characteristics of luminaires:

- IP65 protection degree;
- stainless steel or corrosion-resistant thermoplastic housing;
- pipes are to be installed on the side wall from the cable duct to the luminaire;
- cable deriving from the backbone fire resistant cable and having characteristics “B2ca-s1a, d1, a1” according to European standard EN 50575 - CPR EU 305/2011, for each luminaire.

Mounting and fixing system:

The luminaires will be fixed to the ceiling/wall of the escape route by means of two brackets (mounting system). The minimum characteristics:

- bracket with vertical upright with adequate length and with the possibility of fixing brackets for the cable duct and fixing plates to the ceiling / wall. The plates allow the adjustment of the inclination to allow the adaptation to any surface.
- horizontal brackets for fixing the cable duct and in stainless steel; ○ each fixing point is protected against self-loosening;
- each mounting system is calculated for a load capacity corresponding to a static load of at least 1kN (100 kg per lamp);
- each mounting system allows easy adaptation to the irregularities and inclination of the supporting surface (reinforced concrete);
- all metal elements are sandblasted;
- the material of all the components, including the bolts, and metal bushings for fixing the supports, must be adequate for the place of installation.

Electric power estimation

The estimate of the total power absorbed from the normal network (power supply from technical room north/south):

- Lighting circuit F1 = 1.5 KW (cosphi =0.9) ○ Lighting circuit F2 = 1.5 KW (cosphi =0.9) ○ Lighting circuit F3 = 1.5 KW (cosphi =0.9)

Total = 4.5 KW

4.3 Ventilation

The ventilation system is described in the reference A2.

The document contains the dimensioning of jet-fans and sensors. Regarding to traffic in reference year, this is irrelevant as the dimensioning case was the fire operation, and it was judged that the resulting fresh-air supply during normal operation was more than adequate in all traffic density conditions.

It will be the task of the contractor to define, in the final design phase of the system, the functioning of the ventilation in the normal case (sanitary ventilation) and in the event of a fire (operation of the system in the various fire scenarios in the tunnel).

4.4 Signage

4.4.1 Traffic and signalling

The implementation of the tunnel is accompanied by a larger-scale traffic and signalling concept that makes it possible to manage traffic flows as efficiently as possible, in normal conditions and in the event of tunnel closure.

The tunnel consists of a two-lane tube (1 lane per direction). Under normal traffic conditions, traffic flows to the left of the roadway in a northerly direction (Tansen) and to the right in a southerly direction (Butwal).

4.4.2 Traffic principles

With the future tunnel, the current H10 road becomes the pedestrian/bicycle way on the section concerned. With a clear space gauge of **3.5 m x 5.0 m**, it allows the mixed circulation of numerous bicycles and pedestrians as well as the passage of emergency vehicles in case of need (to be coordinated with the intervention of a security guard).

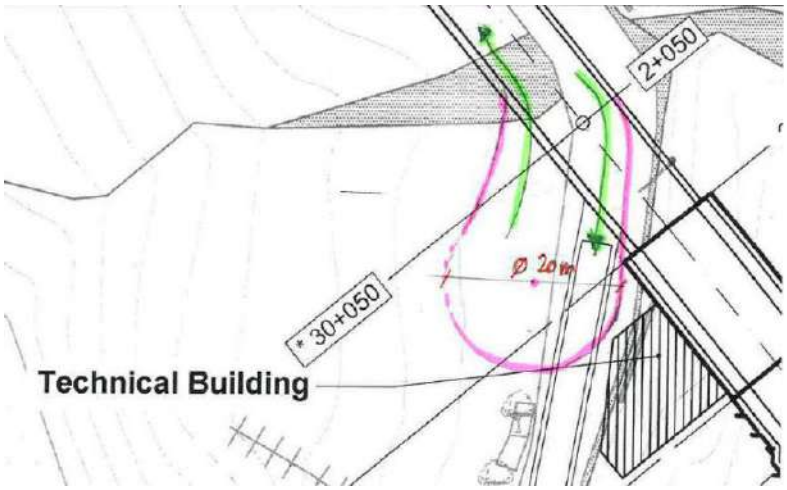
The pedestrian/bicycle path is the collector of the tunnel's pedestrian bypasses (emergency exits).

In the event of tunnel closure (accident, fire, maintenance), the road route via the H10 between Butwal and Tansen is no longer possible. The alternative road route is via the H01 and Rahabas Jhadewa Sadak, via Rupse (see Reference A9). This alternative route is very long (about 4h30) compared to the H10 (1h25 today). The alternative route should therefore only be used in the event of prolonged tunnel closure.

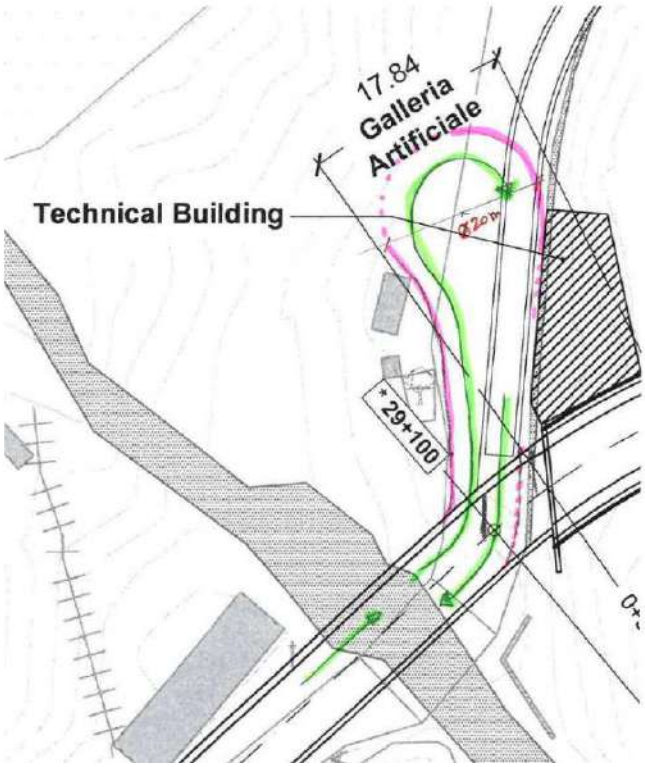
Variable traffic signs will be installed between Butwal and Tansen to inform and direct users to the alternative route (see Reference A10).

The closure of the tunnel will result in vehicle queues on the H10. In order to allow users to turn back, turnaround spaces must be provided at both gates. The radius of curvature must be large enough to allow a truck or bus to turn (min. 20 m in diameter) - see illustrations below.

Depending on the context (slope, slope, ground conditions), an adaptation of the turning back zone will be necessary.



Picture 6: North portal



Picture 7: South portal

Emergency vehicles will be accessible to the tunnel via the H10. A helicopter landing site can be considered near the tunnel to ensure a very fast response time, as road access can be disrupted by the lines of cars or turning back.

4.4.3 Control system of the Signage

An operating condition (OC) is a specific status for all variable signs in the area managed by the traffic control system.

For the operation of the tunnel, a few OCs will be needed; they will be stored in the traffic control system which is part of the tunnel control system (chapter 3.6.2). Here we must point out the fact that the signage must have a very reliable control system.

The OCs constitute “states”. Only the logically possible transitions (based on the indications of the traffic specialist and the current Nepali legislation) between these states must be able to be carried out in the system. Using the tunnel control system, operators in the control room must be able to select the desired states of the tunnel signage and to command its activation.

Each OC contain the status of every single variable traffic sign. When an OC is loaded, all traffic signs assume the new status defined in the OC. Not every OC can be loaded at any time, the relations between the OCs is described in the so-called interlock matrix.

The interlock matrix, as well as the list of possible OCs for the tunnel signage, will have to be defined in the execution phase by the traffic specialist of the project team of the general contractor.

In case of failure of a traffic sign, operators in the control room must be informed trough the SCADA system. The system will not lock any OC because of a defected sign; the operator must decide, if a requested OC can be applied even in case of faulty signs.

The traffic control system must exclude the possibility to activate a combination of signs which is not foreseen by the interlock matrix or contradictory (for example: green at the same time by two traffic lights allowing traffic flow in opposite directions). To archive this request, measures must be taken on different levels (SCADA, PLC). In particular, the display of contradictory signs must be prevented (such as green light and red light at the same time on a traffic light).

Given the relevance in legal and insurance terms (for example in case of an accident) all the commands entered for the signage and all the transitions made by the same must be traced in a log (command, status of each sign, operator who has sent the command, date, hour, etc.).

Because of their distance from the technical rooms to the north and south portals of the tunnel, the VDS1, VDS 2, VDS 6 and VDS 7 signs will be equipped with photovoltaic panels or wind micro-turbines. These signs will have their own local control with microprocessor (PLC, RTU) connected to the tunnel control system through the data network on mobile telephony.

4.4.4 Traffic signs

Fixed and variable signs must be placed on the tunnel access road to inform users of the accessibility status of the tunnel and to regulate traffic through the tunnel.

The schemas in References A9 and A10 illustrate the traffic signs that should be placed in order to properly inform users and allow drivers' behaviour to be adapted. These signs refer to the Nepalese Traffic signs manual (August 97) and the number of the corresponding sign is mentioned.

Before entering the tunnel, prohibition signs should be placed to inform pedestrians and cyclists that they must use the current road and not the tunnel.

For motor vehicles, a no-overtaking sign and a speed limit of 60 km/h should also be placed near the entrance (as soon as the marking of the double white line on the roadway begins).

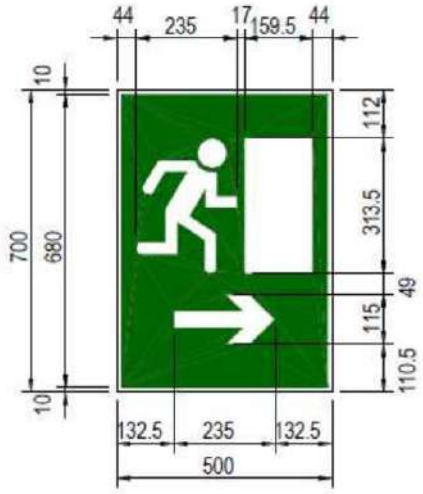
In order to limit the damage that could be caused by a very high vehicle (gauge of more than 4.50 m), a prohibition sign must be placed before the entrance and a gauge can be installed, either at the two tunnel entrances (possible at the level of the gates - see example below), or upstream on the H10.

Depending on local usage, it may be appropriate to mark a pedestrian crossing before the tunnel entrances, in order to provide relative safety for pedestrians who will have to join the pedestrian/bicycle path.

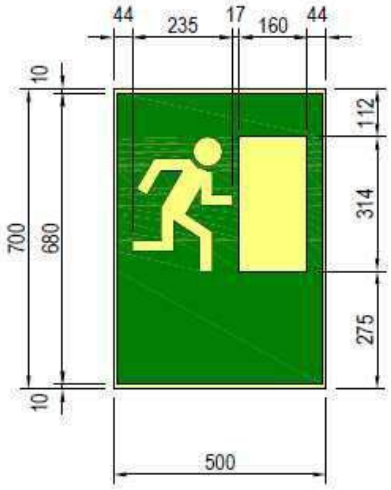
4.4.5 Emergency exits and safety signs

For the arrangement of the emergency exits and safety signs in the tunnel, see the document A1. For multilingual signals, the languages to be considered (in addition to Nepalese and English) must be defined by the general contractor in agreement with the client.

Within the tunnel, emergency exits shall be marked with appropriate signs (colour RAL 6029, dimensions in mm):

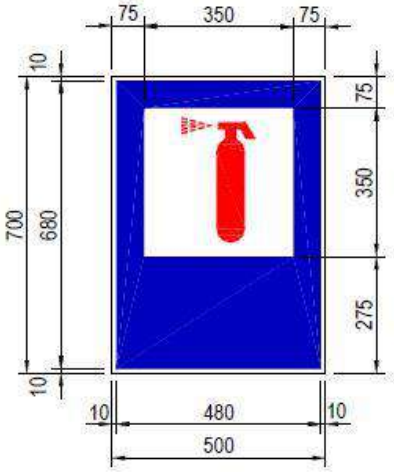


The following signage shall be affixed to the emergency exits' access doors (colour RAL 6029, internal yellow, dimensions in mm):

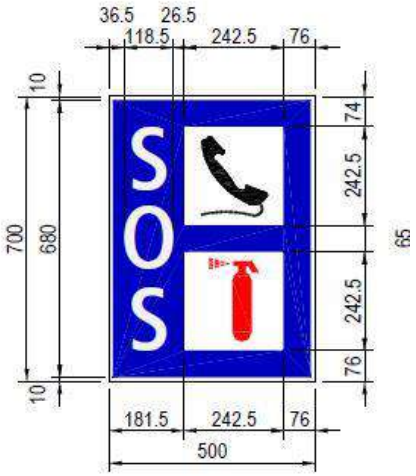


In the SOS niches in the gallery, a multi-lingual sign must be affixed to indicate that the location is unsafe:

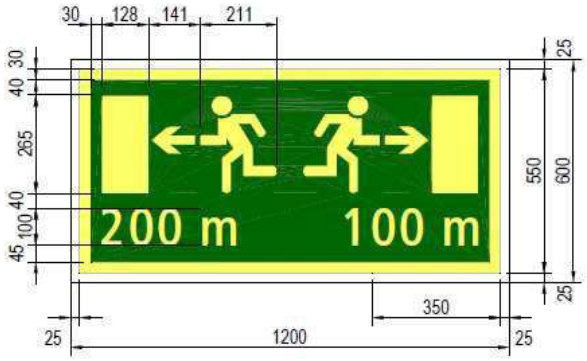
The presence of fire extinguishers must be indicated by a special illuminated signal (dimension in mm):



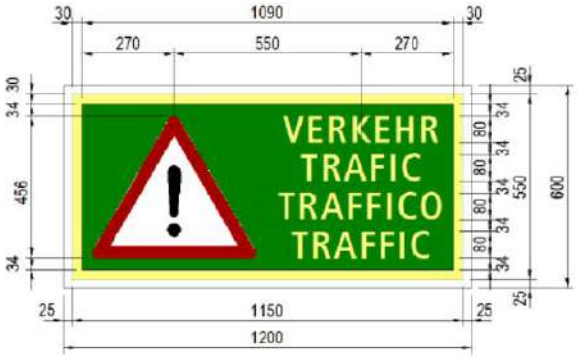
The presence of emergency phone combined with fire extinguishers must be indicated by a special illuminated signal (dimension in mm):



Signs indicating the distance to the nearest emergency exits in both directions shall be installed at regular intervals throughout the tunnel. These signs shall have residual lighting. The dimensions are expressed in mm:



The exit doors from the cross passages to the outside road shall be marked with signs indicating the presence of traffic.



4.4.6 Traffic barriers

At both tunnel-entrances a movable barrier must be installed. Aim of these barriers is closing the access to the tunnel in case of dangers in it.

The barriers are controlled from the control room; operators must be able to check the situation via the video surveillance to be sure that barriers can be closed safely.

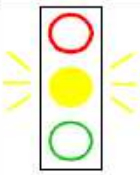
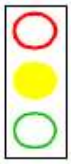
Depending on the final layout of the reversing places at both gates, the barrier must be provided in such a way as not to disturb the vehicles. If possible, barriers should be provided on both lanes to prevent users from using the lane in the wrong direction.

4.4.7 Signs transitions

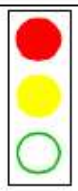
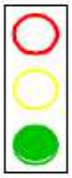
Traffic lights: traffic lights are mounted at the sides of the tunnel portals

From “OFF” to “RED” → In accordance with Nepalese law

In the absence of legal regulations under Nepalese law (to be verified again by the general contractor after obtaining the contract) the following table can be considered.

	Status	Duration	Frequency
	All lights off.		
	Yellow blinking	6 sec	1 sec ON 0.5 sec OFF
	Yellow on	6 sec	-
	RED on		

From “RED” to “OFF” → In accordance with Nepalese law
In the absence of legal regulations under Nepalese law (to be verified again by the general contractor after obtaining the contract) the following table can be considered.

	Status	Duration	Frequency
	RED on		
	RED and YELLOW on	6 sec	1 sec ON 0.5 sec OFF
	GREEN ON	2 min	
	All lights OFF		

Traffic guides: traffic guides are the signs mounted on the ceiling inside the tunnel.

	ON or OFF
	ON or OFF
	OFF

Each status can be assumed directly, starting from any other status.

4.4.8 Traffic detection and counting

To allow the management of signage and ventilation it is necessary to detect the traffic conditions.

For this reason, 6 detection points are planned, 3 per direction, based on inductive coils embedded in the road surface. These positions will be at the portals of the tunnel and at the centre of it.

Each detection-station must be able to detect:

- vehicle speed (km/h)
- number of vehicles (vehicles per minute, vehicles per hour)
- type of vehicles (at least the following: motorcycle, car, light truck, heavy truck, lorry with trailer, bus)
- vehicle direction (possible presence of vehicles in contravention)
- degree of occupation of the lane (percentage)
- presence of stationary vehicles.

These data must be detected by specific detection stations connected to the tunnel control system. The data collected must be able to be displayed in the SCADA both on-line ("live" display) and as historical archives (display of data through curves and histograms in freely definable time windows).

4.5 Surveillance systems

4.5.1 Tunnel fire detection system

4.5.1.1 Description of the tunnel fire detection system

This system will be responsible for the detection of fires in the tunnel. This is a system separate from the fire detection system provided in buildings.

Fire detection in the tunnel will be based on two separate technologies, both controlled by the detection system:

- detection of the increase in temperature, by means of a fibr*E* optic sensor cable
- detection of the presence of smoke, by means of point-sensors installed.

Sensors with a maintenance interval <1 year are not allowed;

The checks and calibrations of the sensors that must be carried out periodically must be communicated by the supplier at the time of the offer, in order to be able to guarantee the function of the sensors with the necessary maintenance.

Operating interruptions must be eliminated within 72 hours.

Easy assembly/disassembly of the components in the tunnel should be preferred.

In case of fault or damage, simple replacement must be guaranteed without the use of special tools. The cleaning of the construction elements, if necessary, is only possible in conjunction with the ordinary cleaning of the tunnel.

4.5.1.2 Description of the elements of the tunnel fire detection system

4.5.1.2.1 Fibre optic sensor cable

As a fire detection cable or linear probe, a fibre optic probe must be used. The technology chosen must be state of the art.

The cable used must withstand the aggressive environment of the traffic compartment and possible mechanical stress during maintenance work (tunnel cleaning).

- temperature measurement range: -30 ° C to 85 ° C
- measurement resolution: 10 m

If the cable is interrupted, the measurement must continue and be ensured by the side still connected, i.e. on the entire cable between the fire control unit and the breaking point.

The linear probe fixings to the vault must be made of stainless steel and must withstand the aggressive environment of the traffic compartment and possible mechanical stress during normal functioning (vibrations due to the passage of vehicles) and during maintenance work. The minimum bending radii, the maximum distance between supports, the tensile strength during laying and the resistance to mechanical stress during operation and maintenance (e.g. tunnel washing) must also be considered. The linear probe must be placed 8-9 centimetres from the vault so as not to be in contact with the concrete surface. Appropriate spring-type fasteners must be used that do not exert an excessive pressure on the probe itself, in order not to damage the probe or cause disturbances to its operation. The section of the probe which goes from the fire control unit in the technical room to the end of the tunnel will be laid in a cable duct and must be adequately protected mechanically, for example, with a pipe.

4.5.1.2.2 Smoke detectors

Diffused light smoke detectors with continuous measurement must be installed, connected as a ring or as a star. Fog, including salt fog, should not be detected as smoke and changes in temperature or humidity should not cause measurement errors. The duration for calculating the average value and the delay of the alarm activation must be centrally parameterized in the SCADA tunnel control system. It is planned to install 10 smoke sensors (see reference A3).

Requested features for smoke detectors are:

- measurement range: 0 ÷ 3 E / m;
- measurement resolution: 1 mE / m;
- IP 66 protection degree;

The detector used must withstand the aggressive environment of the traffic compartment and possible mechanical stress during normal functioning and maintenance work.

4.5.1.2.3 Fire control units and smoke control units

The units of analysis and evaluation of the temperatures measured in the traffic compartment must be composed of components of well-known suppliers, widely used and easily available, and must have a user interface (minimal display panel, LEDs, etc.). The technical characteristics must in any case satisfy the purpose for which they are foreseen and what is described in the present document as far as operation and construction are concerned.

The control units must guarantee:

- processing of data detected by the probes
- reporting of the exact point of an event and of the fire-sector concerned;
- management of several (>20) fire sectors
- indication of the current average temperatures of each fire sector (for the fire control unit)
- indication of the current average values of each probe (for the smoke control unit)
- inhibition of measurement in one or more fire sectors (for the fire control unit)
- inhibition of the measurement of the presence of smoke in one or more smoke detectors (for the smoke control unit)
- transmission to the PLC Fire of detected data.

The communication between the PLC Fire and the fire control unit and the smoke control unit must be on fieldbus.

4.5.1.3 Description of the functionality of the tunnel fire detection system

The tunnel will be divided into 11 fire alarm sectors (see Reference A3). The tunnel fire detection system must provide:

- independent management of each individual fire sector;
- data acquisition from the tunnel (temperature, air opacity);
- detection for each fire sector of temperature variations with relative position where this variation takes place. In particular, the maximum values and speed with which these are reached (gradient) are to be shown and recorded in the SCADA tunnel control system
- display of the data collected in the SCADA tunnel control system
- visualization of the system status in the SCADA tunnel control system
- transmission of commands from the SCADA tunnel control system to the tunnel fire detection system (such as: start data recording, inhibit of one or more sector)
- analysis of the data collected, determination of the fire sector affected by the fire event and transmission of the data to the SCADA tunnel control system to show measures and alarms
- receiving notification of fire presence from the SCADA tunnel control system (fire-alarm declared by an operator at the SCADA-client level)
- system calibration, so that it can be adapted to the specifics of the tunnel (e.g.: different thresholds by tunnel portals, etc.).

In case of operation in normal situation the fire detection system is required

- reading of sensor values;
- saving data in a ring buffer;
- applying algorithms for the verification of the presence of fire events.

In the case of operation in the presence of a fire, the same functionalities as in the normal case are required, but with the addition of the data recording.

In order to always guarantee the greatest possible accuracy of the measurements, it must be possible to calibrate the system to compensate for any drifts of the measurements over time. These interventions must be possible without the need to intervene in the traffic compartment and there must not be more than one operation per year.

The fire detection system data must be archived. The storage of this data must be done in the SCADA tunnel control system

Data from the last 30 minutes (configurable time) must always be available, while the oldest data can be overwritten.

In case of a fire it is necessary to guarantee the availability of all data starting from 30 minutes before and up to 30 minutes after the time of the event; these data and cannot be overwritten. The data must be stored with a resolution of 1 second and must be marked with the date, time, minutes and seconds. In case of multiple events the data must be stored in a separate file for each event.

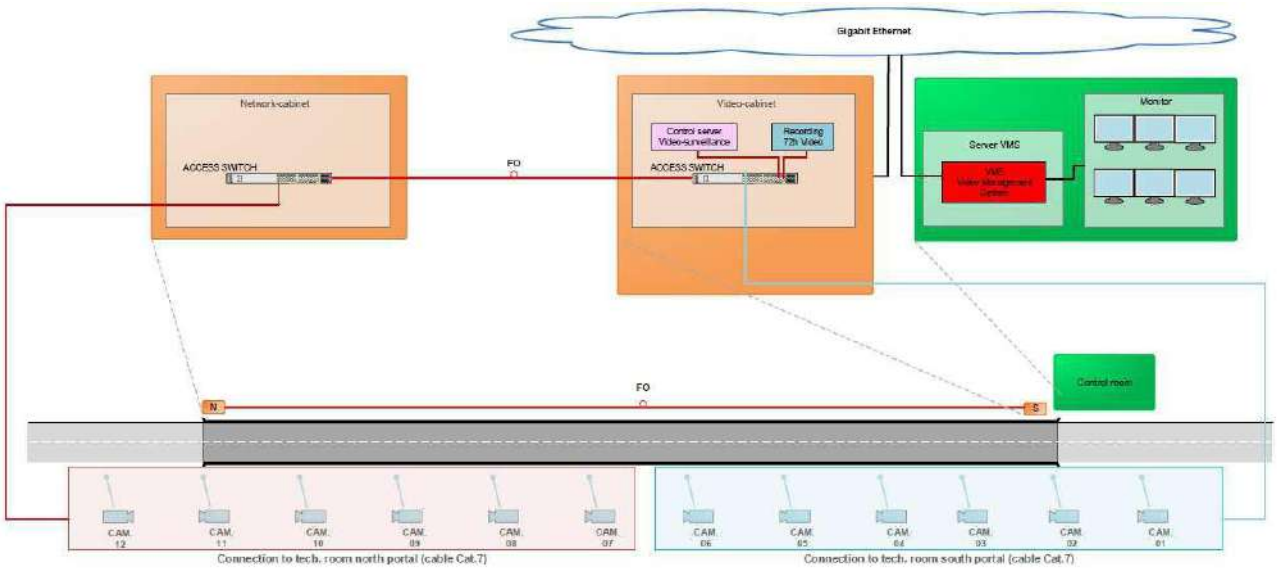
The data must be stored in a format that allows the graphic representation and the export such as .xls, .csv or .xml.

4.5.2 Video-surveillance system

4.5.2.1 Description

The structure of the video surveillance system foresees 10 IP cameras in tunnel and 2 IP cameras outside the tunnel, a server with an application that manages video-images and a recording server (for 72 hours). The cameras will be connected via cable cat.7 to the access-switches installed in the north and south technical rooms, inside cabinets. The connection between the access-switches and the video control server will be over single-mode fibre optic connection. The control server, as well as the cameras will be connected to the tunnel's communication network. The Video Management System (VMS) will be installed in the technical room at the south portal of the tunnel and will allow the users in the control room to direct the images on the 6 displays there installed.

The diagram in the figure shows the new video surveillance system:



Picture 8: structure of the video-surveillance system

4.5.2.2 Video-surveillance control server and software

The graphic interface of the control system of the video-surveillance must be accessible via web-browsing. The control system will have the task of interacting with the tunnel control system (cap. 4.6.2) sending alarms, warnings and the general state of the video surveillance system, including the status of the cameras (alarm / disturbance). The video-surveillance control system will receive the automatic reactions from the tunnel control system to start the recording of events. Remote control of the cameras via the interface is possible on the video-surveillance control system. Activation of video-images on the 6 display in the control room, on the other hand, are handled by the VMS.

Control System technical features

- Popular branded server products with wide distribution in Nepal and good assistance in Nepal
- Products released for at least 1 year from the date of submission of the offer and for which there is no foreseen replacement in the following 5 years from the date scheduled for the final installation on site
- At least 50% reserve in terms of computing power, working memory, non-volatile memory

- Console for system administration (keyboard, mouse, 16:9 display of at least 21")
- Video software product renowned and widespread on the Nepalese market, in a stable version (versions released for less than a year from the start of application development date are to be avoided)
- Server operating system in English, stable, released for at least 1 year from the date of submission of the offer and for which there is no foreseen replacement in the following 5 years from the date scheduled for the final installation on site
- Remote accessibility (web-browsing server)
- Complete software documentation
- User interface is to be agreed with the Customer during the executive design phase.

4.5.2.3 Recording system

The recording system digitally stores the video streams of all the cameras and consists of a permanent recording (circular buffer) and an event recording (on event-recording, according to the matrix of the automatic reactions).

The permanent recording stores the video streams continuously and with a reduced image rate which can be configures from 1 image per second up to 25 images per second and is available up to a maximum of 72 hours. Files are created separately for each camera and must retain hourly information.

The on-event recording system processes and records the images of 3 cameras near the event (incident, call by an emergency phone, etc.) and creates one or more event files that will not be deleted automatically. These files contain images from a configurable (from 10 to 60 minutes) time prior to the event to a configurable (from 10 to 60 minutes) time after the event, at recording rate of 25 images per second. The automatic reactions matrix is the basis for defining the relationship between an event and the cameras to be recorded. The format of the recordings must be in known and widespread video-format and the video stream encoded in a freely available format. In addition, in order to watch recorded videos, it must also be possible to view up to 4 video streams in real time on the control system.

Recording System technical features

- Popular branded server products with wide distribution in Nepal and good assistance in Nepal
- Products released for at least 1 year from the date of submission of the offer and for which there is no foreseen replacement in the following 5 years from the date scheduled for the final installation on site
- At least 50% reserve in terms of computing power, working memory, non-volatile memory
- Console for system administration shared with the video-surveillance control server
- Software product renowned and widespread on the Nepalese market, in a stable version (versions released for less than a year from the start of application development date are to be avoided)
- Operating system in English, stable, released for at least 1 year from the date of submission of the offer and for which there is no foreseen replacement in the following 5 years from the date scheduled for the final installation on site
- Possibility of contemporary reading and writing
- Web-interface for configuring the recordings
- Complete software documentation.

4.5.2.4 Cameras in the tunnel

The 10 internal IP cameras must have the following minimum characteristics:

- Fixed color camera, with mechanical removal of the IR filter
- Sensor: ≥ 1/3"
- Sensitivity: min 0.3 lux (colors) - 0.1 lux (B/W)

- Wide dynamic range
- Video compression: H.264
- Resolution: HD720p
- Transmission speed: up to 25 fps
- Multistreaming (minimum 2 independent video streams) configurable independently (Unicast / Multicast)
- Minimum protocols supported: TCP / IP, UDP / IP, HTTP, RTSP, RTCP, RTP / UDP, RTP / TCP, SNTP, mDNS, UPnP, SMTP, SOCK, IGMP, DHCP, FTP, DDNS, SSL v2 / v3, SSH
- Power supply: 12VDC / PoE
- Lens: VARIO (5-15mm)
- Web-server integrated on the camera for configuration
- Case: Stainless steel gr.II, with integrated heating (with power splitter)
- Mounting brackets: stainless steel, mounting in tunnel-roof.

4.5.2.5 Cameras outside the tunnel

The 2 external IP cameras must have the following minimum characteristics:

- Fixed color camera day&night, with mechanical removal of the IR filter
- Sensor: ≥ 1/3"
- Sensitivity: min 0.3 lux (colors) - 0.1 lux (B/W)
- Wide dynamic range
- Video compression: H.264
- Resolution: HD720p
- Transmission speed: up to 25 fps
- Multistreaming (minimum 2 independent video streams) configurable independently (Unicast / Multicast)
- Minimum protocols supported: TCP / IP, UDP / IP, HTTP, RTSP, RTCP, RTP / UDP, RTP / TCP, SNTP, mDNS, UPnP, SMTP, SOCK, IGMP, DHCP, FTP, DDNS, SSL v2 / v3, SSH
- Power supply: 12VDC / PoE
- Lens: VARIO (5-15mm)
- Web-server integrated on the camera for configuration
- Case: Stainless steel, with integrated heating (with power splitter). If necessary, an external sunshade device must be added to the case for external cameras in order to avoid reflections of light
- Mounting brackets: stainless steel, mounting on poles.

4.5.2.6 Video-streams

The cameras must be able to provide a minimum of two configurable video streams independently (Unicast / Multicast) as follows:

Stream 1: main stream used for live view

- Video compression: H.264
- Resolution: HD720p
- Transmission speed: 25 fps
- Multicast stream

- RTSP protocol enabled.

Stream 2: stream used for recording on the recording system and on display in the control room

- Video compression: H.264
- Resolution: HD720p
- Transmission speed: 25 fps
- Unicast stream
- RTSP protocol enabled.

4.6 Communication network and Tunnel control system

4.6.1 Communication network

4.6.1.1 Description of the communication network

To allow the monitoring and control of the tunnel facilities through the transport of data, voice and images, a communication network is required.

The communication network will be based on Gigabit Ethernet technology; all connections must allow a speed of 10 gigabit per second on the main backbone between the technical rooms by the tunnel portals and 1 gigabit within the technical rooms.

The connection topology of the main backbone between the technical rooms by the tunnel portals is a ring, in order to assure a redundancy in case of interruption of the cable. The communication ring must extend over two different cables so that the interruption of a single cable does not affect the operation of the ring (see chapter 4.7.2).

4.6.1.2 Description of the elements of the communication network

4.6.1.2.1 Main switches

Main switches are the switches in the two technical rooms of the tunnel and in the control room (see reference A7).

Hardware

- Switches of renowned brands with wide distribution in Nepal and good assistance in Nepal
- Products released for at least 1 year from the date of submission of the offer and for which there is no foreseen replacement in the following 5 years from the date scheduled for the final installation on site
- Redundant power supply
- Low heat and noise emissions
- At least 50% reserve in terms of computing power, working memory, non-volatile memory
- At least 30% reserve in terms of connections (RJ45, fibre optic)
- Support for ring network topology
- Suitable for the installation location (temperature, humidity, vibration, air quality).

Software

- Complete documentation of the software and of the configuration.

4.6.1.2.2 Secondary switches

The secondary switches are all the switches needed to transmit data, video and voice and not classified as “main switches” in the reference A7.

- Switches of renowned brands with wide distribution in Nepal and good assistance in Nepal
- Low heat and noise emissions
- At least 50% reserve in terms of computing power, working memory, non-volatile memory

- At least 30% reserve in terms of connections (RJ45)
- Support for ring network topology, where necessary
- Industrial design suitable for the installation location (temperature, humidity, vibration, air quality). Software
- Complete documentation of the software and of the configuration.

4.6.1.2.3 Network management system (NMS)

Hardware

- Dedicated hardware (no hardware sharing with the SCADA servers) of renowned brands with wide distribution in Nepal and good assistance in Nepal
- Products released for at least 1 year from the date of submission of the offer and for which there is no foreseen replacement in the following 5 years from the date scheduled for the final installation on site
- Low heat and noise emissions
- At least 50% reserve in terms of computing power, working memory, non-volatile memory
- Console (keyboard, video, mouse).

Software

- Operating system in English, stable, issued for at least 1 year and for which there is no foreseen replacement in the following 5 years from the date scheduled for final installation on site
- Network management environment, in a stable version (versions released for less than a year from the start of application development are to be avoided)
- Interface to the SCADA server for the communication of the status of the network and of alarms
- Complete documentation of the software.

4.6.2 Tunnel control system

4.6.2.1 Description of the control system

The tunnel facilities will be controlled by a system based on a SCADA server interfaced with PLC in control of the processes of the different plants.

The tunnel control system must collect and present to the operators in the control room all the conditions present in the installations, in particular diagnostic conditions (presence of faults and defects) and information on the operation (states, measures, etc.).

The tunnel control system must also show alarm conditions related to safety events.

The annex A7 shows the architecture planned for the tunnel control system.

4.6.2.2 Description of the elements of the control system

4.6.2.2.1 SCADA Client

Hardware

- PC-based workstations of renowned brands with wide distribution in Nepal and good assistance in Nepal
- For each PC, 2 flat panel displays 16:9 Full HD at least 24"
- PC hardware with low heat and noise emissions, installed far from workstations (e.g. in technical rooms on the same floor of the control room, connected by KVM extender) so as not to disturb operators in the control room
- At least 50% reserve in terms of computing power, working memory, non-volatile memory

- For each PC: extended keyboard, mouse.

Software

- Operating system in English, stable, released for at least 1 year from the date of submission of the offer and for which there is no foreseen replacement in the following 5 years from the date scheduled for the final installation on site
- Renowned SCADA product widely available on the Nepalese market, in a stable version (versions released for less than a year from the start of application development are to be avoided)
- Complete documentation of the software.

4.6.2.2.2 SCADA Server

Hardware

- Popular branded server products with wide distribution in Nepal and good assistance in Nepal
- Products released for at least 1 year from the date of submission of the offer and for which there is no foreseen replacement in the following 5 years from the date scheduled for the final installation on site
- Redundant hardware execution: primary server and hot-stand-by server
- At least 50% reserve in terms of computing power, working memory, non-volatile memory
- Console for system administration (keyboard, mouse, 16:9 display of at least 21").

Software

- SCADA product renowned and widespread on the Nepalese market, in a stable version (versions released for less than a year from the start of application development date are to be avoided) and perfectly compatible with the installed SCADA product
- Server operating system in English, stable, released for at least 1 year from the date of submission of the offer and for which there is no foreseen replacement in the following 5 years from the date scheduled for the final installation on site
- Remote accessibility (web-browsing server)
- Complete software documentation.

4.6.2.2.3 PLC

PLC distributed in the cabinets of the individual systems; each PLC must be related to a single technology (it is forbidden to manage multiple technologies, such as lighting and signage, with the same PLC). The PLCs can be connected to remote terminal units (RTU) for remote data collection.

Hardware

- PLC products of renowned brand with wide distribution in Nepal and good assistance in Nepal
- One only series, one only model (the proliferation of the variety of hardware must be avoided)
- At least 50% reserve in terms of computing power, working memory, non-volatile memory, addressable I/O periphery.
- Products issued for at least one year from the date of submission of the offer and for which there is no foreseen replacement in the 3 years following the date of the final installation on site.

Software

- Modular programming according to IEC 61131, with exhaustive comments
- Non-volatile memory resident programming
- Complete documentation of the software (contact lists, comments, etc.).

4.6.2.2.4 Communication bus between SCADA and PLC

- Fieldbus with wide diffusion and good assistance in Nepal or Ethernet
- Product natively supported by both SCADA and PLCs

- Redundant topology (ring).

4.6.2.2.5 Operator panel

Hardware

- Products of renowned brand with wide distribution in Nepal and good assistance in Nepal
- One only series, one only model (the proliferation of the variety of hardware must be avoided)
- At least 50% reserve in terms of computing power, working memory and non-volatile memory.
- Diagonal of at least 10", touch-screen colour panel
- Products issued for at least one year from the date of submission of the offer and for which there is no foreseen replacement in the 3 years following the date of the final installation on site
- Connection to operator panels via fieldbus or Ethernet.

Software

- Modular programming according to IEC 61131, with exhaustive comments
- Non-volatile memory resident programming
- Complete documentation of the software.

4.6.2.3 Description of the functionality of the control system

The control system must allow operators to continuously monitor and control the systems. For this reason, a redundant execution of the SCADA server has been foreseen.

If the SCADA server, although running redundantly, is unavailable, it must be possible for operators to perform the basic functions for the safety of tunnel users at the operator panel level:

- Command the lighting
- Command the signage (closing of the tunnel, fire-scenario)
- Control the ventilation (fire-scenario).

The SCADA server must primarily present the operators with the actual situation of the tunnel facilities. Separate visualization, by plant, as well as an overall summary view, are required. The resolution of the HMI is left free and must be adapted to the complexity of the images to be shown (display without scrolling, easy comprehension) and present good ergonomics (choice of colours, size of images and characters).

Therefore, at SCADA level, a visualization of the tunnel status and a presentation of the data will be carried out. Settings and control operations on board the SCADA are possible, but they do not have to concern functionality related to the safety of tunnel users, such as the reaction to a fire.

The SCADA server will allow the management (surveillance and command) of the following systems:

- Energy supply
- Lighting
- Ventilation
- Signage
- Fire detection
- Auxiliaries

The Auxiliaries plant is a fictitious installation, not corresponding to a real installation. This system collects single signals (contacts) from a set of installations in the tunnel for which it is not convenient to dedicate a PLC to each technology:

- Emergency call stations (status of the call lever and contact of fire extinguishers, general status, summary alarms)

- Air conditioning of the technical rooms of the tunnel and of the control centre (general status, summary alarms)
- Fire detections in building (general status, fire alarms)
- Pumping stations (general status, summary alarms, levels, flow rates)

In the pages of each system, the status of the equipment must be shown (in operation, stationary, in alarm, inhibited, etc.) and the configuration of the individual equipment must be possible (thresholds, hysteresis, etc.).

The HMI of the SCADA will also have to clearly show the presence of alarms. There are two types of alarms and two priorities:

- Technical alarms: failure situations or technical problem on the plants
  - Priority 1: urgent intervention (7/24) by maintenance staff
  - Priority 2: not urgent intervention by the maintenance staff
- Operative alarms: danger situations for tunnel users
  - Priority 1: urgent intervention (7/24) by the police and/or firefighters
  - Priority 2: intervention by the police and/or firefighters not necessary, but it is required that the police get to know the situation

Examples:

- Energy supply loss: technical alarm with priority 1
- Fault to a camera: technical alarm with priority 2
- Tunnel fire: operational alarm with priority 1
- Column formation in tunnel: operational alarm with priority 2.

The activation of an alarm will cause an acoustic and luminous warning (e.g. coloured lamp, a different colour for each priority) at the SCADA client workstations, which will be suppressed with the acknowledge of the alarm by the operator in the SCADA client, and sends, if configured, an alarm message via SMS, phone call or email, to the maintenance staff.

The SCADA system will have to maintain a log, visible within the HMI (separate page), reporting in chronological sequence of all events of the system, with all the necessary detail information (time, date, user name, etc.):

- Login / logout with user details
- Sending command (with the username of the user who sent it)
- Alarm activation / deactivation
- Acknowledgment of an alarm (with the name of the user who has acknowledged it)
- Main measurements (temperatures, air speed, luminance at portals, number of vehicles per minute, etc.).

The system will have to allow to reconstruct, in a simple and precise way, the sequences of all the actions (without exclusion) resulting from the occurrence of a security event, such as (but not only) a fire:

- Temperatures before the fire
- Reaction of the systems to the fire
- Ventilation, activation of the corresponding scenario and fan reaction
- Lighting, switching on of the corresponding scenario and system reaction
- Signage, activation of tunnel closure and signs' reaction.

The SCADA system must allow the sending of commands by the operators; every command must always request a confirmation from the operator before the sending takes place. The result of sending the command (executed / not executed) must always be shown to the operator.

At the SCADA level the log data of at least 13 months for the whole system must be saved. At the end of the 13 months the oldest month must be saved in a separate file to allow the export by the operators on other support, if necessary.

4.6.2.3.2 Functions of PLC

At the PLC level will reside the functions of

- reading the plant status (reading of the analog and digital inputs),
- processing the status read (with sending data to SCADA if required for the visualization),
- and writing in the plants (activation of analog or digital outputs) based on processing performed and/or of the data received from the SCADA.

Basically, the process control functions (lighting, ventilation, etc.) must be maintained at the PLC level. Functions concerning the safety of road users will have to reside only at the PLC level.

The PLC processing cycle- time must be reduced and made constant (stabilization of the cycle time).

4.6.2.3.3 Functions of the operator panel

The operator panels have the following two purposes:

- allow a low-level control acting locally (on site)
- act as a back-up of the SCADA display if the latter should be lost.

All operations requiring the on-site presence of the operator (for example, for safety reasons, having to make sure of the physical possibility of executing a command) must only be possible by acting at the level of the operator panels.

For the operator panels, a resolution appropriate to the images shown on them is required. On the operator panels the alarms (active, acknowledged or not) present in the part of the system supervised by them must be shown.

4.6.2.4 Automatic safety reactions

All the tunnel facilities must be managed by the SCADA and the PLCs in such a way that certain automatic security reactions are always ensured.

These reactions are shown in A8 (matrix of automatic safety reactions).

The matrix contains reactions:

- automatic (with orange background), which do not require any intervention by the operator

- manual (with a pink background), which require the consent of the operator. This means that, upon the occurrence of the event (column), the operator is asked to confirm before executing the relative reaction

Since the safety of tunnel users will depend on these reactions, they must be implemented in a simple (avoiding complex software routines), effective (avoiding the introduction of delays in the application of actions) and easily testable/maintainable manner.

In the matrix there is then an exception (cells with a green background), consisting of a command sent by the operator to the SCADA client: the operator can select one of the 11 planned fire sectors, and declare (command window) the presence of a fire in that sector. The tunnel control system will then ensure that the tunnel plants react according what defined in the matrix. This command is required if the operator becomes aware of the presence of a fire before the tunnel installations have detected it (for example through video-surveillance, or because a call has been made by a motorist in the tunnel).

4.6.2.5 Plants with own control system

The following installations have their own server or dedicated control system, which is not integrated into the SCADA:

- video surveillance
- emergency telephone stations
- communication network
- radio.

It is foreseen the reading in the control system of contacts from these systems (general status, summary alarms, etc.) through the PLCs of the "Auxiliaries" plant.

4.6.3 Control room layout

The control room has two work stations, equipped as follows:

- SCADA client place (mouse, keyboard and 2 display)

- client place of the video system (mouse, keyboard and 1 display) from which it is possible to see the images of the cameras on the display and to direct the images on the 6 wall displays of the control room

- optical signalling system for the presence of alarms (coloured lamps)

- acoustic warning system for the presence of alarms (gong, siren, or similar)

- a telephone.

Between the two workstations there are (equipment shared by the operators):

- a client for the emergency phone system, which displays the system status and calls (mouse, keyboard and 1 display)

- a client for the radio system, which displays the status of the system and allows the use of the radio (mouse, keyboard, microphone, speaker and 1 display)

These work places are laid on one or more tables. Each operator has an ergonomic chair which is adjustable in height and inclination.

The installation of hardware that emits heat or noise in the control room must be avoided: the servers and PCs can be installed remotely in technical rooms at the same floor of the control room and made accessible to operators by means of a KVM connection.

On the wall in front of the operators, there are 6 displays of the video system, on which the images of all the available cameras can be freely routed through the client places of the video system.

In the control room is also foreseen a shared colour laser printer for printing images from the SCADA (system views, event logs, etc.) and from the other systems in the control room (video surveillance, radio, etc.).

The lighting conditions of the control room must allow the operators to easily use the systems (avoid dark areas, direct reflections, direct lighting, etc.).

There must also be natural lighting with a view towards the outside of the building.

4.6.4 Radio diffusion in tunnel

The tunnel will be equipped with a Radio system that will be responsible for the transmission of the radio signals throughout the tunnel.

The project will transmit inside the tunnel the radio signals existing outside of the tunnel. The bands considered are the following three:

- FM - Frequency Modulation: for a maximum of 4 radio channels (range from 87 to 107 MHz).

- VHF - Very High Frequency: typically used for fire brigade, rescue services and ambulance, tunnel maintenance's men (range from 160 to 180 MHz).

- UHF - Ultra High Frequency: reserved for Police in the 400 MHz band.

Note: the DAB+ technology will not be considered in this project because not yet broadcasted on the Nepali territory.

Standards

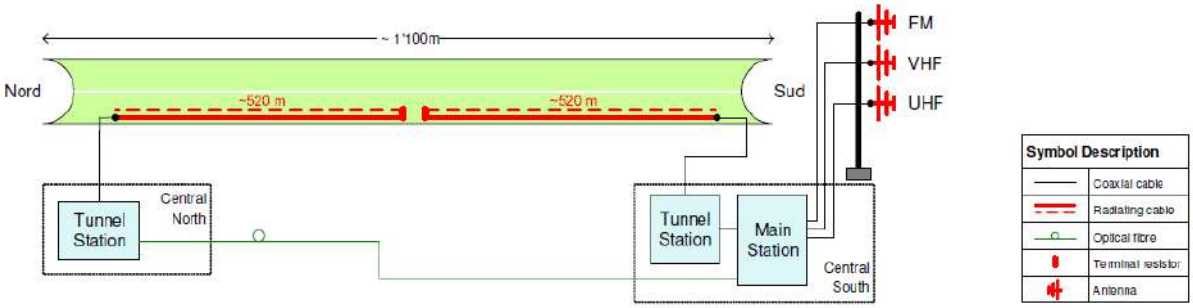
The Radio system shall comply with the following recommendations and regulations:

- IEC (International Electrotechnical Commission).
- IEE (Institution of Electrical Engineers).

Important remark: all metal equipment installed in the tunnel (clips, box, etc) must be stainless steel 1.4571 or higher and all cables must be halogen free.

Technical solution

The tunnel has a technical building at each portal. The Main Station is the heart of the radio system and is installed in the technical building by the technical building by tunnel south portal. The external frequencies are captured through the antennas, located outside the building, filtered and converted into optical signals and transmitted on the secondary technical building by the north portal of the tunnel. On each technical building a radio tunnel station will distribute the signals inside the tunnel through a radiating cable. Here a simple schematic of the chosen solution:



Picture 9: radio diffusion in tunnel

Radiating cable

The radiating cable is used for both one-way and two-way communication systems and because of its broadband capability, a single radiating cable can handle multiple communication systems simultaneously. The cable will be installed inside the tunnel under the vault of the tunnel. The cable will be secured with special clips.

Here an example of a standard radiating cable:

Picture 10: radiating cable

Clips

As mentioned, the radiating cable will be fixed on the vault of the tunnel. This will be done with special plastic clips every meter. For security reasons, for example in case of fire, every ten meter will be installed a stainless-steel clip.

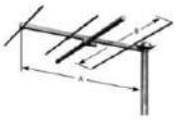
Here an example of a plastic clips:

Here an example of a stainless-steel clips:

Antennas

The antennas are externally mounted on a dedicated pole and connected to the radio system through coaxial cables.

Here an example of a FM antenna:



Here an example of a VHF antenna:

Here an example of a UHF antenna:

Dispatching position for Police announcements - Option

As an option, the system should allow the police to broadcast into the tunnel messages instead of FM programs. Drivers can so listen on the radio the advertisements broadcasted by the police. The police operator has the possibility to choose a varied type of message or to speak “live”.

GSM

The GSM frequencies will not be considered because they are not part of the radio system - see also chapter 2 paragraph 14).

4.6.5 Emergency telephone system

This installation allows the tunnel’s users to call the operators in the dispatching/maintenance centre in case of emergencies or need of help.

Along the tunnel, alternately on the right and left side and at a distance of 150 meters, there are 9 niches with an emergency telephone (SOS). In each niche a SOS cabinet should be installed.

Each SOS cabinet should have:

- 1 SOS telephone
- 2 fire extinguishers, with switches to detect their removal
- RTU of the tunnel control system to collect I/O signals
- lighting for the users.

Moreover, each portal of the tunnel is provided with the installation of an additional SOS cabinet, as the ones in tunnel.

The removal of an extinguisher from its seat is potentially related to a fire risk and has to be tracked and communicated to the tunnel control system in order to grant consistent reactions by other installations in the tunnel.

In the tunnel technical rooms at south portal all the necessary equipment for treating the SOS calls and redirect them to the control room are installed; they are, mainly, a telephone exchange and a call

recorder. By the cabinet, the telephone call will take place by means of a lever or of a button; the user will speak through an intercom grille. The actuation of the lever or of the button must be easy even for people with little force.

The SOS cabinets and the tunnel technical rooms at south portal are be connected via the fibre-optic infrastructure of the tunnel. The connection topology is a ring, in order to assure a redundancy in case of interruption of the cable. The communication ring must extend over two different cables so that the interruption of a single cable does not affect the operation of the ring (see chapter 4.7.2).

The SOS calls will be received in the control room by the operators using a receiving station with: telephone, graphic display with layout of the tunnel showing where the call is taking place, direct connection to the SOS cabinets, direct connection to the nearest Police station. SOS calls can be diverted to the Police station by the operators.

The execution of the cabinets must comply to the aggressive atmosphere of the gallery; the material must be steel. In particular, an IP rating of at least 55 must be guaranteed. The opening of the cabinet by the user for picking up a fire extinguisher must be simple, clearly indicated, easy even for people with little force.

The cabinets installed on the portals must be protected from sun and rain by means of a small canopy.

The colour of the cabinets must be orange, well visible even in low light conditions or in the presence of smoke.

Each cabinet must be clearly marked with a unique code that identifies its location (reference for the caller).

Picture 11: example of a SOS-cabinet

4.7 Cabling system

4.7.1 Earthing and lightning protection system

Goal of the earthing system is to avoid dangerous potential differences between the different parts of a tunnel or between those and the neutral ground.

Technical buildings will have an earth electrode with a determined impedance ZE given by property of the concrete reinforcement steel, of the earth rod and of the ground in proximity of the building. The impedance ZE will determine the potential of the buildings related to the 0-potential of the neutral earth.

4.7.1.1 General concepts

A flat galvanized copper conductor must be placed in every electrical pipe battery outside and inside the tunnel and be made accessible in every cable drawing pit. Important metallic parts placed along the tunnel and the motorway (guard rail, field cabinets, lighting columns, portal frames, etc.) must be connected to this conductor.

The pipe for the water supply of the tunnel, if metallic, must be connected to the earthing system of the tunnel.

The technical rooms will have a flat galvanized copper conductor posed in their foundations. One access point to the earthing system must be provided in every technical room.

Cable sheaths and armours of optic-fibre or copper cables must be earthed at every joint and on both sides.

Concrete reinforcement steel bars shall not be welded together.

All metallic parts of the SOS-niches will be connected to the equipment earthing conductor of the tunnel.

The earthing rod in every technical room must be connected at least to the concrete reinforcement steel.

The equipotential interconnections must be made with an insulated copper wire disposed inside every group of pipes. The earthing of metallic parts must be done by means of a bare copper wire.

All needed action to avoid direct or indirect line surges must be taken. These include:

- For High-Voltage: install lightning protection at every transition from overhead electric line to cable line.
- For Low-Voltage: for all cables leaving the tunnel, install over-voltage protection on the metallic conductor.

4.7.2 Fibre-optic infrastructure

The FO network ensures the transmission of data between different management and control systems. The main parts of the optical fibre system are:

- FO cables;

- FO distribution elements (19" drawers, boxes and connectors).

All optical equipment must be single-mode. The main equipment containing the FO distribution elements will be installed in the two technical rooms (south and north), in the emergency phone cabinets.

The two technical rooms will be connected by two 48 core FO backbones that will be arranged in a ring and laid in the two cable ducts at the sides of the tunnel, in order to obtain a "mechanical" redundancy and thus increase the level of safety.

The backbone cables must have the following characteristics:

- Singlemode cable 9/15µm;

- The cable must be suitable for installation in cable ducts and PE pipes;

- armoured rodent resistant fibre optic cable,

- FR/LSOH sheaths (fire retardant / low smoke emission and halogen free);

- Glass armor;

- Must not contain metals.

- Maintain insulation for 180 minutes;

- Maintain function for 30 minutes;

4.7.3 Universal structured wiring

Structured voice and data cabling using Ethernet or fibre optic technology forms the communication infrastructure in the buildings.

A set of passive components will be laid on site: cables, connectors, sockets, change-over switches, etc., properly installed and prepared to interconnect active devices (computers, telephones, printers, monitors, etc.).

Only halogen-free cables with limited fire propagation and low smoke emissions should be used.

Specifications:

- Twisted pair, at least category 6

- Type S/FTP

- Ethernet 10GBase-T

- AWG 22 or AWG 23.

Each circuit must be labelled and once installation is complete, all technical measures must be taken to ensure the completeness and functionality of each connection.

4.7.4 Cable shelves and pipe infrastructure

In the technical rooms the cables will be housed in cable ducts installed under the floor and reach the electrical cabinets from below.

All cables in the tunnel shall be installed in the cable ducts located in the vault and/or in the cable routes provided on the sides of the carriageway.

The electrical cables for the distribution of the stand-by electrical network (UPS) will be provided with a functional maintenance of 180 minutes, while the electrical cables for the normal distribution of the electrical network will be provided with a functional maintenance of 5 minutes. All cables must be halogen-free, without emission of toxic or flammable or corrosive gases, with a reduced emission of non-flammable and self-extinguishing gases having characteristics “B2ca-s1a, d1, a1” (performances requirements from European standard EN 50575 - CPR EU 305/2011 and IEC 60331 series International Electrotechnical Commission).

In the technical rooms and in tunnel, technical compartments will be made on the walls to contain cable ascents and serve the electrical components at a time. The cable ascents will be mechanically protected by PE pipes and metal sheets.

The characteristics of the covers just be as follows:

- Galvanized steel

The characteristics of the tubes will be:

- Internal Ø 120 mm

- Polyethylene

- Halogen-free

- Not fire propagating

The characteristics of the fasteners of the tubes will be:

- Brackets or profiles in Galvanized steel

- suitable fastening material compatible with the materials used, avoiding contact corrosion (or bimetallic corrosion).

The jet fans will be powered by cable lines that must withstand fire for a minimum of 120 minutes at 250°C. Cable ducts and support brackets shall be made of stainless-steel cat. 1.4571.

4.8 Secondary installations

4.8.1 Electrical and lighting system in buildings

Electrical sockets

At least one 230 VAC socket must be provided for each room, and there must also be a socket at each work station. Exceptions are service sockets located inside the cabinets of the individual systems, which must be commensurate with the needs of the system itself. The sockets must be divided into sockets to the normal network and to the emergency network; the latter must be at least 25% of the former and must be marked with a different colour (e.g. orange).

The definitive position and quantity of the sockets and data will be evaluated by the contractor on the basis of a final layout.

On the ground floor of the two technical buildings, the supply backbone lines of the various plants will lay on cable trays located under the floor that can be inspected to facilitate entry into the various distribution cabinets.

In rooms not equipped with a technical floor, the lines will hang mainly to the ceiling by means of metal cable ducts suspended to the ceiling/wall data and signal. Descents will be carried out at planned points by metal or PVC pipes fixed to the wall or, if possible, in under track execution.

Lighting

The average lighting for offices and work areas with video terminals is 500 lux, while in the technical rooms, ceiling lighting with a minimum intensity of 300lux is required. 10% of the lights must be connected to the UPS network. The room lighting must be switched on and off by means of a switch located near the entrance doors.

In the escape routes in buildings a minimum lighting of 20 lux is required (located in the middle of the window, 80 cm from the floor).

The lighting system will be made of lamps installed to the ceiling, made of highly impact-resistant material, equipped with anti-glare devices and suitable for the place of installation.

Lighting in the rooms will be provided by energy-saving, and easy-to-maintain lamps.

4.8.2 Chain hoists

Technical building by south portal

A 1 ton hoist will be installed in the central to the south portal, on the first floor, and will be used for transporting the different equipment between the ground floor and the first floor of the building. The hoist rail will be fixed to the ceiling. The movement will be on 2 axes, horizontally on the track and vertically. After the installation, the free space under the hoist (from the lowest point to the hook) must have a height greater than 2.2 m.

Features:

- Manual chain hoist;
- Minimum lifting capacity 1.0 t;
- Axes of displacement 2 (advancement and lifting);
- Advancement length:> 6 m;
- Lifting length:> 7 m;
- Degree of protection for the motor: IP 54;
- Chain according to the DIN 50049 standard;
- Hook according to DIN 15404, certificates of conformity according to the standard DIN 50049;
- Container for the plastic chain;

- Hot galvanized steel (sizing carried out by the contractor) beams (according to the SN EN ISO 1461 standard) and painted in the same colour as the bridge of the hoist.

Technical building by north portal

A 1 ton hoist will be installed in the central to the north portal, on the ground floor, and will be used for transporting the different equipment between the ground floor and the basement of the building. The hoist rail will be fixed to the ceiling. The movement will be on 2 axes, horizontally on the track and vertically. After the installation, the free space under the hoist (lowest point / hook) must have a height greater than 2.2 m.

Features:

- Manual chain hoist;

- Minimum lifting capacity 1.0 t;

- Axes of displacement 2 (advancement and lifting);

- Advancement length:> 2 m;

- Lifting length:> 7 m;

- Degree of protection for the motor: IP 54;

- Chain according to the DIN 50049 standard;

- Hook according to DIN 15404, certificates of conformity according to the standard DIN 50049;

- Container for the plastic chain;

- Hot galvanized steel (sizing carried out by the contractor) beams (according to the SN EN ISO 1461 standard) and painted in the same colour as the bridge of the hoist.

4.8.3 Fire barriers

The fire barriers build the fire resistance in the case of the crossings through walls; they are products that must be EI certified according to the specific standards in conditions similar to those of use and must be applied in the quantities and with the construction methods described in the certification itself.

Fire and smoke barrier must be installed at cable and pipe crossings between fire compartments using products suitable for the purpose (for example for crossing from low voltage room and MV/LV transformation room):

May be used:

1) Fire-resistant foam for
- Combined and single sealing
- Single cables, cable bundles and cable tracks
- Metallic Pipes
- Gas-tight
- Water and vapor resistant
- Suitable for fire compartment

2) Closure with fireproof panels
- Ideal for large openings
- Smoke-tight
- Suitable for fire compartment

Every barrier must be labelled with and identification code.

4.8.4 Telephone system in rooms and buildings

4.8.4.1 Description of the telephone system

A fixed telephone system must be created that allows:

- communication (internal dialling) between the technical rooms of the tunnel, the control room, the workshop, the office, the meeting room, etc.

- communication (external dialling) to the outside with connection to the national telephone network.

The telephone system must use the Phone over IP technology and the structured universal wiring for the connection of the devices.

4.8.4.2 Description of the elements of the telephone system

4.8.4.2.1 Telephone switchboard

Telephone switchboard, either hardware or software (virtual), for telephony over IP capable of:

- connect the internal telephone system to the external national telephone network

- manage an internal telephone numbering

- provide, for external access, a different number for each telephone of the internal network. A solution with the following characteristics is required:

- Popular branded products with wide distribution in Nepal and good assistance in Nepal
- Products released for at least 1 year from the date of submission of the offer and for which there is no foreseen replacement in the following 5 years from the date scheduled for the final installation on site
- At least 50% reserve in terms of dialling numbers, computing power, working memory, non-volatile memory
- Dedicated console for system administration
- Remote accessibility (web-browsing server)
- Complete documentation of the software and of the configuration.

4.8.4.2.2 Telephones

A telephone connected to the fixed network must be installed in every room that sees the presence, permanent or occasional, of people of the staff or has no coverage of the mobile network.

The precise number, type and location of the telephones will be defined during the execution phase of the works, in agreement with the client.

There are two types of phones:

- fixed phones

- cordless phones

General features of telephone devices will be:

- Devices of renowned brands with wide distribution in Nepal and good assistance in Nepal
- High charge duration (for cordless)
- Complete documentation of the software and of the configuration
- robustness, impact resistance
- suitable to the installation place.

4.8.5 HVAC system in buildings

The technical buildings at north and south portal shall be equipped with an HVAC system. The system is required to regulate the internal temperature of the control and technical rooms to suitable values in order to guarantee the proper operation of all the foreseen electronic and electrical devices, electrical cabinets and UPS machines with batteries while providing comfortable environmental conditions to the operators.

A typical system shall be mainly composed of:

- An indoor module including an evaporator (indoor heat absorption via exchanger) unit, a condenser (indoor heat release via exchanger) unit, a ventilation unit and an additional electrical heater unit (indoor heat release) if required.
- Regulation dampers at the air intake of the indoor module to modulate the ratio between internal recirculation air and external fresh air. Normal mode is mainly recirculating.
- A ventilation air duct system to provide air distribution to all the rooms of the building with separate supply and aspiration channels. The air duct system shall include internal fire dampers at each dividing wall between rooms that close in event of fire to actively prevent the propagation.
- An extraction fan (ATEX certified) to be installed in the chimney of the UPS battery room in order to prevent the risk of explosive atmosphere in case of gas release during the charging process of the batteries.
- An additional electrical heater unit for the air duct of the UPS battery room, if required, to prevent operation below the minimum allowed temperature values accordingly to the environmental requirements of the selected battery pack.
- An outdoor or outdoor connected module including a compressor unit with evaporator (outdoor heat absorption), a condenser (outdoor heat release) unit and a ventilation unit.

Indoor temperature measurement(s) shall be used to adjust as required the heat/cool demand by means of the regulation dampers at the indoor module air intake and the activation of the heating/refrigerating unit (compressor). In standard cases the indoor relative humidity is not controlled.

The HVAC system shall be properly dimensioned by the Contractor accordingly to the expected heat dissipation generated by the electrical installation and with the required air flows in order to maintain the environmental conditions within the required ranges. The following typical general environmental conditions can be considered:

- Technical rooms dedicated to electrical installations and other rooms (e.g. garage)
  - Temperature: +5 °C <= <= +40 °C
  - Relative humidity: 25% <= <= 65%
- Control and meeting rooms (offices)
  - Temperature: +21 °C <= <= +23 °C (winter), +23 °C <= <= +26 °C (summer)
  - Relative humidity: 30% <= <= 50% (winter), 40% <= <= 60% (summer)

The HVAC system shall be managed by a dedicated control system with the main control unit and the local operator panel installed into the related electrical cabinet. In principle each independent part of the system should be controlled by means of a dedicated control module capable of providing all the related local functionalities.

The integration of the HVAC control system into the tunnel SCADA system shall be implemented by means of the Auxiliary System. The HVAC shall provide all the required measurements and status information to the Auxiliary System, including related warnings and alarms, eventually accepting commands from the SCADA through the Auxiliary system if necessary.

5 References

A1. Synoptic plan of exploitation and safety equipment

A2. Report 695013-D-A-E-T-002-C00 “Ventilation – Technical Report”

A3. Synoptic plan of the ventilation system

A4. Layout of the EES in the technical building at the south portal

A5. Layout of the EES in the technical building at the north portal

A6. Tunnel-sections with EES layout

A7. Tunnel control system architecture

A8. Automatic reactions matrix

A9. Traffic Pattern

A10. Signage plan

ANNEX D: VENTILATION SYSTEM - TECHNICAL REPORT AND DESIGN BASIS

Project Specific Section

ROCKFALL PROTECTION ALONG SIDDHABABA SECTION OF SIDDHARTHA HIGHWAY
Ch. 28+200 km – Ch. 30+600 km

695013-T-A-Z-F-003-ANNEX_D-B00
Attached)

ROCKFALL PROTECTION ALONG SIDDHABABA SECTION OF SIDDHARTHA HIGHWAY
Ch. 28+200 km – Ch. 30+600 km

ANNEX- D

TECHNICAL REQUIREMENTS
VENTILATION SYSTEM - TECHNICAL REPORT AND DESIGN BASIS

Doc. n. **695013-T-A-Z-F-003-ANNEX_D-B00**					
Rev.	Date	Description	Prepared	Checked	Approved
B00	14/06/2019				

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1 Introduction

The 1130 m long Siddhababa Tunnel is located on the H10 road at the foothills of the Himalaya about 30 km north of the Nepali-Indian boarder. It lies in a valley with an approximate north-south orientation and is planned to bypass an area prone to landslides.
The length of tunnel requires a ventilation system for safety purposes.

This report constitutes the documentation of the preliminary design of the tunnel-ventilation system.

2 Objectives of report

This report summarises the boundary conditions, geometric input and results of the dimensioning of the ventilation system for the tunnel. Moreover, the report summarises the quantity of necessary ventilation equipment and gives guidance on how the equipment shall be installed in the tunnel to function properly.

3 Methodology and tools

The dimensioning of the ventilation system of the Siddhababa Tunnel was performed applying HBI internal calculation tools which are based on the Swiss guideline FEDRO for tunnel ventilation [3].

4 Fundamentals, assumptions and further details

4.1 Overview

The Siddhababa Tunnel is located on the H10 road at the foothills of the Himalaya about 30 km north of the Nepali-Indian boarder, lies in a valley with an approximate north-south orientation and is planned to bypass an area prone to landslides, see Figure 4.1.

The tunnel opening is forecasted for 2023 (design year).

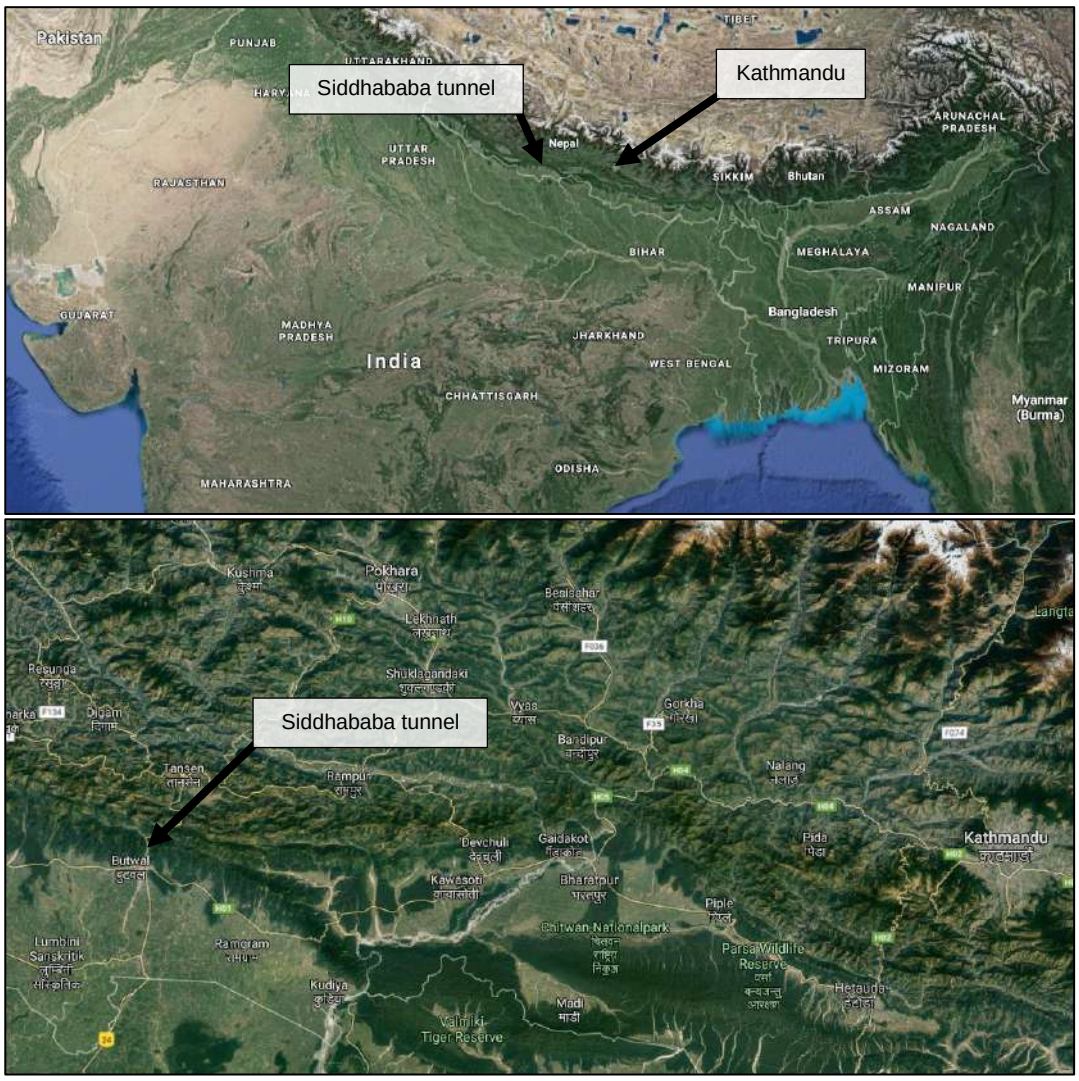


Figure 4.1: Overview location

The tunnel:

- will be operated with bidirectional traffic with one lane in each direction,
- is 1’130 m long,
- rises from the southern portal to the northern portal with about 35 m,
- and provides 3 bypass tunnels (escape tunnels) towards a parallel road, see Figure 4.2.
- The tunnel is located approx. 210 m above sea level

The lengths of the bypass tunnels are about 155 m, 129 m and 125 m.

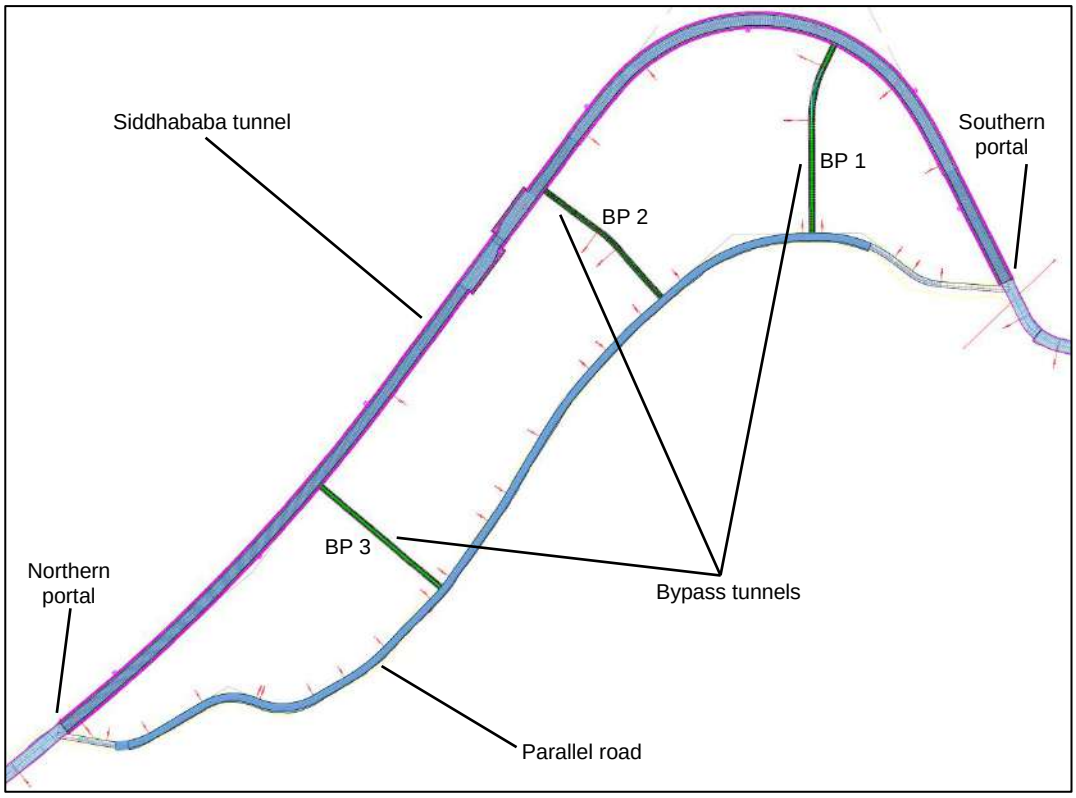


Figure 4.2: Overview Siddhababa tunnel with the bypass tunnels (towards the parallel road)

Emergency exits inside the tunnel are provided every 300 m, which means that an emergency exit is 245 m from the southern portal and another 285 m from the northern portal, see Figure 4.3.

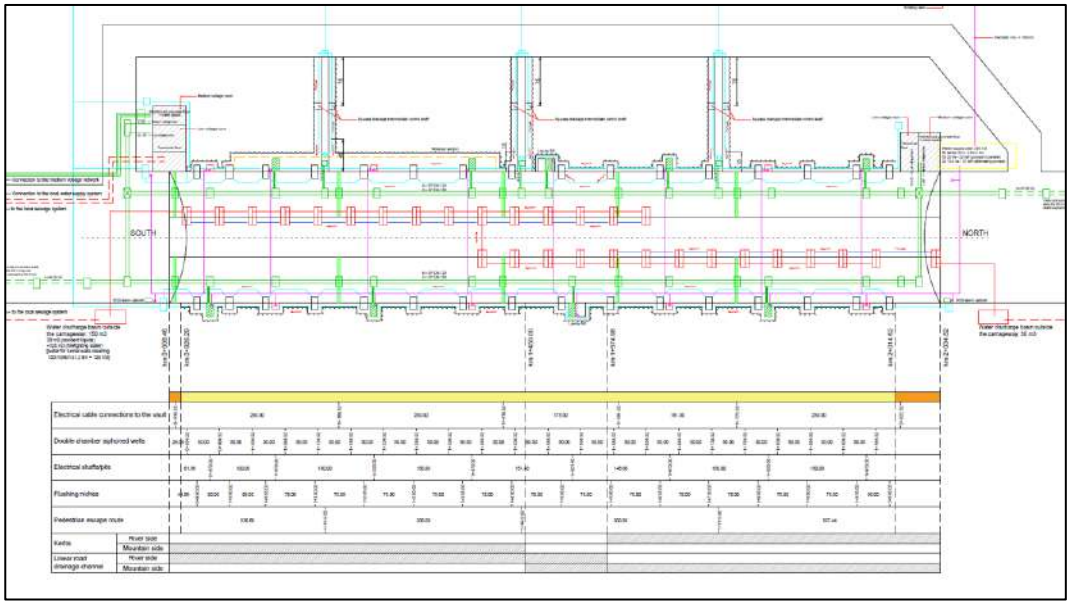


Figure 4.3: Layout of the Siddhababa tunnel

4.2 Geometry

4.2.1 Road tunnel

The longitudinal profile of the Siddhababa tunnel is given in Table 4.1

Table 4.1: Longitudinal tunnel profile from south to north

Section number	Section length	Section slope	Tunnel km	Chainage	Altitude
1	50 m	1.3%	0 m	1’600 m	200 m
			50 m	1’650 m	201 m
2	484 m	4.0%			
			534 m	2’134 m	219 m
3	133 m	0.53%			
			667 m	2’267 m	221 m
4	371 m	4.0%			
			1’038 m	2’638 m	235 m
5	92 m	-0.5%			
			1’130 m	2’730 m	235 m
Total length and difference in altitude:			1’130 m		35 m

Three types of cross sections were provided for the road tunnel, see Figure 4.4 to Figure 4.6. The information regarding the tunnel areas and the perimeters of the different cross sections is given in Table 4.2.

Table 4.2: Information of cross sections for the road tunnel

	Excavation area	Tunnel area (measured)	Perimeter (measured)
Cross section type 1	111 m^2	70 m^2	33 m
Cross section type 2	117 m^2	75 m^2	34 m
Cross section type 3	148 m^2	97 m^2	39 m

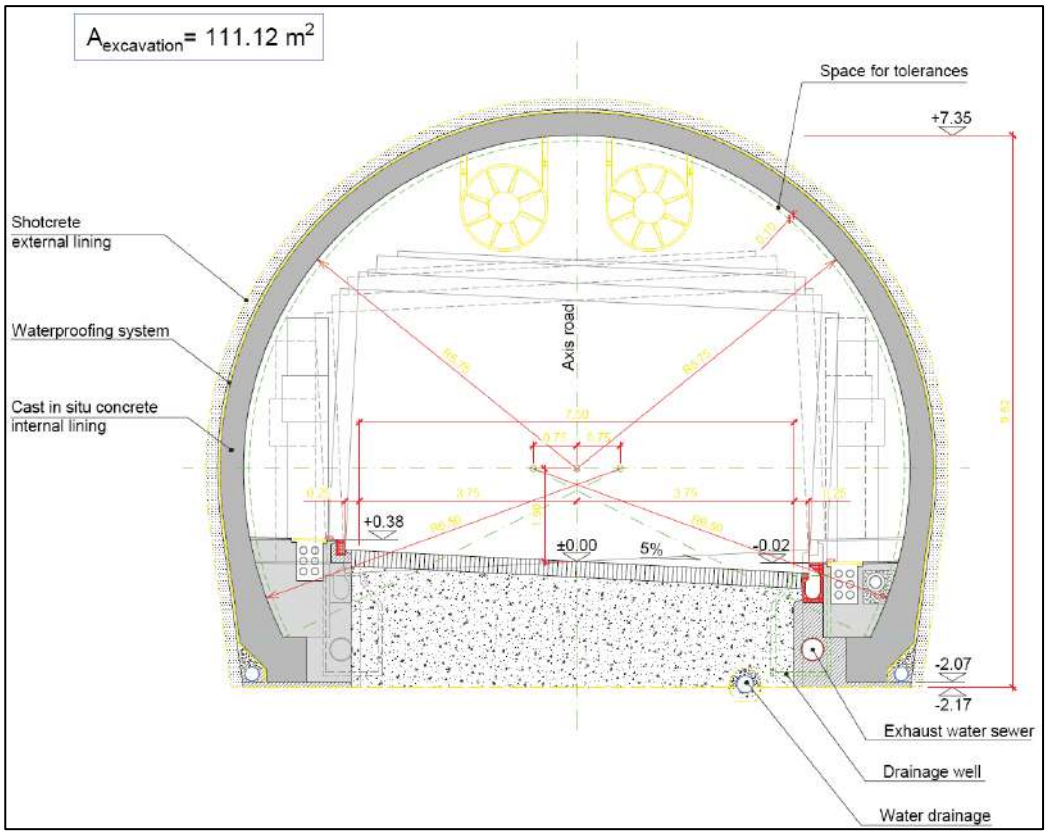


Figure 4.4: Road tunnel cross section type 1

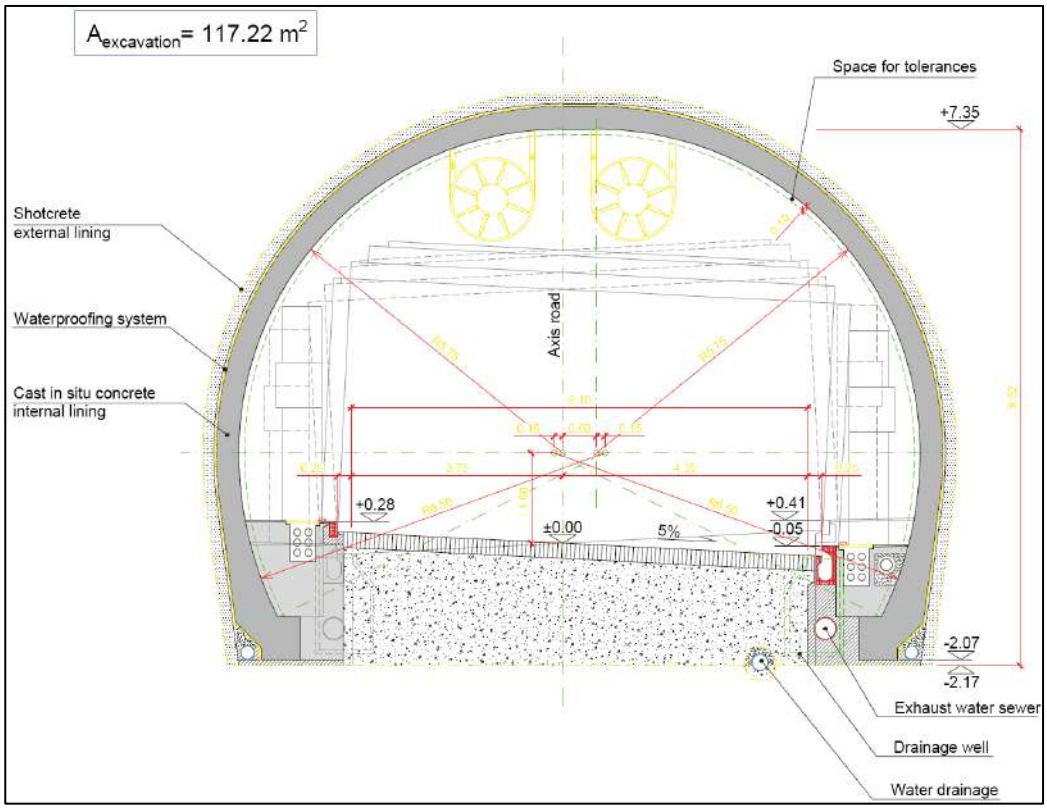


Figure 4.5: Road tunnel cross section type 2

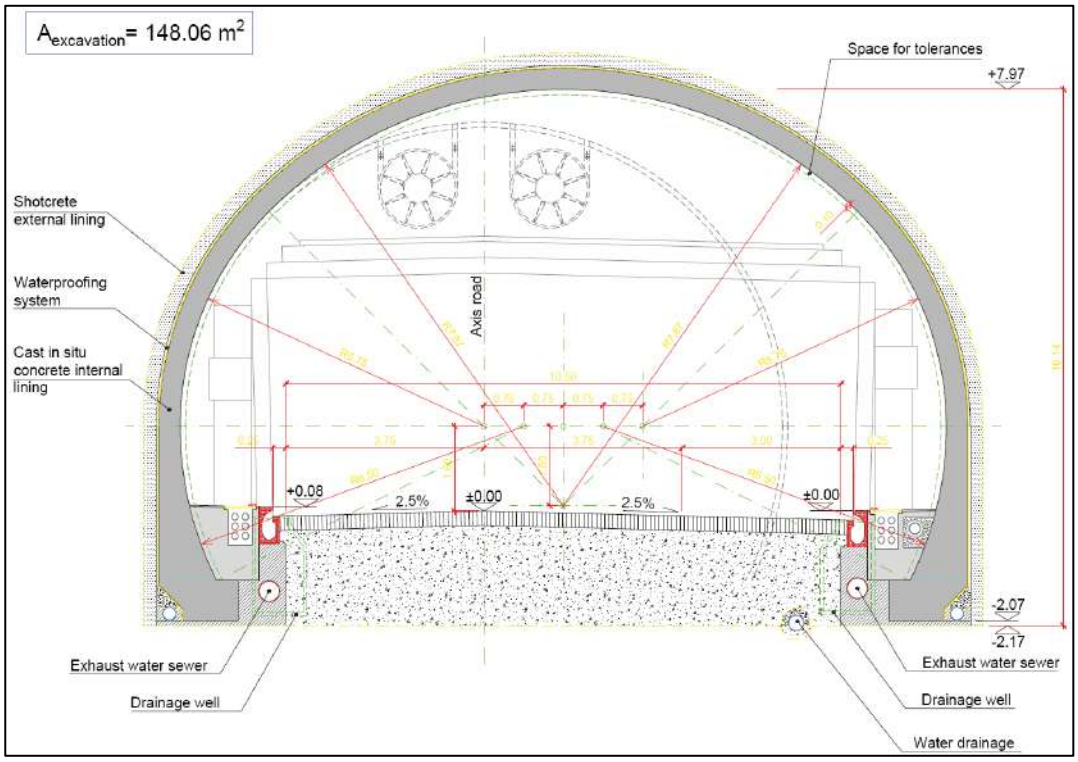


Figure 4.6: Road tunnel cross section type 3

Generally, the cross section type 1 is applied. The cross section type 2 is constructed in the area of long curve in the southern part of the Siddhababa tunnel. For the 42 m long break-down bays, the cross section type 3 is used. This information is summarised in Table 4.3.

Table 4.3: Tunnel sections with different cross section types (see also Figure 4.3)

Sections with different cross sections	Section length	Cross section type	Tunnel km	Chainage
1	95 m	Type 1	0 m	1’600 m
			95 m	1’695 m
2	430 m	Type 2		
			525 m	2’125 m
3	33 m	Type 1		
			558 m	2’158 m
4	42 m	Type 3		
			600 m	2’200 m
5	3 m	Type 1		
			603 m	2’203 m
6	42 m	Type 3		
			645 m	2’245 m
7	485 m	Type 1		
			1’130 m	2’730 m

4.2.2 Bypass tunnels

The longitudinal profiles of the bypass tunnels are given in Table 4.4 to Table 4.6.

Table 4.4: Longitudinal profile of the bypass tunnel 1 (bypass tunnel south), from the parallel road to the Siddhababa tunnel

Section number	Section length	Section slope	Tunnel km	Chainage	Altitude
1	127 m	1.0%	0 m	6 m	208 m
			127 m	133 m	209 m
5	28 m	-2.0%			
			155 m	161 m	207 m
Total length and difference in altitude:			155 m		1 m

Table 4.5: Longitudinal profile of the bypass tunnel 2 (bypass tunnel south), from the parallel road to the Siddhababa tunnel

Section number	Section length	Section slope	Tunnel km	Chainage	Altitude
1	21 m	1.0%	0 m	6 m	212 m
			21 m	27 m	213 m
2	88 m	9.1%			
			109 m	115 m	220 m
3	20 m	-2.0%			
			129 m	135 m	220 m
Total length and difference in altitude:			129 m		8 m

Table 4.6: Longitudinal profile of the bypass tunnel 3 (bypass tunnel south), from the parallel road to the Siddhababa tunnel

Section number	Section length	Section slope	Tunnel km	Chainage	Altitude
1	13 m	1.0%	0 m	6 m	217 m
			19 m	25 m	218 m
2	89 m	12.4%			
			107 m	113 m	228 m
3	23 m	-2.0%			
			125 m	131 m	228 m
Total length and difference in altitude:			125 m		11 m

The given cross section for the bypass tunnels is shown in Figure 4.7 and the information regarding the bypass tunnel area and the perimeters is summarised in Table 4.7.

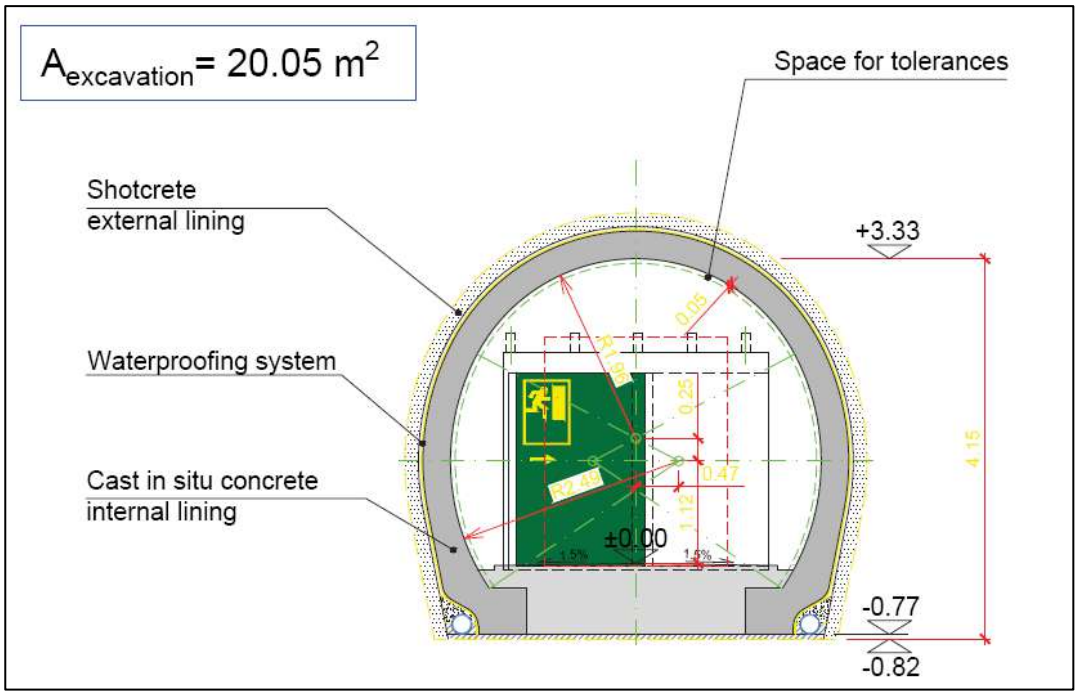


Figure 4.7: Cross section of bypass tunnels

Table 4.7: Information of cross section for the bypass tunnels

	Excavation area	Tunnel area (measured)	Perimeter (measured)
Cross section	20.05 m²	12 m²	13 m

4.3 Traffic

The Siddhababa tunnel has to be designed for forecasted traffic for the following years (according to [1]):

- Design year (i.e. tunnel opening year): 2023
- Design year + 20 years: 2043

It was informed that the yearly traffic increase of 7% is not to be applied to this project.

According to traffic counts, following data was provided to us:

- Average Annual Daily Traffic (AADT) for both traffic directions: 12'444
- Thereof:
  - Heavy goods vehicles (trucks, busses, utility vehicles, tractor): 1'474
  - Passenger cars (car/taxi/motorised three, rickshaw, bullock): 1'886
  - Motorcycles: 9'084

Irrespectively of the traffic forecast, the tunnel ventilation is dimensioned to cater for traffic of up to 20'000 PCU.

For the calculation of the piston effect in of the vehicles and the blockage by standing vehicles, only heavy goods vehicles and passenger cars are being considered. Based on this, it can be concluded that 44% of genuine vehicles are heavy good vehicles.

Table 4.8: Vehicle types and equivalent factors, [1], section 4.2

SN	Vehicle Type	Equivalency Factor
4	Bicycle,Motorcycle	0.5
1	Car, Auto Rickshaw, SUV,Light Van and Pick Up	1.0
2	Light (Mini) Truck, Tractor, Rickshaw	1.5
3	Truck,Bus,Minibus,Tractor with trailer	3.0
5	Non-motorized carts	6

4.4 Meteorology

4.4.1 Wind

Ten numbers of txt-Files with wind measurements are provided. Table 4.9 shows the summary of the analysis of the data.

Table 4.9: Analysis of provided wind data

	AW070720.03.txt	AW070720.04.txt	AW070720.05.txt	AW070720.06.txt	AW070720.07.txt	AW070720.10.txt	AW070720.11.txt	AW070720.12.txt	AW070720.13.txt	AW070720.14.txt
Minimum	0.0	0.1	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0
Maximum	9.4	21.7	11.0	13.5	11.1	5.4	6.1	7.2	5.6	5.5
Average	2.5	2.8	2.5	2.7	3.2	0.2	0.5	0.6	0.7	0.4
90-percentile	4.9	5.7	5.5	5.5	6.2	0.5	1.3	1.8	2.1	1.5
95-percentile	5.9	6.9	6.8	7.5	8.1	1.2	2.2	2.4	3.0	2.3
98-percentile	6.7	9.3	7.8	8.9	10.1	3.4	3.3	2.9	3.6	3.1

→

	Minimum	Average	Maximum
Minimum	0.0	0.0	0.1
Maximum	5.4	9.7	21.7
Average	0.2	1.6	3.2
90-percentile	0.5	3.5	6.2
95-percentile	1.2	4.6	8.1
98-percentile	2.9	5.9	10.1

↓

The above values are in [km/h] and the correspondig values in [m/s] are as follows:

	Minimum	Average	Maximum
Minimum	0.0	0.0	0.0
Maximum	1.5	2.7	6.0
Average	0.1	0.5	0.9
90-percentile	0.1	1.0	1.7
95-percentile	0.3	1.3	2.3
98-percentile	0.8	1.6	2.8

Upon request, it was informed that the unit of the values is km/h. Further, information with regard to the wind direction is not given. However, as a worst-case scenario the given data can be applied to the direction of the portals.

The wind data was measured in the years 2003 till 2014 at Bhairahawa (Lat. 27.529030555556, Lon. 83.4581166666669), which is about 20 km south of the tunnel location, see Figure 4.8. It was confirmed that the provided wind data was measured 10 m above ground level.

As the wind data shows fairly low air velocities, the typical maximum value for mountain regions of 30 Pa, was implemented as portal pressure for the dimensioning.

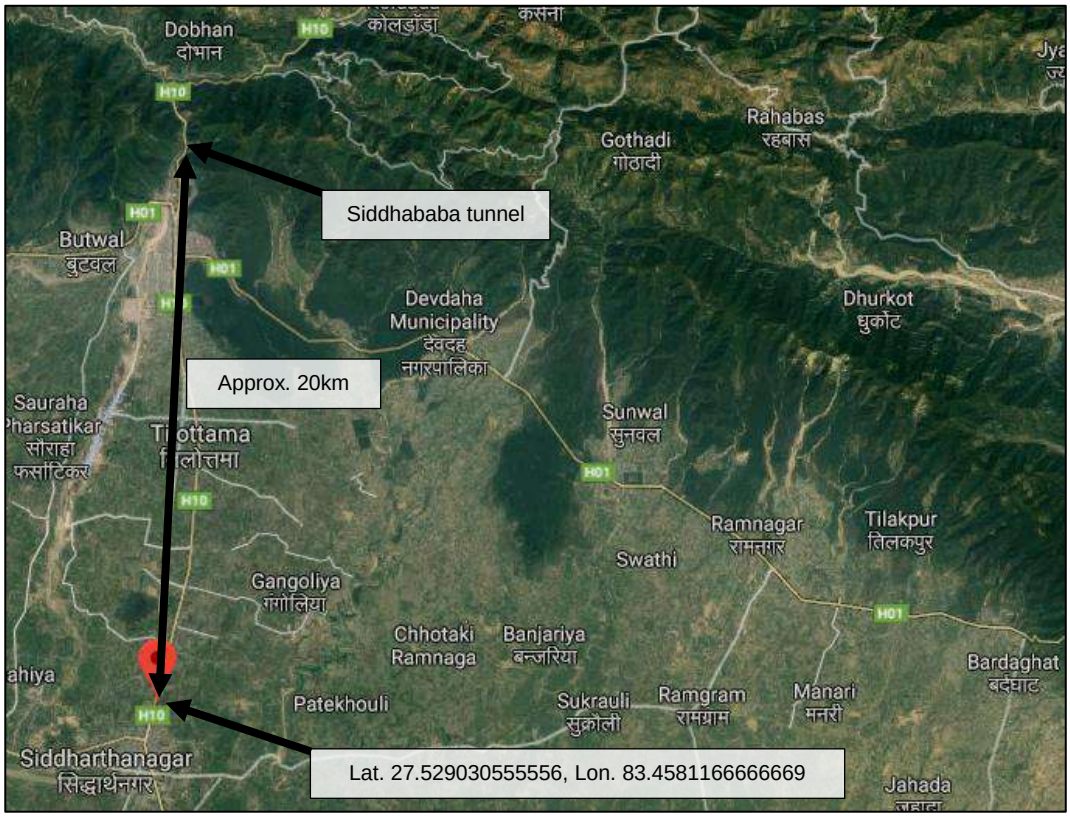


Figure 4.8: Comparison of location of tunnel and location of given wind data

4.4.2 Temperature

Ten numbers of txt-Files with temperature measurements are provided. Table 4.10 shows the summary of the analysis of the data.

Table 4.10: Analysis of provided temperature data

	TA070320.08.txt		TA070320.09.txt		TA070320.10.txt		TA070320.11.txt		TA070320.12.txt		TA070320.013.txt		TA070320.14.txt		TA070320.15.txt		TA070320.16.txt		TA070320.17.txt	
	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin
Minimum	16.2	7.0	13.5	7.0	11.5	7.0	11.0	6.0	12.5	6.5	8.0	5.2	11.4	7.0	12.0	5.6	12.6	4.5	19.5	5.0
Maximum	39.0	29.0	41.5	30.0	43.0	32.0	39.4	24.0	42.0	28.5	25.4	14.6	42.5	29.4	535.5	29.5	42.6	28.0	41.5	29.6
Average	30.6	21.3	31.4	21.4	31.0	21.4	31.7	16.7	30.7	18.8	19.7	8.8	30.0	19.6	31.7	19.6	31.7	18.9	31.7	19.3
90-percentile	36.5	26.5	37.4	27.5	38.0	27.5	37.0	20.2	39.3	23.9	24.8	12.6	38.0	25.6	36.6	26.0	38.0	24.5	37.0	25.5
95-percentile	37.8	27.2	38.5	28.0	39.5	28.0	38.0	21.0	40.2	24.2	25.0	13.1	39.0	26.6	38.0	26.8	40.5	25.0	39.2	26.5
98-percentile	38.5	27.6	39.8	28.5	40.5	29.0	38.4	22.0	41.0	25.0	25.2	13.8	40.4	27.5	39.9	27.5	41.6	26.0	39.9	27.5

Tmax			
	Min.	Av.	Max.
Minimum	8.0	12.8	19.5
Maximum	25.4	89.2	535.5
Average	19.7	30.0	31.7
90-percentile	24.8	36.3	39.3
95-percentile	25.0	37.6	40.5
98-percentile	25.2	38.5	41.6

Tmin			
	Min.	Av.	Max.
Minimum	4.5	6.1	7.0
Maximum	14.6	27.5	32.0
Average	8.8	18.6	21.4
90-percentile	12.6	24.0	27.5
95-percentile	13.1	24.6	28.0
98-percentile	13.8	25.4	29.0

According the Swiss guideline [3], it can be assumed that the temperature in the tunnel differs from the ambient temperature by 2°C for 450 m of tunnel length for tunnels in mountainous areas. Applying this relation, a temperature difference between inside and ambient of about 5°C can be assumed for the Siddhababa tunnel.

4.4.3 Barometric pressures

The Siddhababa tunnel does not underpass a mountain chain, hence the same meteorological conditions for both portals can be assumed. However, the height difference of the portals of about 35 m shall be accounted for:

- Southern portal: Chainage 1'600 m: 200 ASL
- Northern portal: Chainage 2'730 m: 235 ASL

4.5 Ventilation requirements by the Nepali Road Standard

Irrespectively of the traffic forecast, the tunnel ventilation is dimensioned to cater for traffic of up to 20'000 PCU. The design speed of the tunnel is 60 km/h.

Figure 4.9 shows a note on the dependence of the ventilation costs.

k. Ventilation costs depend on length, grades, natural and vehicle-induced ventilation, type of system, and air quality constraints.

Figure 4.9: Note regarding the dependence of the ventilation costs, [1], section 17.3

Tunnels of more than 150 m length should be provided with artificial ventilation. It is assumed that this requirement applies to road tunnels and not to bypass tunnels.

n. Tunnels of more than 150m length should be provided with artificial ventilation.

Figure 4.10: Requirement regarding mechanical ventilation, [1], section 17.3

The maximum air speed within the tunnel from mechanical ventilation shall not be more than 6 m/s, see Figure 4.11.

o. Maximum speed of air inside the tunnels(without considering the motion of air due to movement of vehicles) from artificial ventilation should be 6m/s.

Figure 4.11: Limitation of air speed due to mechanical ventilation, [1], section 17.3

4.6 Other guidelines for the ventilation design

In addition to the requirements by section 4.5 and [1], the tunnel ventilation design of the Siddhababa tunnel is based on the Swiss tunnel ventilation design code.

4.7 Constraints on equipment

It was informed that jet fans with an outer diameter of 1.5 m comply with the required distances to the tunnel and the traffic envelope according the Swiss standards and guidelines.

5 Tunnel-ventilation concept and dimensioning

5.1 Selection of ventilation system

The Swiss design guideline provides a methodology to determine the ventilation system based on the tunnel length and secondary tunnel characteristics, see Figure 5.1.

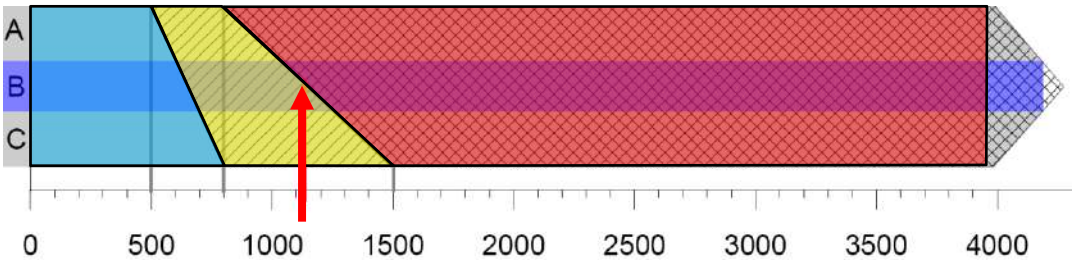


Figure 5.1: Comparison of location of tunnel and location of given wind data
blue: no mechanical ventilation;
yellow: longitudinal ventilation;
red: with smoke duct

After the evaluation of the total traffic data, the percentage of HGV and the level of inclination of the tunnel, the category of the Siddhababa was set to category “B”. In combination with the tunnel length of 1’130 m, the Siddhababa is in the region where longitudinal ventilation system is acceptable

5.2 Dimensioning for the fire case

The fire case is dimensioned for a fire size of 30 MW and the tunnel filled 50% with vehicles, as vehicles stop on both sides of the fire.

Details of the computations are documented in Appendix A: Dimensioning cases for fire ventilation.

5.3 Ventilation system for normal operation

The tunnel ventilation system dimensioned for the fire case can achieve fresh-air supply of 285 m³/s i.e. 252 m³/s per kilometre, which with a comfortable margin is judged to be more than adequate for normal operation.

5.4 Ventilation equipment

5.4.1 Jet fans

Calculations were performed assuming standard jet fans with the largest possible impeller diameters i.e. 900 mm, 1000 mm and 1120 mm. The results showed that the largest jet fan was the most suitable.

The jet fans shall be of reversible type. As the tunnel is short and the space to fit jet fan groups is limited, the largest jet fan that will fit into the tunnel cross section shall be used. This results in a jet fan with an impeller diameter of 1120 mm. The following table summarises the main specifications of the jet fans that were used for the dimensioning.

Table 5.1: Main jet-fan specifications at standard condition with air density 1.20 kg/m^3

Jet Fan Specifications		
Type		Reversible
Outer diameter, max	[mm]	1500
Impeller diameter	[mm]	1120
Outlet velocity	[m/s]	32.7
Minimum thrust in still air at ρ=1,20 kg/m^3	[N]	1011
Power	[kW]	35
Voltage	[V]	400/690
Thrust efficiency	[-]	0.8
Installation factor	[-]	1.2

Table 5.2: Resulting number of jet fans

Results, number of jet fans, impeller diameter 1120 mm		
Number of jet fans per group	[-]	2
Resulting number of groups incl. one redundant group	[-]	7
Total resulting number of jet fans	**[-]**	**14**

For further details on how the dimensioning was performed, please refer to Appendix A.

5.4.2 Anemometers AVD

The AVDs are vital the airflow control during emergencies (smoke control), as the ventilation control system needs to rely on the accuracy of their measurements. Therefore, we recommend:

- the ultrasonic measurement principle (2 ultrasonic transducers typically installed at an angle of 45° to 60° to the tunnel axis operate alternately as sender and receiver), see Figure 5.2
- each indicated (and overall) measurement consists of 3 independent single measurements (which allow for a plausibility check performed by the control system) with a distance of 10 m to each other

If the space requirements shown in chapter 5.4.4.1 cannot be met and the spacing has to be reduced the measurement may be faulty. An individual check of this situation is then required.

Based on the length of the tunnel, 2 locations with groups of 3 AVDs are required to handle the fire cases in the Siddhababa Tunnel

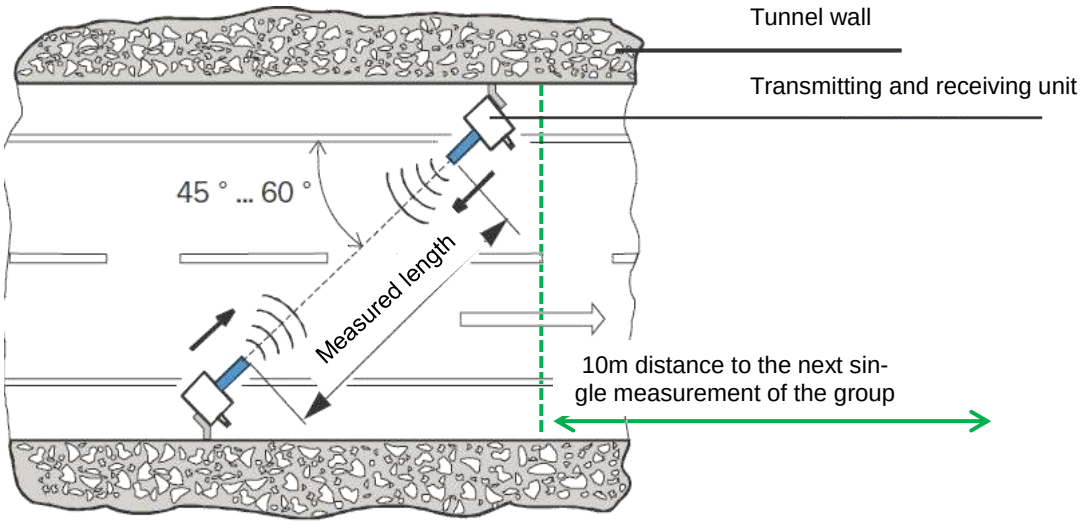


Figure 5.2: AVD-measurement point within the tunnel.

5.4.3 Air quality meters

To survey the air quality during normal operation, two air quality monitors shall be installed. The Air quality monitor shall monitor the turbidity and the CO concentration.

5.4.4 Installation requirements

5.4.4.1 Jet Fans

Jet fans shall be positioned according to the following minimum spacing [3], [4].

- Distance to the portal (vent. direction to environment): min. 100 m
- Distance between two jet fan groups: min. 100 m
- Distance to large signs: min. 100 m
- Distance to medium signs min. 60 m
- Distance to small signs: min. 30 m

The definition of the traffic sign size for ventilation purposes is based on the overall area of the sign (including frame) and is as follows:

- Large = 2.5 m^2 ≤ A_sign
- Medium = 1.0 m^2 < A_sign < 2.5 m^2
- Small = A_sign ≤ 1.0 m^2

Note: If two or more signs are located at the same location, the sign area for ventilation purposes is then determined by the overall area of all signs at that location.

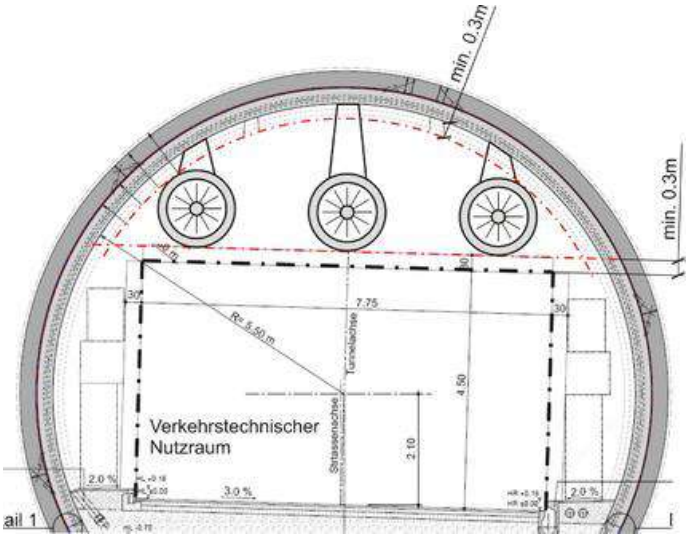


Figure 5.3: Example of jet fan installation distances to tunnel wall and traffic envelope.

Distance between casing and tunnel ceiling or side wall	min. 0.3 m
Distance between casing and traffic envelope	min. 0.3 m
Distance between the jet fans of a group	min. 1 inner fan diameter

5.4.4.2 Air Velocity and Direction Monitors

For a correct measurement of the airspeed and direction, the air-velocity and direction (AVD) monitors shall be installed in tunnel sections with a developed airflow. Depending on the size of the obstruction the airflow may need up to 7-8 hydraulic tunnel diameters to fully develop. This leads to the following space provisions for the positioning of the AVDs:

- Distance to adjacent jet fan groups: min. 100 m
- Distance to changes in cross section (breakdown bays): min. 60 m
- Distance between two AVDs of one group: min. 10 m
- Distance to large signs: min. 40 m
- Distance to medium signs: min. 20 m
- Distance to small signs: min. 5 m

The definition of the traffic sign size for ventilation purposes is based on the overall area of the sign (including frame) and is as follows:

- Large = 2.5 m² ≤ A_sign
- Medium = 1.0 m² < A_sign < 2.5 m²
- Small = A_sign ≤ 1.0 m²

Note: If two or more signs are located at the same location the sign area for ventilation purposes is then determined by the overall area of all signs at that location.

For the installation of the AVDs within the tunnel cross-section, the space provisions as shown in Figure 4 2 shall be provided.

If the AVDs are installed too close to the tunnel ceiling, reflections may occur which falsify the measurement. Interferences with other equipment have to be checked.

If these space requirements cannot be met and the AVDs have to be positioned at a lower height within the cross section, the measurement may be disturbed by high vehicles passing or interrupted in case of congestion.

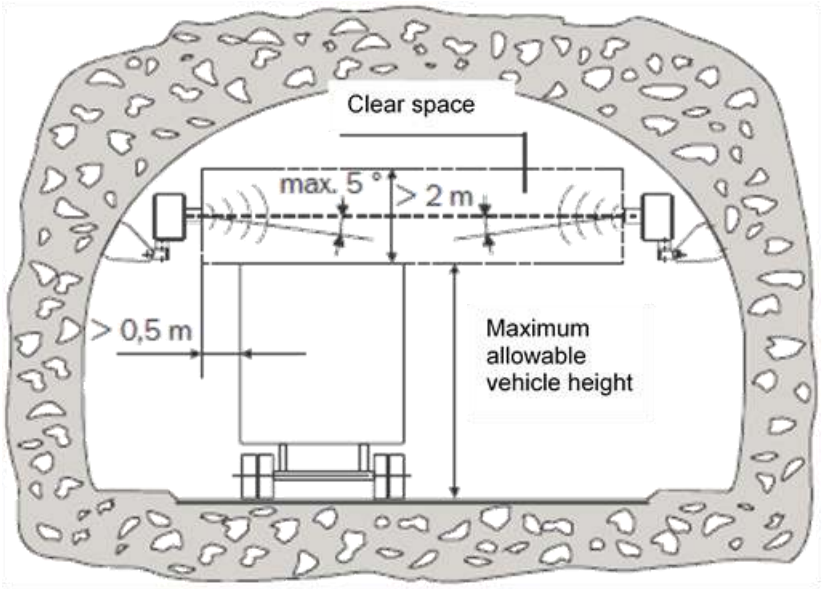


Figure 5.4: Minimum clearances for AVDs within the tunnel section.

5.4.4.3 Air quality meters

The two air-quality meters shall be located between 200 and 300 m from each portal.

5.4.5 Equipment schedule

The following table summarizes the equipment required for the ventilation of the Siddhababa Tunnel:

Table 5.3: Equipment schedule of in-tunnel equipment

Equipment Schedule	Number
Jet fans ,1120 mm impeller, 1011 N, 35 kW	14
Air velocity and direction measuring devices (ultrasonic measurements across the traffic space)	6
Air quality meters e.g. turbidity and CO combined	2

6 Egress tunnel ventilation concept and dimensioning

6.1 Overview

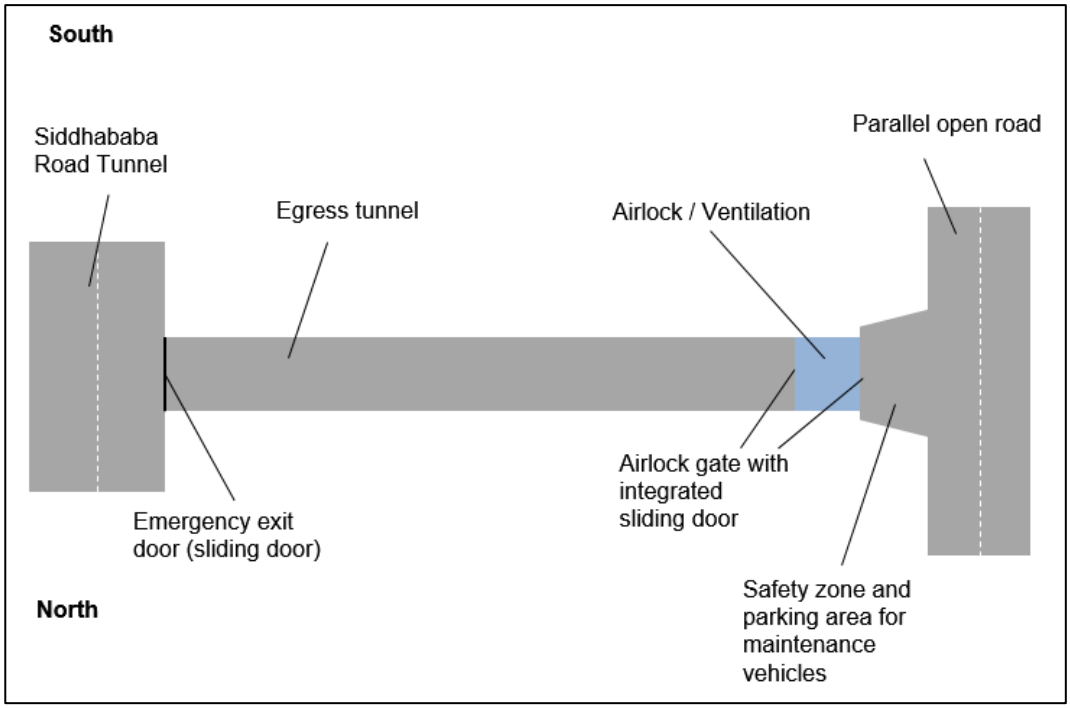


Figure 6.1: Egress tunnel with airlock at portal.

Each egress tunnel is equipped with a sliding emergency exit door at the intersection with the road tunnel. At the portal, each egress tunnel is equipped with an airlock with sliding doors on each side of the airlock. The ventilation of the egress tunnels is provided by two axial fans at the portal of each egress tunnel. The fans are installed parallel to the airlock.

6.2 Assumptions

- For the dimensioning of the fans of the egress ventilation an air speed of at least 2 m/s through open doors toward the tunnel was assumed. This value must be achieved also if one fan fails.
- For normal operation a leakage flow rate of 0.15 m³/s per door is assumed.
- The overpressure in the egress tunnel is set to 300 Pa with a pressure relief damper.

6.3 Normal operation

During normal operation, the ventilation of the egress tunnel ensures a defined overpressure relative to the traffic area. The operation of a fan at low speed (50% speed) is sufficient. The fan in operation (green in Figure 6.2) is changed periodically depending on the number of operating hours. The fan that is not in operation (grey in Figure 6.2) is shut off with a damper.

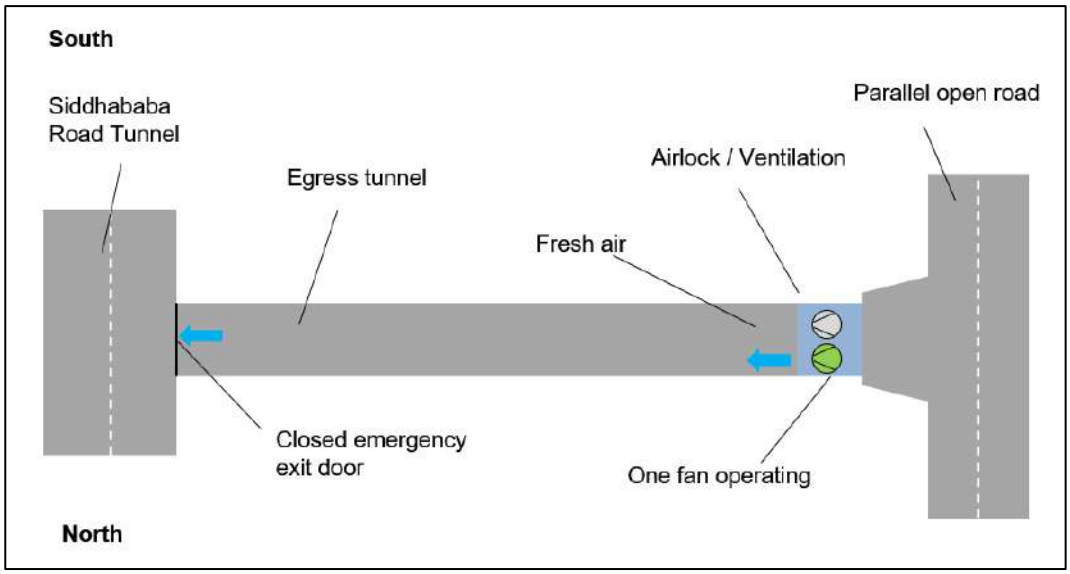


Figure 6.2: Ventilation concept for normal operation

6.4 Emergency operation

The ventilation concept for emergency operation is shown schematically in Figure 6.3. In the event of an emergency, both fans (green in Figure 6.3) operate at the full speed (100% speed). This way, the greatest possible flow is achieved through the open door and an over-pressure is built up relative to the traffic area when the door is closed.

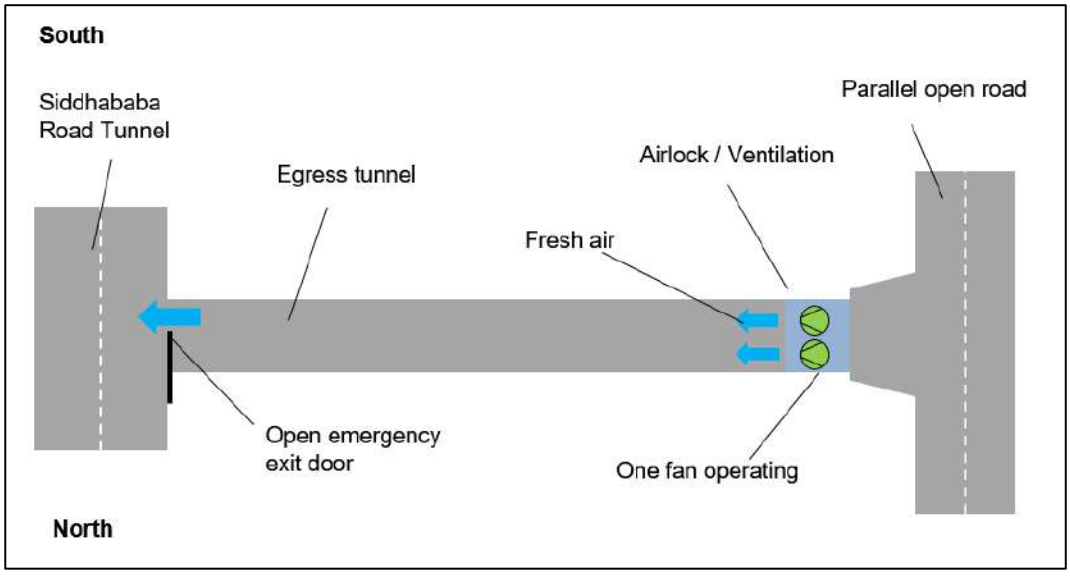


Figure 6.3: Ventilation concept for emergency operation with open door.

In order to avoid excessive pressure in the egress tunnel, a pressure relief damper is provided parallel to the fans. The damper closes as soon as the emergency exit door to the tunnel is opened and the pressure in the egress tunnel drops. In the event of a fan failure, the shut-off damper of the affected fan is closed. The egress tunnel is then ventilated with the remaining fan.

6.4.1 Redundancy

All fans of the egress tunnel ventilation system shall ideally be supplied via two independent electrical feeds.

The redundancy of the system is designed to ensure that 100% flow is achieved if one fan fails during emergency operation.

6.5 Egress tunnel ventilation equipment

6.5.1 Overview

Each ventilation system of an egress path consists of 2 axial fans with VSDs (variable speed drive), motorised shut-off dampers and flow meters. For excess pressure, a pressure relief damper with duct to the ambient is installed.

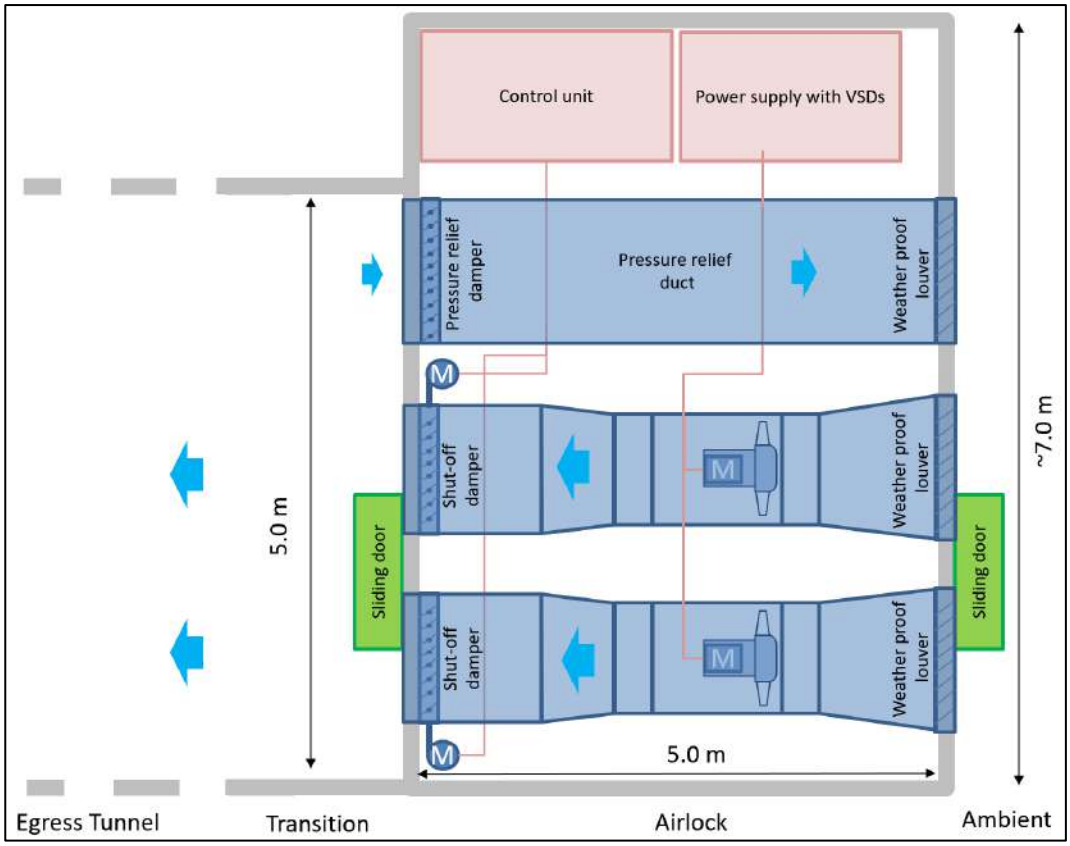


Figure 6.4: Airlock with ventilation equipment setup.

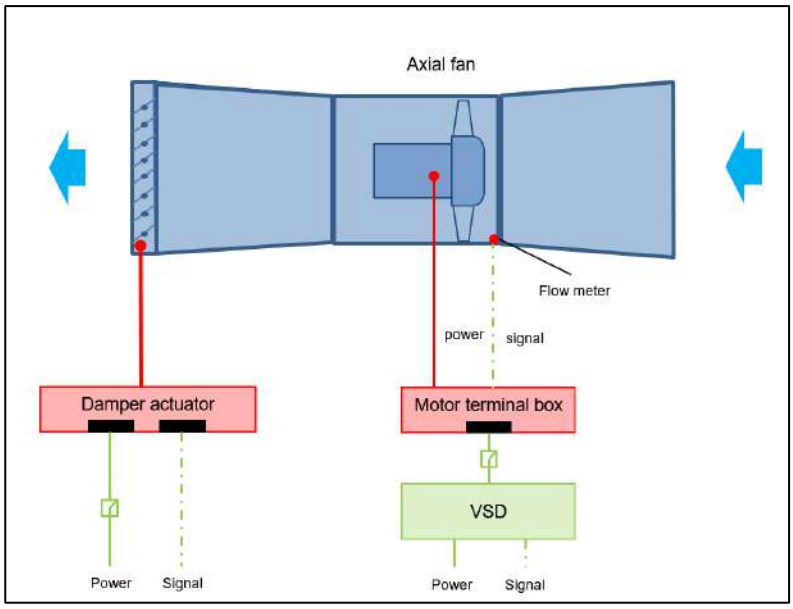


Figure 6.5: Fan unit with shut-off damper of the egress-tunnel ventilation.

In Figure 6.6, the estimated dimensions are given for the airlock including space for the ventilation equipment and electrical equipment.

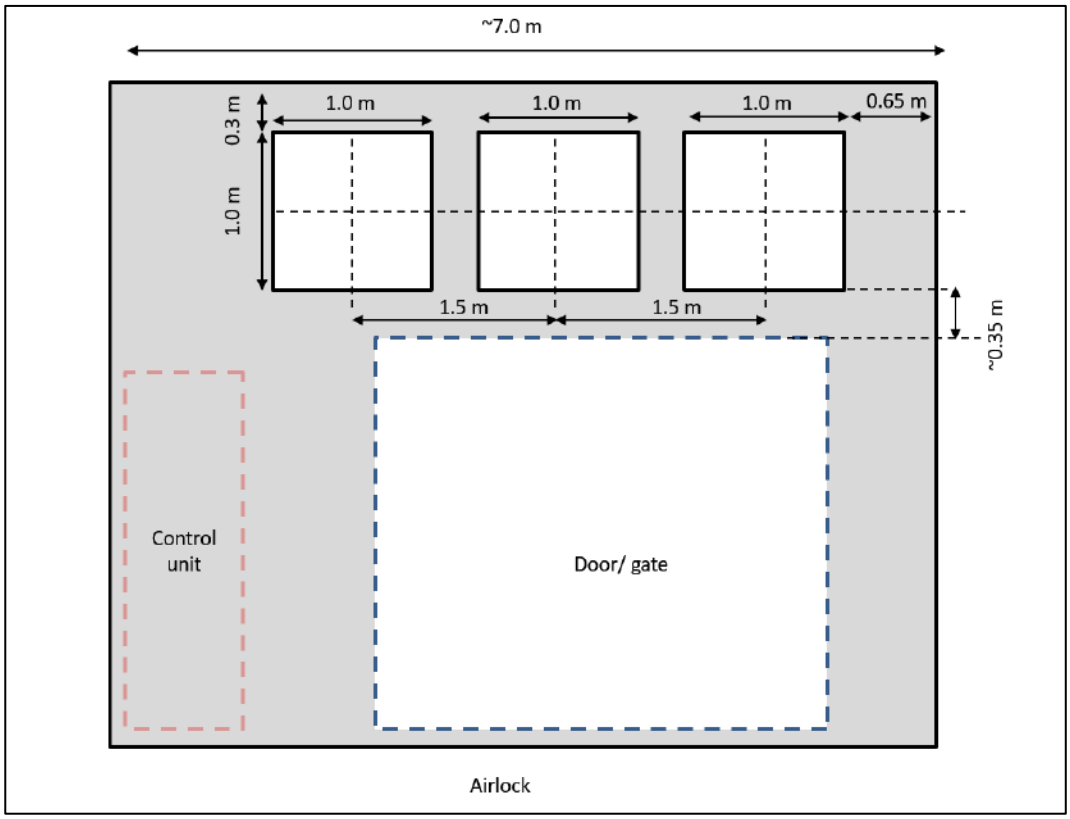


Figure 6.6: Airlock front view wall openings for ventilation equipment.

6.5.2 Monitoring devices

6.5.2.1 Damper limit switches

Each fan shut-off damper shall be equipped with a limit switch to monitor whether the damper is open or closed.

6.5.2.2 Flow meter

Each fan shall be equipped with a flow meter to determine that the fan is functioning properly.

6.5.2.3 Supervision of egress doors

Each egress door has to be supervised in such a manner that when the door is not closed, the associated egress tunnel ventilation automatically engages in emergency mode.

6.6 Equipment schedule of egress tunnel ventilation

Table 6.1: Ventilation equipment schedule of egress tunnels

Equipment Schedule considering all 3 egress tunnels	Number
Axial fans with VSD*, 800 mm impeller, 5.5 kW 6.0 m^3/s @ 280 Pa with stall-free fan curve	6
Flow meters	6
Shut-off dampers with actuators and limit switch, 0.3 kW	6
Pressure relief dampers	3

*VSD (variable speed drive)

7 References

[1] Nepal Road Standard 2070, Government of Nepal, Ministry of Physical Infrastructure & Transport, Department of Roads, Planning and Design Branch, Road and Traffic Unit, Babarmahal, Kathmandu, July 2013

[2] Road Tunnels: Vehicle Emissions and Air Demand for Ventilation, Technical Committee D.5 Road Tunnels, PIARC, World Road Association, 2018R038EN

[3] Swiss Tunnel Ventilation Design Code (Federal Roads Office “FEDRO”; Richtlinie Lüftung der Strassentunnel, Systemwahl, Dimensionierung und Ausstattung), V2.03, 2008

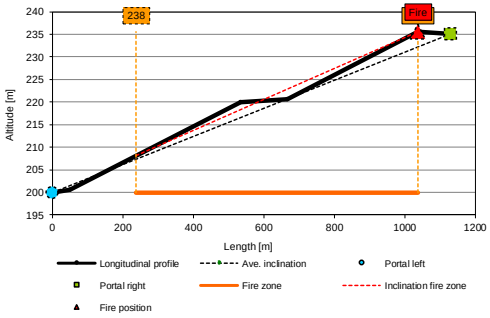
[4] Strahlventilatoren bei Portalen und in Nischen, Anordnung und Wirkungsgrad, CFD, Franz Zumsteg, 2007

Appendix A: Dimensioning cases for fire ventilation

Calculation of buoyancy due to fire and determination of the number of jet fans for longitudinal ventilation without exhaust

Project:	Siddhababa Tunnel Nepal	Reference year:	2031	Name:	NKR/RBR
Tunnel:	Siddhababa	File name:	KAL_18-304_001_V1-2_2019-06-02 - Siddhababa - SV_Längslüftung_mitAbsaugun	Date:	06.02.2019

Longitudial section of the tunnel



Geometry

Tunnel lenght L	1130 m
Gradient i (l -> r)	3,11 %
Altitude H	217,5 amsl
Tunnel cross-section A	75,00 m²
Cross-section at jetfan positions	75,00 m²
Hydraulic diameter Dh	8,82 m
Wall friction coefficient	0,015

Traffic

Significant traffic per hour STH	1000 Veh./h
HGV fraction	44,0 %
Mean cw*A vehic.	2,79 m²
Travel speed	60 km/h
Detection time	15 min
Traffic density	150 PCU/km,lane
Degree of admission	100%
Vehicles inside the tunnel	118 Veh

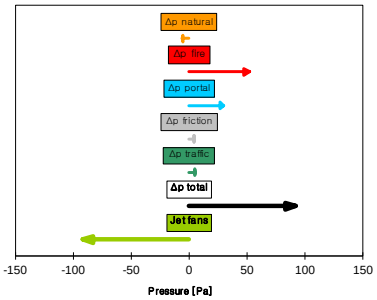
Meteorology and fire

Atmospheric pressure p(h)	98747 Pa
Atmospheric pressure p(h)	98974 Pa
External temperature (5th percentile)	13,10 °C
External temperature (95th percentile)	40,50 °C
Internal temperature	35,48 °C
Heat-release rate HRR	30 MW
Fire location (from the left portal)	1038 m
Lenght of the fire section	800 m
ΔT fire	65 K
Gradient of the fire section	3,42 %

Calculation bases

Category of traffic [OWT1, OWT2, TWT]	TWT
Extraction capacity	0 m³/s
Required flow velocity left of fire	-1,5 m/s
Required flow velocity right of fire	-1,5 m/s

Pressures at T_{A_95}



Pressure differences

Δp fire	52,20 Pa
Δp natural	-6,16 Pa
Δp portal due to wind	30,00 Pa
Δp portal effective	30,00 Pa
Δp friction	4,43 Pa
Δp traffic	5,51 Pa
Total pressure difference	**92,13 Pa**
Required thrust	**-6910 N**

Jet fans

Specifications

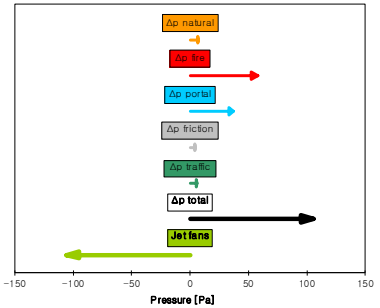
Internal diameter D	900 mm	1000 mm	1120 mm
Jet velocity	30,20 m/s	32,70 m/s	32,70 m/s
Volume flow rate	17,18 m³/s	22,24 m³/s	28,82 m³/s
Installation factor	1,2	1,2	1,2
Static thrust	557 N	756 N	1011 N

Results

Thrust of 1 jet fan	**-363 N**	**-477 N**	**-662 N**
No. of jet fans	**19,1**	**14,5**	**10,4**
Min. no. of jet fans*	**17,2**	**13,0**	**9,4**

*Redundancy case

Pressures at T_{A_5}



Pressure differences

Δp fire	57,87 Pa
Δp natural	7,13 Pa
Δp portal due to wind	30,00 Pa
Δp portal effective	37,13 Pa
Δp friction	4,68 Pa
Δp traffic	5,82 Pa
Total pressure difference	**105,50 Pa**
Required thrust	**-7913 N**

Jet fans

Specifications

Internal diameter D	900 mm	1000 mm	1120 mm
Jet velocity	30,20 m/s	32,70 m/s	32,70 m/s
Volume flow rate	17,18 m³/s	22,24 m³/s	28,82 m³/s
Installation factor	1,2	1,2	1,2
Static thrust	557 N	756 N	1011 N

Results

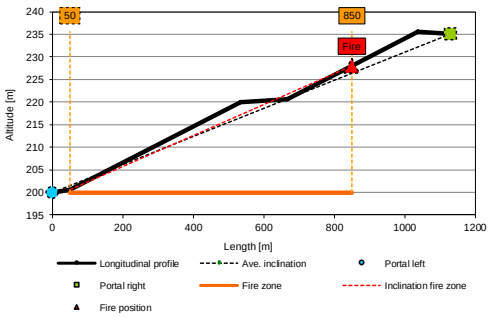
Thrust of 1 jet fan	**-383 N**	**-504 N**	**-699 N**
No. of jet fans	**20,6**	**15,7**	**11,3**
Min. no. of jet fans*	**18,6**	**14,1**	**10,2**

*Redundancy case

Calculation of buoyancy due to fire and determination of the number of jet fans for longitudinal ventilation without exhaust

Project:	Siddhababa Tunnel Nepal	Reference year:	2031	Name:	NKR/RBR
Tunnel:	Siddhababa	File name:	KAL_18-304_001_V1-2_2019-06-02 - Siddhababa - SV_Längslüftung_mitAbsaugun	Date:	06.02.2019

Longitudial section of the tunnel



Geometry

Tunnel lenght L	1130 m
Gradient i (l -> r)	3,11 %
Altitude H	217,5 amsl
Tunnel cross-section A	75,00 m^2
Cross-section at jetfan positions	75,00 m^2
Hydraulic diameter Dh	8,82 m
Wall friction coefficient	0,015

Traffic

Significant traffic per hour STH	1000 Veh./h
HGV fraction	44,0 %
Mean cw*A vehic.	2,79 m^2
Travel speed	60 km/h
Detection time	15 min
Traffic density	150 PCU/km,lane
Degree of admission	100%
Vehicles inside the tunnel	118 Veh

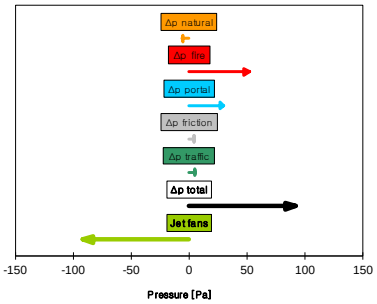
Meteorology and fire

Atmospheric pressure p(h)	98747 Pa
Atmospheric pressure p(h)	98974 Pa
External temperature (5^{th} percentile)	13,10 °C
External temperature (95^{th} percentile)	40,50 °C
Internal temperature	35,48 °C
Heat-release rate HRR	30 MW
Fire location (from the left portal)	850 m
Lenght of the fire section	800 m
ΔT fire	65 K
Gradient of the fire section	3,42 %

Calculation bases

Category of traffic [OWT1, OWT2, TWT]	TWT
Extraction capacity	0 m^3/s
Required flow velocity left of fire	-1,5 m/s
Required flow velocity right of fire	-1,5 m/s

Pressures at T_{A_95}



Pressure differences

Δp fire	52,20 Pa
Δp natural	-6,16 Pa
Δp portal due to wind	30,00 Pa
Δp portal effective	30,00 Pa
Δp friction	4,43 Pa
Δp traffic	5,51 Pa
Total pressure difference	**92,13 Pa**
Required thrust	**-6910 N**

Jet fans

Specifications

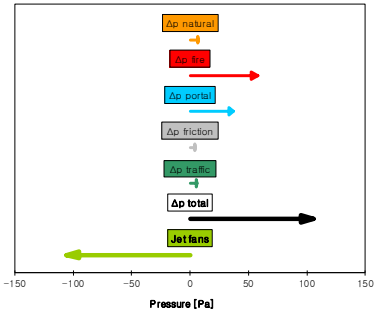
Internal diameter D	900 mm	1000 mm	1120 mm
Jet velocity	30,20 m/s	32,70 m/s	32,70 m/s
Volume flow rate	17,18 m^3/s	22,24 m^3/s	28,82 m^3/s
Installation factor	1,2	1,2	1,2
Static thrust	557 N	756 N	1011 N

Results

Thrust of 1 jet fan	**-363 N**	**-477 N**	**-662 N**
No. of jet fans	**19,1**	**14,5**	**10,4**
Min. no. of jet fans*	**17,2**	**13,0**	**9,4**

*Redundancy case

Pressures at T_{A_5}



Pressure differences

Δp fire	57,87 Pa
Δp natural	7,13 Pa
Δp portal due to wind	30,00 Pa
Δp portal effective	37,13 Pa
Δp friction	4,68 Pa
Δp traffic	5,82 Pa
Total pressure difference	**105,50 Pa**
Required thrust	**-7913 N**

Jet fans

Specifications

Internal diameter D	900 mm	1000 mm	1120 mm
Jet velocity	30,20 m/s	32,70 m/s	32,70 m/s
Volume flow rate	17,18 m^3/s	22,24 m^3/s	28,82 m^3/s
Installation factor	1,2	1,2	1,2
Static thrust	557 N	756 N	1011 N

Results

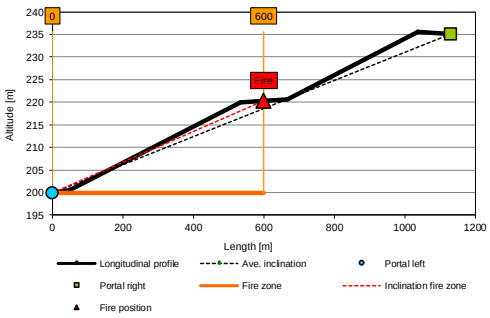
Thrust of 1 jet fan	**-383 N**	**-504 N**	**-699 N**
No. of jet fans	**20,6**	**15,7**	**11,3**
Min. no. of jet fans*	**18,6**	**14,1**	**10,2**

*Redundancy case

Calculation of buoyancy due to fire and determination of the number of jet fans for longitudinal ventilation without exhaust

Project:	Siddhababa Tunnel Nepal	Reference year:	2031	Name:	NKR/RBR
Tunnel:	Siddhababa	File name:	KAL_18-304_001_V1-2_2019-06-02 - Siddhababa - SV_Längslüftung_mitAbsaugung	Date:	06.02.2019

Longitudial section of the tunnel



Geometry

Tunnel lenght L	1130 m
Gradient i (l -> r)	3,11 %
Altitude H	217,5 amsl
Tunnel cross-section A	75,00 m^2
Cross-section at jetfan positions	75,00 m^2
Hydraulic diameter Dh	8,82 m
Wall friction coefficient	0,015

Traffic

Significant traffic per hour STH	1000 Veh./h
HGV fraction	44,0 %
Mean cw*A vehic.	2,79 m^2
Travel speed	60 km/h
Detection time	15 min
Traffic density	150 PCU/km,lane
Degree of admission	100%
Vehicles inside the tunnel	118 Veh

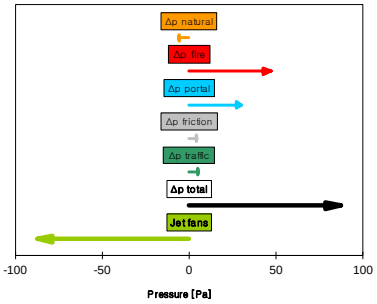
Meteorology and fire

Atmospheric pressure p(h)	98747 Pa
Atmospheric pressure p(h)	98974 Pa
External temperature (5th percentile)	13,10 °C
External temperature (95th percentile)	40,50 °C
Internal temperature	35,48 °C
Heat-release rate HRR	30 MW
Fire location (from the left portal)	600 m
Lenght of the fire section	600 m
ΔT fire	65 K
Gradient of the fire section	3,40 %

Calculation bases

Category of traffic [OWT1, OWT2, TWT]	TWT
Extraction capacity	0 m^3/s
Required flow velocity left of fire	-1,5 m/s
Required flow velocity right of fire	-1,5 m/s

Pressures at T_{A_95}



Pressure differences

Δp fire	47,39 Pa
Δp natural	-6,16 Pa
Δp portal due to wind	30,00 Pa
Δp portal effective	30,00 Pa
Δp friction	4,43 Pa
Δp traffic	5,51 Pa
Total pressure difference	**87,32 Pa**
Required thrust	**-6549 N**

Jet fans

Specifications

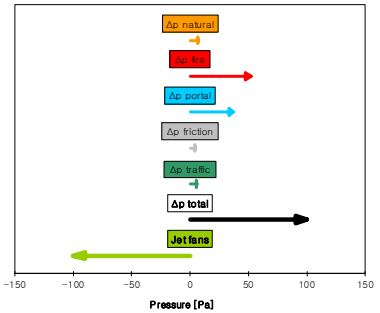
Internal diameter D	900 mm	1000 mm	1120 mm
Jet velocity	30,20 m/s	32,70 m/s	32,70 m/s
Volume flow rate	17,18 m^3/s	22,24 m^3/s	28,82 m^3/s
Installation factor	1,2	1,2	1,2
Static thrust	557 N	756 N	1011 N

Results

Thrust of 1 jet fan	**-363 N**	**-477 N**	**-662 N**
No. of jet fans	**18,1**	**13,7**	**9,9**
Min. no. of jet fans*	**16,3**	**12,4**	**8,9**

*Redundancy case

Pressures at T_{A_5}



Pressure differences

Δp fire	52,54 Pa
Δp natural	7,13 Pa
Δp portal due to wind	30,00 Pa
Δp portal effective	37,13 Pa
Δp friction	4,68 Pa
Δp traffic	5,82 Pa
Total pressure difference	**100,18 Pa**
Required thrust	**-7513 N**

Jet fans

Specifications

Internal diameter D	900 mm	1000 mm	1120 mm
Jet velocity	30,20 m/s	32,70 m/s	32,70 m/s
Volume flow rate	17,18 m^3/s	22,24 m^3/s	28,82 m^3/s
Installation factor	1,2	1,2	1,2
Static thrust	557 N	756 N	1011 N

Results

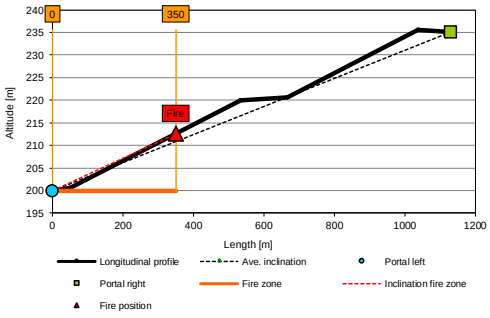
Thrust of 1 jet fan	**-383 N**	**-504 N**	**-699 N**
No. of jet fans	**19,6**	**14,9**	**10,7**
Min. no. of jet fans*	**17,6**	**13,4**	**9,7**

*Redundancy case

Calculation of buoyancy due to fire and determination of the number of jet fans for longitudinal ventilation without exhaust

Project:	Siddhababa Tunnel Nepal	Reference year:	2031	Name:	NKR/RBR
Tunnel:	Siddhababa	File name:	KAL_18-304_001_V1-2_2019-06-02 - Siddhababa - SV_Längslüftung_mitAbsaugung	Date:	06.02.2019

Longitudial section of the tunnel



Geometry

Tunnel lenght L	1130 m
Gradient i (l -> r)	3,11 %
Altitude H	217,5 amsl
Tunnel cross-section A	75,00 m^2
Cross-section at jetfan positions	75,00 m^2
Hydraulic diameter Dh	8,82 m
Wall friction coefficient	0,015

Traffic

Significant traffic per hour STH	1000 Veh./h
HGV fraction	44,0 %
Mean cw*A vehic.	2,79 m^2
Travel speed	60 km/h
Detection time	15 min
Traffic density	150 PCU/km,lane
Degree of admission	100%
Vehicles inside the tunnel	118 Veh

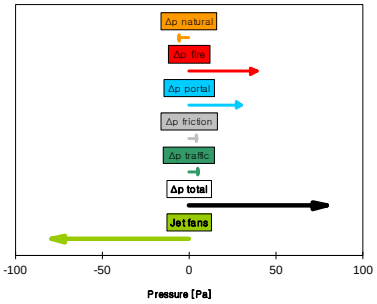
Meteorology and fire

Atmospheric pressure p(h)	98747 Pa
Atmospheric pressure p(h)	98974 Pa
External temperature (5th percentile)	13,10 °C
External temperature (95th percentile)	40,50 °C
Internal temperature	35,48 °C
Heat-release rate HRR	30 MW
Fire location (from the left portal)	350 m
Lenght of the fire section	350 m
ΔT fire	65 K
Gradient of the fire section	3,62 %

Calculation bases

Category of traffic [OWT1, OWT2, TWT]	TWT
Extraction capacity	0 m^3/s
Required flow velocity left of fire	-1,5 m/s
Required flow velocity right of fire	-1,5 m/s

Pressures at T_{A_95}



Pressure differences

Δp fire	39,29 Pa
Δp natural	-6,16 Pa
Δp portal due to wind	30,00 Pa
Δp portal effective	30,00 Pa
Δp friction	4,43 Pa
Δp traffic	5,51 Pa
Total pressure difference	**79,22 Pa**
Required thrust	**-5941 N**

Jet fans

Specifications

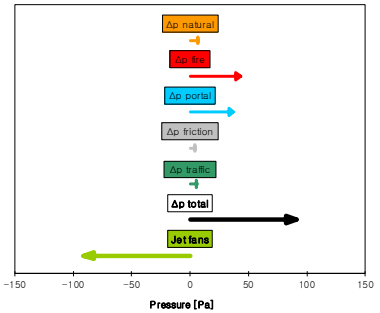
Internal diameter D	900 mm	1000 mm	1120 mm
Jet velocity	30,20 m/s	32,70 m/s	32,70 m/s
Volume flow rate	17,18 m^3/s	22,24 m^3/s	28,82 m^3/s
Installation factor	1,2	1,2	1,2
Static thrust	557 N	756 N	1011 N

Results

Thrust of 1 jet fan	**-363 N**	**-477 N**	**-662 N**
No. of jet fans	**16,4**	**12,5**	**9,0**
Min. no. of jet fans*	**14,8**	**11,2**	**8,1**

*Redundancy case

Pressures at T_{A_5}



Pressure differences

Δp fire	43,56 Pa
Δp natural	7,13 Pa
Δp portal due to wind	30,00 Pa
Δp portal effective	37,13 Pa
Δp friction	4,68 Pa
Δp traffic	5,82 Pa
Total pressure difference	**91,19 Pa**
Required thrust	**-6839 N**

Jet fans

Specifications

Internal diameter D	900 mm	1000 mm	1120 mm
Jet velocity	30,20 m/s	32,70 m/s	32,70 m/s
Volume flow rate	17,18 m^3/s	22,24 m^3/s	28,82 m^3/s
Installation factor	1,2	1,2	1,2
Static thrust	557 N	756 N	1011 N

Results

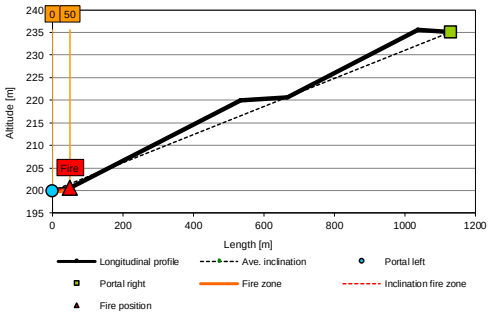
Thrust of 1 jet fan	**-383 N**	**-504 N**	**-699 N**
No. of jet fans	**17,8**	**13,6**	**9,8**
Min. no. of jet fans*	**16,1**	**12,2**	**8,8**

*Redundancy case

Calculation of buoyancy due to fire and determination of the number of jet fans for longitudinal ventilation without exhaust

Project:	Siddhababa Tunnel Nepal	Reference year:	2031	Name:	NKR/RBR
Tunnel:	Siddhababa	File name:	KAL_18-304_001_V1-2_2019-06-02 - Siddhababa - SV_Längslüftung_mitAbsaugung	Date:	06.02.2019

Longitudial section of the tunnel



Geometry

Tunnel lenght L	1130 m
Gradient i (l -> r)	3,11 %
Altitude H	217,5 amsl
Tunnel cross-section A	75,00 m²
Cross-section at jetfan positions	75,00 m²
Hydraulic diameter Dh	8,82 m
Wall friction coefficient	0,015

Traffic

Significant traffic per hour STH	1000 Veh./h
HGV fraction	44,0 %
Mean cw*A vehic.	2,79 m²
Travel speed	60 km/h
Detection time	15 min
Traffic density	150 PCU/km,lane
Degree of admission	100%
Vehicles inside the tunnel	118 Veh

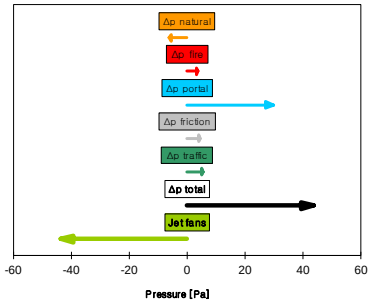
Meteorology and fire

Atmospheric pressure p(h)	98747 Pa
Atmospheric pressure p(h)	98974 Pa
External temperature (5th percentile)	13,10 °C
External temperature (95th percentile)	40,50 °C
Internal temperature	35,48 °C
Heat-release rate HRR	30 MW
Fire location (from the left portal)	50 m
Lenght of the fire section	50 m
ΔT fire	65 K
Gradient of the fire section	1,33 %

Calculation bases

Category of traffic [OWT1, OWT2, TWT]	TWT
Extraction capacity	0 m³/s
Required flow velocity left of fire	-1,5 m/s
Required flow velocity right of fire	-1,5 m/s

Pressures at T_{A_95}



Pressure differences

Δp fire	3,70 Pa
Δp natural	-6,16 Pa
Δp portal due to wind	30,00 Pa
Δp portal effective	30,00 Pa
Δp friction	4,43 Pa
Δp traffic	5,51 Pa
Total pressure difference	**43,64 Pa**
Required thrust	**-3273 N**

Jet fans

Specifications

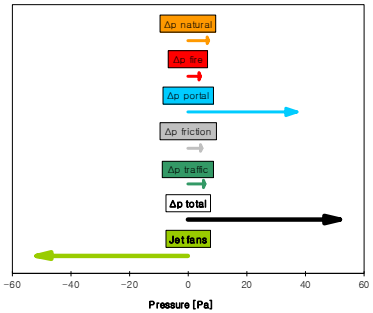
Internal diameter D	900 mm	1000 mm	1120 mm
Jet velocity	30,20 m/s	32,70 m/s	32,70 m/s
Volume flow rate	17,18 m³/s	22,24 m³/s	28,82 m³/s
Installation factor	1,2	1,2	1,2
Static thrust	557 N	756 N	1011 N

Results

Thrust of 1 jet fan	**-363 N**	**-477 N**	**-662 N**
No. of jet fans	**9,0**	**6,9**	**4,9**
Min. no. of jet fans*	**8,1**	**6,2**	**4,5**

*Redundancy case

Pressures at T_{A_5}



Pressure differences

Δp fire	4,11 Pa
Δp natural	7,13 Pa
Δp portal due to wind	30,00 Pa
Δp portal effective	37,13 Pa
Δp friction	4,68 Pa
Δp traffic	5,82 Pa
Total pressure difference	**51,74 Pa**
Required thrust	**-3881 N**

Jet fans

Specifications

Internal diameter D	900 mm	1000 mm	1120 mm
Jet velocity	30,20 m/s	32,70 m/s	32,70 m/s
Volume flow rate	17,18 m³/s	22,24 m³/s	28,82 m³/s
Installation factor	1,2	1,2	1,2
Static thrust	557 N	756 N	1011 N

Results

Thrust of 1 jet fan	**-383 N**	**-504 N**	**-699 N**
No. of jet fans	**10,1**	**7,7**	**5,5**
Min. no. of jet fans*	**9,1**	**6,9**	**5,0**

*Redundancy case

ANNEX E : MINIMUM SAFETY REQUIREMENTS FOR ROAD TUNNELS

Project Specific Section

ROCKFALL PROTECTION ALONG
SIDDHABABA SECTION OF SIDDHARTHA
HIGHWAY
Ch. 28+200 km – Ch. 30+600 km

Minimum Safety Requirements for Road Tunnels (Attached)

Employer’s Requirement (ERQ)

Minimum Safety Requirements for Road Tunnels

This Section aims at ensuring a minimum level of safety for road users in tunnels in the Strategic Road Network by the prevention of critical events that may endanger human life, the environment and tunnel installations, as well as by the provision of protection in case of accidents.

It shall apply to all tunnels in the Strategic Road Network , whether they are in operation, under construction or at the design stage.

Definition: "Emergency services" means all local services, whether public or private or part of the tunnel staff, which intervene in the event of an accident, including police services, fire brigades and rescue teams.

Definition: "Tunnel length" means the length of the longest traffic lane, measured on the fully enclosed part of the tunnel.

Safety measures :-

The Contractor shall ensure that tunnel meets the minimum safety requirements laid down as below :

1. Basis for deciding on safety measures

1.1.Safety parameters

1.1.1. Safety measures to be implemented in a tunnel shall be based on a systematic consideration of all aspects of the system composed of the infrastructure, operation, users and vehicles.

1.1.2. The following parameters shall be taken into account:

–tunnel length,

–number of tubes,

–number of lanes,

–cross-sectional geometry,

–vertical and horizontal alignment,

–type of construction,

–uni-directional or bi-directional traffic,

–traffic volume per tube (including its time distribution),

–risk of congestion (daily or seasonal),

–access time for the emergency services,

–presence and percentage of heavy goods vehicles,

–presence, percentage and type of dangerous goods traffic,

–characteristics of the access roads,

–lane width,

–speed considerations,

1.1.3. Where a tunnel has a special characteristic as regards the aforementioned parameters, a risk analysis shall be carried out to establish whether additional safety measures and/or supplementary equipment is necessary to ensure a high level of tunnel safety. This risk analysis shall take into consideration possible accidents, which clearly affect the safety of road users in tunnels and which might occur during the operating stage and the nature and magnitude of their possible consequences.

Risk analyses, where necessary, shall be carried out by a body which is functionally independent from the Contractor and Employer at Contractor Cost. The content and the results of the risk analysis shall be included in the safety documentation submitted to the Employer. A risk analysis is an analysis of risks for a given tunnel, taking into account all design factors and traffic conditions that affect safety, notably traffic characteristics and type, tunnel length and tunnel geometry, as well as the forecast number of heavy goods vehicles per day.

1.2. Minimum requirements

1.2.1. The safety measures required by the following paragraphs shall be implemented at a minimum in order to ensure a minimum level of safety in all the tunnels covered by the **Specification**.

1.2.2. In order to provide a unified interface in all tunnels to which this **Specification** applies, no derogation from the requirements of the following paragraphs shall be allowed regarding the design of the safety facilities at the disposal of the tunnel users (emergency stations, signs, lay-bys, emergency exits, radio re-broadcasting when required).

1.3. Traffic volume

1.3.1. Where "traffic volume" is mentioned in this section of Specification, it refers to the annual average daily traffic through a tunnel per lane. For the purpose of determining the traffic volume, each motor vehicle shall be counted as one unit.

1.3.2. Where the number of heavy goods vehicles over 3.5 t exceeds 15% of the annual average daily traffic, or seasonal daily traffic significantly exceeds the annual average daily traffic, the additional risk will be assessed and taken into account by increasing the traffic volume of the tunnel for the application of the following paragraphs.

2. Infrastructure measures

2.1. Number of tubes and lanes

2.1.1. The main criteria for deciding whether to build a single or a twin-tube tunnel shall be projected traffic volume and safety, taking into account aspects such as the percentage of heavy goods vehicles, gradient and length.

2.1.2. In any case, where, for tunnels at the design stage, a 15-year forecast shows that the traffic volume will exceed 10000 vehicles per day per lane, a twin-tube tunnel with unidirectional traffic shall be in place at the time when this value will be exceeded.

2.1.3. With the exception of the emergency lane, the same number of lanes shall be maintained inside and outside the tunnel. Any change in the number of lanes shall occur at a sufficient distance in front of the tunnel portal; this distance shall be at least the distance covered in 10 seconds by a vehicle travelling at the speed limit. When geographic circumstances prevent this, additional and/or reinforced measures shall be taken to enhance safety.

2.2. Tunnel geometry

2.2.1. Special consideration shall be given to safety when designing the cross-sectional geometry and the horizontal and vertical alignment of a tunnel and its access roads, as these parameters have a significant influence on the probability and severity of accidents. The geometrical requirement along with the cross sectional details shall comply the **Nepal Road Standard – 2070, 2013** and/or requirements in below paragraphs

2.2.2. Longitudinal gradients above **4%** shall not be permitted in new tunnels, unless no other solution is geographically possible.

2.2.3. In tunnels with gradients higher than **3%,** additional and/or reinforced measures shall be taken to enhance safety on the basis of a risk analysis.

2.2.4. Where the width of the slow lane is less than 3,5 m and heavy goods vehicles are allowed, additional and/or reinforced measures shall be taken to enhance safety on the basis of a risk analysis.

2.2.5 Inner section requirements: The space above the carriageway is determined by the required usable space, as well as the constructional and technical execution requirements. The usable space consists of the following elements:

- Usable space for traffic, consisting of:

  - clearance profile for passage through the tunnel;

  - space for walkways (service and emergency escape route);

  - space for equipment including any free space (safety margin).

- Usable space for constructional purposes, consisting of:

  - space for tolerances (a), which takes into account the deviations due to execution errors;

  - space for later constructional measures (b), which may be necessary during the service phase.

- Usable space for ventilation.

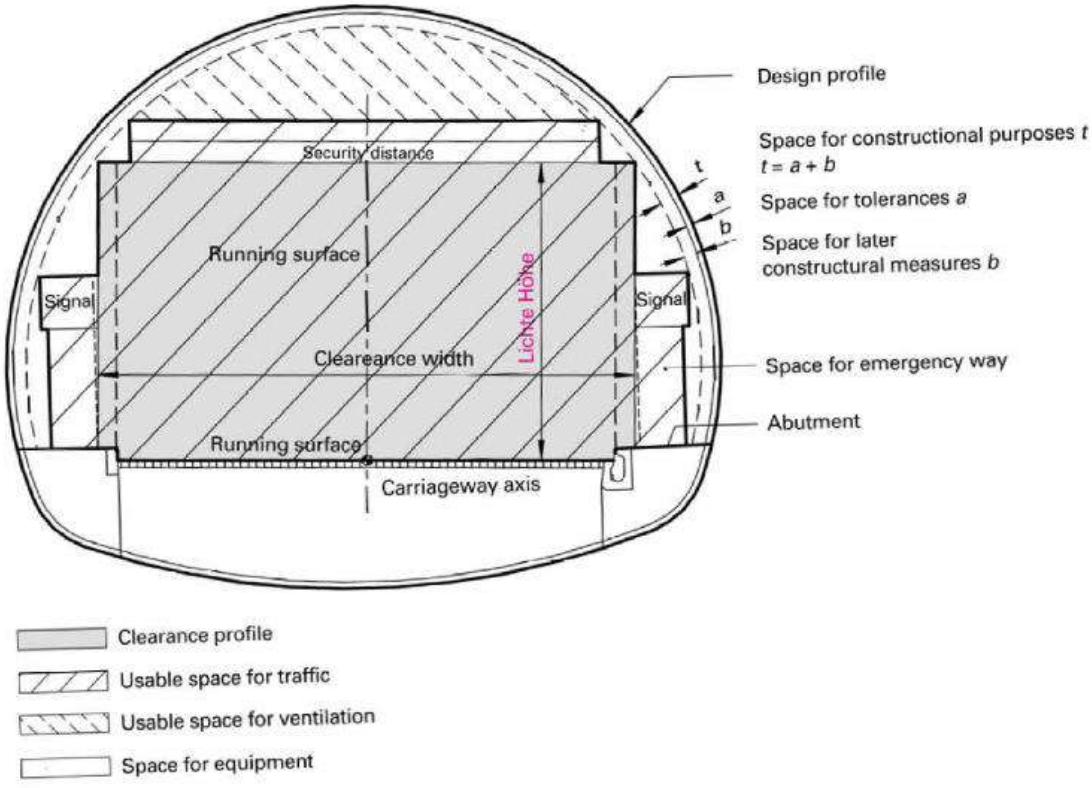


Figure 1: Definition of the usable space (road tunnels) according to SIA 197/2 Design of Tunnels – Road Tunnels

As for the inner tunnel section, minimum space requirements are defined accordingly on the base of SIA197/02 and ASTRA 11001; main dimensions are:

- Sidewalk (to be used only in case of emergency) width ≥ 1 m;
- Available height on carriageway for traffic ≥ 4.5 m + 0.3 m (safety margin);
- Additional available height for signalling and equipment ≥ 0.4 m

The space for ventilation equipment is considered into the ventilation design.

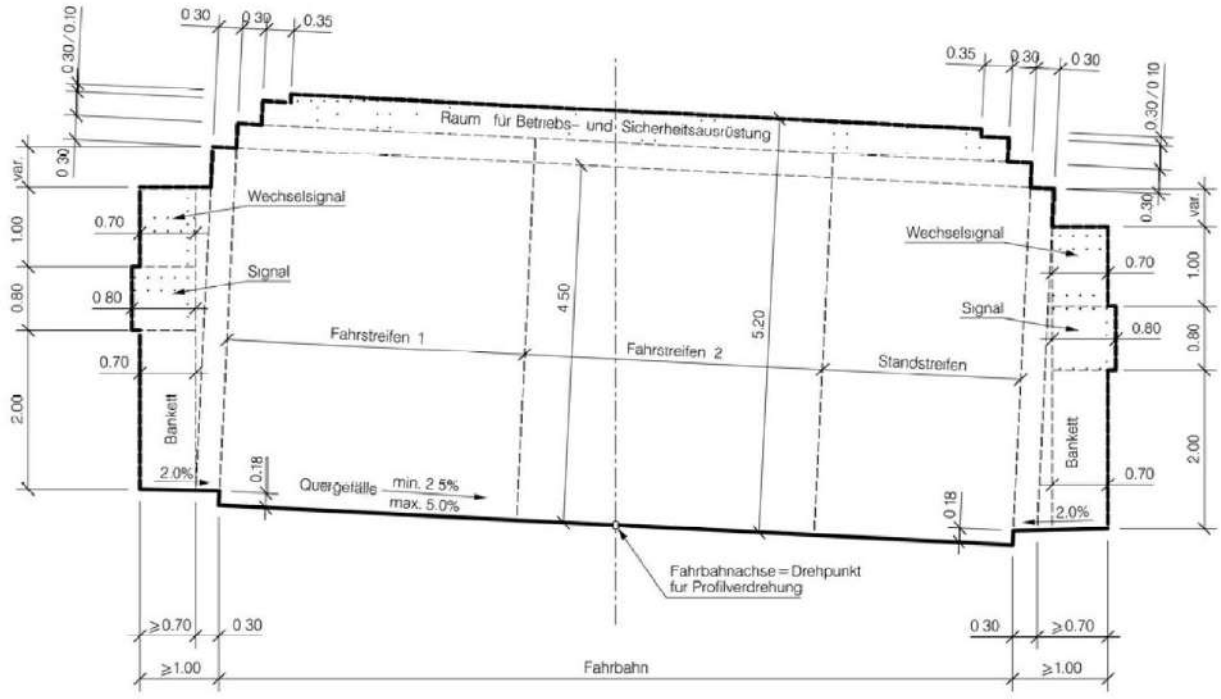


Figure 2: Operational envelope for traffic accordingly to SIA 197/2 Design of Tunnels – Road Tunnels

2.3. Escape routes and emergency exits

2.3.1. Without an emergency lane, emergency walkways, elevated or not, shall be provided for use by tunnel users in the event of a breakdown or an accident. This provision does not apply if the construction characteristics of the tunnel do not allow it or allow it only at disproportional cost and the tunnel is unidirectional and is equipped with a permanent surveillance and lane closure system.

2.3.2. Emergency exits allow tunnel users to leave the tunnel without their vehicles and reach a safe place in the event of an accident or a fire and also provide access on foot to the tunnel for emergency services. Examples of such emergency exits are:

–direct exits from the tunnel to the outside,

–cross-connections between tunnel tubes,

–exits to an emergency gallery,

–shelters with an escape route separate from the tunnel tube.

2.3.3. Shelters without an exit leading to escape routes to the open shall not be built.

2.3.4. Emergency exits shall be provided if an analysis of relevant risks, including how far and how quickly smoke travels under local conditions, shows that the ventilation and other safety provisions are insufficient to ensure the safety of road users.

2.3.5. In any event, emergency exits shall be provided where the traffic volume is higher than 2000 vehicles per lane.

2.3.6. Where emergency exits are provided, the distance between two emergency exits shall not exceed 300 m and SOS niches every 150 m or less.

2.3.7. Appropriate means, such as doors, shall be used to prevent smoke and heat from reaching the escape routes behind the emergency exit, so that the tunnel users can safely reach the outside and the emergency services can have access to the tunnel.

2.4. Access for emergency services

2.4.1. In twin-tube tunnels where the tubes are at the same level or nearly, cross-connections suitable for the use of emergency services shall be provided at least every 1500 m.

2.4.2. Wherever geographically possible, crossing of the central reserve (median strip) shall be made possible outside each portal of a twin- or multi-tube tunnel. This measure will allow emergency services to gain immediate access to either tube.

2.5. Lay-bys

2.5.1. For bi-directional tunnels longer than 1000 m where traffic volume is higher than 2000 vehicles per lane, lay-bys shall be provided at distances which do not exceed 750m, if emergency lanes are not provided.

2.5.2. Lay-bys shall include an emergency station.

2.6. Drainage

2.6.1. Where the transport of dangerous goods is permitted, the drainage of flammable and toxic liquids shall be provided for through well-designed slot gutters or other measures within the tunnel cross sections. Additionally, the drainage system shall be designed and maintained to prevent fire and flammable and toxic liquids from spreading inside tubes and between tubes.

2.6.2 Groundwater management: Water collection along the tunnel shall based on the so called “separate” water management system. It pursues the separation between clean groundwater, collected outside the tunnel lining perimeter, and polluted waters, collected inside the tunnel lining perimeter. In addition to the dirty and water polluted water management, related to road water drainage system, possible groundwater has to be managed by a proper system, based on the following elements.

2.6.3 Groundwater, coming from the surrounding rock mass, shall be collected at the foot of the tunnel vault, thanks to the drainage and waterproofing layers around the tunnel. Flushing niches collect groundwaters and allow maintenance (regular flushing) of both drainage and seepage pipes.

2.7. Fire resistance of structures

2.7.1 The main structure of all tunnels where a local collapse of the structure could have catastrophic consequences, e.g. immersed tunnels or tunnels which can cause the collapse of important neighbouring structures, shall ensure a sufficient level of fire resistance.

2.8. Lighting

2.8.1. Normal lighting shall be provided so as to ensure appropriate visibility day and night for drivers in the entrance zone as well as in the interior of the tunnel.

2.8.2. Safety lighting shall be provided to allow a minimum visibility for tunnel users to evacuate the tunnel in their vehicles in the event of a breakdown of the power supply.

2.8.3. Evacuation lighting, such as evacuation marker lights, at a height of no more than 15 m, shall be provided to guide tunnel users to evacuate the tunnel on foot, in the event of emergency.

2.9. Ventilation

2.9.1. The design, construction and operation of the ventilation system shall take into account:

–the control of pollutants emitted by road vehicles, under normal and peak traffic flow,

–the control of pollutants emitted by road vehicles where traffic is stopped due to an incident or an accident,

–the control of heat and smoke in the event of a fire.

2.9.2. A mechanical ventilation system shall be installed in all tunnels longer than 150 m.

2.9.3. In tunnels with bi-directional and/or congested unidirectional traffic, longitudinal ventilation shall be allowed only if a risk analysis shows it is acceptable and/or specific measures are taken, such as appropriate traffic management, shorter emergency exit distances, smoke exhausts at intervals.

2.9.4. Transverse or semi-transverse ventilation systems shall be used in tunnels where a mechanical ventilation system is necessary and longitudinal ventilation is not allowed under point 2.9.3. These systems must be capable of evacuating smoke in the event of a fire.

2.9.5. For tunnels with bi-directional traffic, with a traffic volume higher than 2000 vehicles per lane, longer than 3000m and with a control centre and transverse and/or semi-transverse ventilation, the following minimum measures shall be taken as regards ventilation:

–air and smoke extraction dampers shall be installed which can be operated separately or in groups,

–the longitudinal air velocity shall be monitored constantly and the steering process of the ventilation system (dampers, fans, etc.) adjusted accordingly.

2.10. Emergency stations

2.10.1. Emergency stations are intended to provide various items of safety equipment, in particular emergency telephones and extinguishers, but are not intended to protect road users from the effects of fire.

2.10.2. Emergency stations can consist of a box on the sidewall or preferably a recess in the sidewall. They shall be equipped with at least an emergency telephone and two fire extinguishers.

2.10.3. Emergency stations shall be provided near the portals and inside at intervals which for new tunnels shall not exceed 150 m.

2.11. Water supply

2.11 A water supply shall be provided for all tunnels. Hydrants shall be provided near the portals and inside at intervals which **shall not exceed 250 m**. If a water supply is not available, it is mandatory to verify that sufficient water is provided otherwise.

2.12. Road signs

2.12.1 Specific signs shall be used for all safety facilities provided for tunnel users. Signs and panels for use in tunnels are given in Annex III.

2.13. Control centre

2.13.1. A control centre shall be provided for all tunnels longer than 3000 m with a traffic volume higher than 2000 vehicles per lane.

2.14. Monitoring systems

2.14.1. Video monitoring systems and a system able to automatically detect traffic incidents (such as stopping vehicles) and/or fires shall be installed in all tunnels with a control centre.

2.14.2. Automatic fire detection systems shall be installed in all tunnels which do not have a control centre where the operation of mechanical ventilation for smoke control is different from the automatic operation of ventilation for the control of pollutants.

2.15. Tunnel closing equipment

2.15.1. In all tunnels longer than 1000 m, traffic signals shall be installed before the entrances so that the tunnel can be closed in case of an emergency. Additional means, such as variable message signs and barriers, can be provided to ensure that instructions are obeyed.

2.15.2. Inside all tunnels longer than 3000 m, with a control centre and a traffic volume higher than 2000 vehicles per lane, equipment to stop vehicles in the event of an emergency is recommended at intervals not exceeding 1000 m. This equipment shall consist of traffic signals and possibly additional means, such as loudspeakers, variable message signs and barriers.

2.16. Communication systems

2.16.1. Radio re-broadcasting equipment for emergency service use shall be installed in all tunnels longer than 1000 m with a traffic volume higher than 2000 vehicles per lane.

2.16.2. Where there is a control centre, it must be possible to interrupt radio re-broadcasting of channels intended for tunnel users, if available, in order to give emergency messages.

2.16.3. Shelters and other facilities where evacuating tunnel users must wait before they can reach the outside shall be equipped with loudspeakers for the provision of information to users.

2.17. Power supply and electrical circuits

2.17.1. All tunnels shall have an emergency power supply capable of ensuring the operation of safety equipment indispensable for evacuation until all users have evacuated the tunnel.

2.17.2. Electrical, measurement and control circuits shall be designed in such a way that a local failure, such as one due to a fire, does not affect unimpaired circuits.

2.18. Fire resistance of equipment

2.18.1 The level of fire resistance of all tunnel equipment shall take into account the technological possibilities and aim at maintaining the necessary safety functions in the event of a fire.

2.19. Table displaying informative summary of minimum requirements

The table set out hereafter gives a summary of the minimum requirements laid down in the previous paragraphs. The minimum requirements are those set out in the operative text of this table A,B,C.

Table A

Summary of Minimum Requirements		Clause	Traffic ≤ 2000 veh. per lane			Traffic > 2000 vehicles per lane				Additional conditions for implementation to be mandatory, or comments
			<150m	150-1000m	>1000m	<150m	150-1000m	1000-3000m	>3000m	
Structural Measures	2 tubes or more	2.1	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Mandatory where a 15-year forecast shows that traffic > 10000 veh./lane.
	Gradient ≤ 4%	2.2	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Mandatory unless not geographically possible
	Emergency Walkways	2.3	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Mandatory where there is no emergency lane, unless the condition in §2.3.1 is respected. In existing tunnels where there is neither an emergency lane, nor an emergency walkway additional / reinforced measures shall be taken.
	Emergency exists at least every 500m	2.3	ϴ	ϴ	Δ	Δ	Δ	Δ	Δ	Implementation of emergency exits in existing tunnels to be evaluated case-by-case.
	Cross connections for emergency services at least every 1500m	2.4.1	ϴ	ϴ / ◊	ϴ / ◊	ϴ	ϴ	ϴ / ◊	◊	Mandatory in twin-tube tunnels longer than 1500 m.
	Crossing of the central reserve outside each portal	2.4.2	◊	◊	◊	◊	◊	◊	◊	Mandatory outside twin- or multi-tube tunnels wherever geographically possible.
	Lay-bys at least every 750m	2.5	ϴ	ϴ	ϴ	ϴ	ϴ	ϴ / ◊	ϴ / ◊	Mandatory in new bi-directional tunnels >1500 m without emergency lanes. In existing bi-directional tunnels >1500 m: depending on analysis. Tunnels, depending on extra usable tunnel width.
	Drainage fro flammable and toxic liquids	2.6	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Mandatory where transport of dangerous goods is allowed.
	Fire resistance of structures	2.7	◊	◊	◊	◊	◊	◊	◊	Mandatory where a local collapse can have catastrophic consequences.

Δ Mandatory with exceptions **◊ Mandatory for all tunnels** **ϴ Not Mandatory**

Table B

Summary of Minimum Requirements		Clause	Traffic ≤ 2000 veh. per lane			Traffic > 2000 vehicles per lane				Additional conditions for implementation to be mandatory, or comments
			<150m	150-1000m	>1000m	<150m	150-1000m	1000-3000m	>3000m	
Lighting	Normal Lighting	2.8.1	Θ	◊	◊	Θ	◊	◊	◊	
	Safety Lighting	2.8.2	Θ	◊	◊	Θ	◊	◊	◊	
	Evacuation Lighting	2.8.3	Θ	◊	◊	Θ	◊	◊	◊	
Ventilation	Mechanical Ventilation	2.9	Θ	Θ	Θ	Θ	Θ	◊	◊	
	Special Provisions for (Semi-) transverse ventilation	2.9.5	Θ	Θ	Θ	Θ	Θ	Θ	◊	Mandatory in bi-directional tunnels where there is a control centre.
Emergency	At least every 150m	2.10	Θ	Δ	Δ	Θ	Δ	Δ	Δ	Equipped with telephone and 2 extinguishers. A maximum interval of 250 m is allowed in existing tunnels.
Water Supply	At least every 250m	2.11	Θ	◊	◊	Θ	◊	◊	◊	If not available, mandatory to provide sufficient water otherwise.
Road Signs		2.12	Θ	◊	◊	Θ	◊	◊	◊	For all safety facilities provided for tunnel users
Control Center		2.13	Θ	Θ	Θ	Θ	Θ	Θ	◊	Surveillance of several tunnels may be centralised into a single control centre
Monitoring Systems	Video	2.14	Θ	Θ	Θ	Θ	Θ	Θ	◊	Mandatory where there is a control centre.
	Automatic incident detection and / or fire detection	2.14	Θ	◊	◊	Θ	◊	◊	◊	At least one of the two systems is mandatory in tunnels with a control centre.
Equipments to close the tunnel	Traffic signals before the entrances	2.15.1	◊	◊	◊	◊	◊	◊	◊	
	Traffic signals inside the tunnel at least every 1000m	2.15.2	Θ	Θ	◊	Θ	Θ	◊	◊	Recommended if there is a control centre and the length exceeds 3 000 m.

Δ Mandatory with exceptions **◊ Mandatory for all tunnels** **Θ Not Mandatory**

Table C

Summary of Minimum Requirements		Clause	Traffic ≤ 2000 veh. per lane			Traffic > 2000 vehicles per lane				Additional conditions for implementation to be mandatory, or comments
			<150m	150-1000m	>1000m	<150m	150-1000m	1000-3000m	>3000m	
Communication Systems	Radio Re-broadcasting for emergency services	2.16.1	ϴ	ϴ	ϴ	ϴ	ϴ	◊	◊	
	Emergency radio messages for tunnel users	2.16.2	ϴ	◊	◊	ϴ	◊	◊	◊	Mandatory where radio is re-broadcasted for tunnel users and where there is a control centre
	Loudspeakers in shelters	2.16.3	ϴ	◊	◊	ϴ	◊	◊	◊	Mandatory where evacuating users must wait before they can reach the outside.
Emergency Poser Supply		2.17	ϴ	◊	◊	ϴ	◊	◊	◊	To ensure the functioning of indispensable safety equipment at least at during evacuation of tunnel users.
Fire Resistance of Equipments		2.18	ϴ	◊	◊	ϴ	◊	◊	◊	Shall aim to maintain the necessary safety functions

Δ Mandatory with exceptions **◊ Mandatory for all tunnels** **ϴ Not Mandatory**

3. Measures concerning operations

3.1. Operating means

Tunnel operation shall be organised and dispose of such means as will ensure the continuity and safety of the traffic through the tunnel. The personnel involved in the operation as well as the emergency services shall receive appropriate initial and continuing training.

3.2. Works in tunnels

Complete or partial closure of lanes due to construction or maintenance works planned in advance shall always begin outside the tunnel. Variable message signs, traffic signals and mechanical barriers may be used for this purpose.

3.3. Management of accidents and incidents

In the event of a serious accident or incident, all appropriate tunnel tubes shall be closed immediately to traffic.

This shall be done by simultaneous activation not only of the abovementioned equipment before the portals, but also of variable message signs, traffic signals and mechanical barriers inside the tunnel, if available, so that all the traffic can be stopped as soon as possible outside and inside the tunnel. Tunnels of less than 1000 m may be closed by other means. Traffic shall be managed in such a way that unaffected vehicles can quickly leave the tunnel.

The access time for emergency services in the event of an incident in a tunnel shall be as short as possible and shall be measured during periodic exercises. In addition, it may be measured during incidents. In major bi-directional tunnels with high traffic volumes, a risk analysis shall establish whether emergency services shall be stationed at the two extremities of the tunnel.

3.4. Activity of the control centre

For all tunnels requiring a control centre, including those starting and finishing, a single control centre shall have full control at any given time.

3.5. Tunnel closure

In the event of tunnel closure (long or short-term), users shall be informed of the best alternative itineraries, by means of easily accessible information systems.

Such alternative itineraries shall form part of systematic contingency plans. They should aim to maintain traffic flow as much as possible and minimise secondary safety effects on the surrounding areas.

The Contractor should make all reasonable efforts to avoid a situation.

3.7. Transport of dangerous goods

The following measures shall be applied concerning access to tunnels for vehicles transporting dangerous goods, as defined in the relevant Nepal legislation regarding the transport of dangerous goods by road:

– perform a risk analysis before the regulations and requirements regarding the transportation of dangerous goods through a tunnel are defined or modified,

– place appropriate signs to enforce the regulation before the last possible exit before the tunnel and at tunnel entrances, as well as in advance so as to allow drivers to choose alternative routes,

– consider specific operating measures designed to reduce the risks related to some or all of the vehicles transporting dangerous goods in tunnels, such as declaration before entering or passage in convoys escorted by accompanying vehicles, on a case by case basis further to the aforementioned risk analysis.

3.8. Overtaking in tunnels

A risk analysis shall be carried out in order to decide whether heavy goods vehicles should be allowed to overtake in tunnels with more than one lane in each direction.

3.9. Distances between vehicles and speed

The appropriate speed of vehicles and the safe distance between them are especially important in tunnels and shall be given close attention. This shall include advising tunnel users of appropriate speeds and distances. Enforcement measures shall be initiated as appropriate.

Road users driving passenger cars should under normal conditions maintain a minimum distance from the vehicle in front of them equivalent to the distance travelled by a vehicle in 2 seconds. For heavy goods vehicles, this distance should be doubled.

When traffic stops in a tunnel, road users should maintain a minimum distance of 5 metres from the vehicle in front, except if this is not possible due to an emergency stop.

3.10. Key Personnel

3.10.1 Tunnel Manager

For each tunnel, whether it is in the design, construction or operating stage, the Contractor shall appoint a Tunnel Manager responsible for the management of the tunnel at the stage in question.

Any significant incident or accident occurring in a tunnel shall be the subject of an incident report prepared by the Tunnel Manager. This report shall be forwarded to the Safety Officer, to the Employer and to the emergency services within a maximum period of one month.

Where an investigation report is drawn up analysing the circumstances of the incident or accident or the conclusions that can be drawn from it, the Tunnel Manager shall forward this report to the Safety Officer, the Employer and the emergency services no later than one month after he receives it himself.

3.10.2 Safety Officer

For each tunnel, the Tunnel Manager shall, with the prior approval of the Employer, nominate one Safety Officer who shall coordinate all preventive and safeguards measures to ensure the safety of users and operational staff. The Safety Officer may be a member of the tunnel staff or the emergency services, shall be independent in all road tunnel safety issues and shall not be under instructions from an employer in respect of those issues.

The Safety Officer shall perform the following tasks/functions:

(a) ensure coordination with emergency services and take part in the preparation of operational schemes;

(b) take part in the planning, implementation and evaluation of emergency operations;

(c) take part in the definition of safety schemes and the specification of the structure, equipment and operation in respect of tunnels;

(d) verify that operational staff and emergency services are trained, and he shall take part in the organisation of exercises held at regular intervals;

(e) give advice on the commissioning of the structure, equipment and operation of tunnels;

(f) verify that the tunnel structure and equipment are maintained and repaired;

(g) take part in the evaluation of any significant incident or accident

3.11. Inspection Entity

The Employer shall perform the inspections, evaluations and tests. Any team/person performing the inspections, evaluations and tests must have a high level of competence and high quality procedures and must be functionally independent from the Tunnel Manager.

3.12 Commissioning

3.12.1. The initial opening of a tunnel to public traffic shall be subject to authorization by the Employer in accordance with the following procedure.

3.12.2. The Tunnel Manager shall transmit the safety documentation to the Safety Officer, who shall give his opinion on the opening of the tunnel to public traffic.

The safety documentation shall describe the preventive and safeguard measures needed to ensure the safety of users, taking into account people with reduced mobility and disabled people, the nature of the route, the configuration of the structure, its surroundings, the nature of the traffic and the scope for action by the emergency services of the **Specification**.

3.12.3. The Tunnel Manager shall forward this safety documentation to the Employer, and shall attach the opinion of the Safety Officer. The Empolyer shall decide whether or not to authorize the opening of the tunnel to public traffic, or whether to do so with restrictive conditions, and shall notify this to the Tunnel Manager. A copy of this decision shall be forwarded to the emergency services.

3.12.4 Modifications

For any substantial modification in the structure, equipment or operation, which might significantly alter any of the constituent components of the safety documentation, the Tunnel Manager shall ask for a new authorisation of operation following the procedure described under point 3.12.2 & 3.12.3.

The Tunnel Manager shall inform the Safety Officer of any other change in construction and operation. Furthermore, prior to any modification work on the tunnel, the Tunnel Manager shall provide the Safety Officer with documentation detailing the proposals.

The Safety Officer shall examine the consequences of the modification and in any event give his opinion to the Tunnel Manager, who shall send a copy to the Administrative Authority and to the emergency services**.**

3.13. Signing for tunnels

3.13.1 General requirements

The following are road signs and symbols to be used for tunnels. Road signs mentioned in this section are described in the Vienna Convention on Road Signs and Signals of 1968, unless otherwise specified.

In order to facilitate international understanding of signs, the system of signs and signals is based on the use of shapes and colours characteristic of each class of sign and, wherever possible, on the use of graphic symbols rather than words.

Road signs shall be used to designate the following safety facilities in tunnels:

Lay-bys;

Emergency exits: the same sign shall be used for all kinds of emergency exits;

Escape routes: the two nearest emergency exits shall be signed on the sidewalls at distances of no more than 25 m, at a height of 1,0 to 1,5 m above escape route level, with an indication of the distances to the exits;

Emergency stations: signs to indicate the presence of emergency phones and fire extinguishers.

Radio: In tunnels where users can receive information via their radio, appropriate signs placed before the entrance shall inform users on how to receive this information.

Signs and markings shall be designed and positioned so that they are clearly visible.

3.13.2 Description of signs and panels

The contractor shall use appropriate signs, if necessary, in the advance warning area of the tunnel, inside the tunnel and after the end of the tunnel. When designing the signs for a tunnel, local traffic and construction conditions as well as other local conditions shall be considered. **Signs according to the Vienna Convention on Road Signs and Signals.**

3.13.2.1 Tunnel sign

The following sign shall be put at each entrance of the tunnel:

Sign E11A for Road Tunnels of the Vienna Convention; The length shall be included either in the lower part of the panel or on a additional panel H2.

For tunnels over 3 000 m, the remaining length of the tunnel shall be indicated every 1000 m.

The name of the tunnel may also be indicated.

3.13.2.2. Horizontal signing

Horizontal delineation should be used at the roadside edge.

In the case of bi-directional tunnels, clearly visible means should be used along the median line (single or twin) separating the two directions.

3.13.2.3. Signs and panels for signing of facilities

Emergency stations

Emergency stations shall bear informative signs, which shall be F signs according to the Vienna Convention and indicate the equipment available to road users, such as:

Emergency telephone

Extinguisher

In emergency stations which are separated from the tunnel by a door, a clearly legible text, written in appropriate languages, shall indicate that the emergency station does not ensure protection in case of fire. An example is given below:

"THIS AREA DOES NOT PROVIDE PROTECTION FROM FIRE

Follow signs to emergency exits"

Lay-bys

The signs to indicate lay-bys should be E signs according to the Vienna Convention. Telephones and fire extinguishers shall be indicated by an additional panel or incorporated in the sign itself.

Emergency exits

The signs to indicate "Emergency exits" should be G signs according to the Vienna Convention. Examples are shown below:

It is also necessary to sign the two nearest exits on the sidewalls. Examples are shown below.

Lane signals

These signs can be circular or rectangular

Variable message signing

Any variable message signs shall have clear indications to inform tunnel users of congestion, breakdown, accident, fire or any other hazards.

4.0 Requirements during Construction

4.1 General Requirements

4.1.1 Safety of Personnel

Safety of personnel on the Site is the first priority above all in all construction activities. The Contractor shall vigilantly observe the requirements described hereunder. Rules and regulations currently effective under the laws of Nepal or bylaws imposed by the local authorities shall prevail in the event of disagreement.

Suitable Personal Protective Equipment (PPE) shall be provided to all persons permitted to be on site. PPE including head protection, respiratory protection, eye protection, reflective vest, etc. shall be of the type approved by the local authorities.

The Contractor shall prepare a written statement (a booklet) of safe systems of working which shall be issued to all persons at site.

4.1.1.1 Safety Training

Persons when first employed on the Site shall be instructed in the hazards inherent in the Site, precautions to be taken, the form of construction, and emergency procedures and firefighting. The Contractor shall maintain a record of all persons on assignments and each person shall be required to sign such record confirming that instruction has been received.

In addition, the Contractor is required to hold a daily toolbox talk before entering into tunnels with the aim of promulgating the inherent risks related to the activities scheduled on the day. The toolbox talk shall be conducted by each ganger in charge of particular activities. The record of assignment mentioned above can be logged at the end of such toolbox meeting before starting the given assignments.

4.1.1.2 Fire Prevention and firefighting Arrangements

Fire protection and proper firefighting arrangements such as fire extinguishers shall be provided on the tunnelling machines, other than machines which are too small to allow personal entry. Similar arrangement shall be provided when operations may emit potentially noxious gases or fumes in addition to ventilation arrangements stated hereinafter.

4.1.2 Temporary Electrical Installations

Unless specified in the Contract, the Contractor shall be responsible for obtaining an adequate electrical supply for all his Site operations.

Installations shall comply with the current edition of the rules and regulations of the local authorities. If required by the Engineer, the Contractor shall make available a copy of all certificates prepared upon completion of electrical installations.

The Contractor shall appoint a competent person to be solely responsible for ensuring the safety of all temporary electrical installations,

4.1.2.1 Ventilation during Construction

Constant supply of high quality breathable air is one of the more challenging safety aspects for tunnel workers. The Contractor shall provide a suitable ventilation system to remove dust caused by drill/blast and shotcrete as well as exhaust gases emitted from diesel engines during construction to comply with the requirements specified in clause 4.2 and Articles 86 [Ventilation] and 89 [Safety and Health] of Standard Specification for Tunnelling – 2006: Mountain Tunnels or as specified in referred codes/standards. The ventilation rate that is required to dilute the gas emissions from diesel engines of construction machines

and dust produced during drill/blast and shotcrete application should be calculated taking account of type and numbers of equipment used inside tunnels.

For safe working of persons in the tunnels, the Contractor shall use the following limit values in calculating the total fresh air requirement at the face area;

(a) The minimum fresh air supply shall not be less than 3 m^3/minute/person measured at the face,

(b) The target dust (respiratory dust) concentration should be not more than 3 mg/m^3 measured at 50 m from the face,

(c) The minimum air velocity throughout the tunnels shall not be less than 0.3 m/second, and

(d) The maximum ambient temperature inside the tunnels shall be maintained below 30 degrees centigrade.

The Contractor shall, as a means of achieving the above values, determine the diameter of air piping and the capacity of fans, considering ventilation efficiency, machine efficiency and dimensions of profiles.

As drill/blast and shotcrete application take place at the face area, the Contractor will be required to provide a mobile dust collector attached extensible air duct at each tunnel face in order to achieve the limit value of the dust concentration.

For monitoring of the ventilation requirements, the Contractor shall provide necessary measuring devices to the satisfaction of the Engineer.

The Contractor shall submit a layout plan of his ventilation systems including dust collection systems along with a calculation of required fresh air supply for agreement with the Engineer before commencing tunnel excavation.

4.1.2.1 Lighting during Construction

Suitable and sufficient lighting shall be provided in working places and pathways, so as to secure safe working environments. Working places such as the face need sufficient light that should exceed seventy (70) lux (1 lux = 1 lumen per square meter) in order that the work can be performed safely and efficiently.

It is also necessary to light walkway areas for the safe passage of workers and the safe operation of vehicles. It may be difficult to secure uniform light in the whole walkway areas, but the light of a minimum of ten (10) lux is necessary at the darkest site and twenty (20) lux in average is desired as recommended in Article 85 [Lighting] of Standard Specifications for Tunnelling – 2006: Mountain Tunnels.

4.1.3 Security and Access Restriction

The Contractor shall be responsible for the security and tunnel entry in and around all tunnels work areas. Tunnel security and exit/entry procedures and controls shall be detailed in the Contractor's safety plan (or health and safety plan) for the Works. The Contractor shall co-ordinate and plan tunnel security and entry with others having access to the tunnels, including all interfacing contractors, so as not to disrupt or interfere with their operations.

The Contractor shall provide and maintain fences and barricades in good conditions. Notice signs shall be displayed at intervals (as consented by the Engineer) around the Site and portal areas to warn the public of the dangers of entrance.

During the progress of the Works the Contractor shall maintain security patrols over the portal areas of the Works as may be necessary to protect the work and prevent trespassing.

4.1.4 Entry/Exit Procedures

The Contractor shall establish a procedure for recording all tunnel entry and exits, preventing unauthorized tunnel entry. This procedure, as a minimum, shall incorporate name cards and entry/exit records at all tunnel portals to record the entrance and exit of all personnel.

The Contractor shall set up and operate a system whereby only those persons entitled to be on the Site and/or in the tunnels can enter the Site and/or tunnel. The Contractor shall provide specific points of entry through a security fence or barricade. The Contractor shall provide gates and barriers at such points of entry and maintain a twenty-four-hour security guard or other security personnel as necessary to maintain security and prevent unauthorized entry

4.1.5 Temporary Communication Systems

The Contractor shall provide both a complete wired and a wireless telephone communication system capable of providing clear and concise communication between all tunnel works and the tunnel portals. The communication systems shall also provide for communication between the tunnel works, Contractor's site office, and Employer's and Engineer's site offices.

The Contractor shall maintain at all times both wired and wireless communication systems in full working order during construction. The communication systems and equipment shall be suitable for use in all area, providing clear and dependable communication. This shall be subject to approval by relevant authority prior to use as the case may be.

The communication systems shall incorporate underground communication stations (telephone receptacle with bell and Indication lamp) within 50-metre of any work and at 100-meter intervals along the driven tunnel. The Contractor shall provide and maintain communication systems until the completion and acceptance of all tunnel works or as otherwise required by the Engineer.

4.1.6 Daily Records/Reports

(a) Notwithstanding reports on other work activities, the Contractor shall prepare daily records and reports of all tunnel works that shall include the following information and data, or as directed by the Engineer.

- duration of sequential excavation,
- all personnel working in tunnel areas,
- work stoppage, with reason for stopping work,
- all instrument recordings with appropriate graphs,
- weather conditions,
- tunnel work equipment,
- tunnel water inflows,
- size of excavated sections,
- length of advance,
- station numbers,
- photographs (not less than 12 Megapixels) of all tunnel faces after excavation, before support system installation,
- the location and number of supports system members etc. for each round, and
- reports and records required under specific specification requirements.

(b) Unless agreed with the Engineer, the Contractors daily records/report shall be submitted to the Engineer before 10 AM on the following working day, and

(c) The Contractor shall, as witnessed in the presence of the Engineer, record in detail geological conditions and prepare geological maps with necessary photographs attached to evaluate the suitability of excavation methods and supports. These details and maps shall serve as the basis for anticipating geological conditions ahead of the excavated tunnel face.

(d) The Contractor shall immediately notify the Engineer in case of substantial difference between actual geological conditions and anticipated ones, or when severe changes in geological conditions are observed.

(e) For the recording of geological data by the Engineer, the Contractor shall give all necessary assistance, and provide all workforce, facilities and equipment as may be required by the Engineer.

4.2 Safety, Hygiene and Environment Protection

(a) The Contractor shall comply with the relevant laws and regulations including laws in relation to health and safety of all persons entitled to be on the Site, particularly in confined working areas such as the tunnels. *Safety and health in underground coalmines, ILO code of practice Geneva, International Labour Office, 2009 and Underground Construction (Tunneling), OSHA 3115-06R 2003, Occupational Safety and Health Administration; may be considered as reference Occupational Safety and Health guidance.*

(b) The Contractor shall provide temporary facilities to reduce blasting noise to the threshold value imposed by the Government of Nepal (GoN).

(c) The Contractor shall minimise physical harm caused by construction vibration that impairs the value, usefulness, or normal function of properties of the nearby residents

(d) It is strongly recommended that the Contractor performs inventory surveys of the properties and maintain photo records before any blasting takes place.

(e) The Contractor shall establish a regular air monitoring scheme through which content of oxygen and noxious gases, in particular carbon dioxide, in tunnels.

(f) The Contractor shall assign a competent person to perform air monitoring required to determine proper ventilation and quantitative measurement of potentially hazardous gasses.

(g) The objective of monitoring the atmosphere in a tunnel is to ensure that it is free from levels of toxicants and that it contains sufficient oxygen for persons to breath.

(h) Routine checking/monitoring of oxygen and other noxious gases at every place where persons normally work or travel is a primary requirement in underground operations.

Entering into tunnels shall be prohibited if the oxygen level in the air is below 18%(*[a]) and the carbon dioxide level exceeds 0.5% (5000ppm) (*[b]).

The oxygen level in the tunnel air body should be monitored at each shift before other gas samples are taken

(*a), (*b): TLV-TWA (Threshold Limit Value - Time weighted Average) recommended by American Conference of Governmental Industrial Hygienists (ACGIH)

(i) Unless the local authorities/GoN provide regulations related to entry to the tunnel, the following threshold points should be strictly observed until safe working condition is confirmed by the person in charge of monitoring. Checking of these gas concentrations shall be performed at every working shifts. If required under the local regulations, the Contractor shall obtain proper approvals in writing from the local authorities/GoN for the gas detectors that the Contractor intends to use. Otherwise, the Contractor shall obtain the Engineer's agreement for the use of such gas detectors before commencing tunnel excavation.\

(j) The Contractor is responsible to disseminate the tunnel safety procedures among all persons entitled to be on the Site, including the Employer's Personnel.

(k) The Contractor shall construct, operate and maintain sedimentation systems complying to the environmental codes and regulations of the local authorities/GoN/GoN. The Contractor shall also observe the following requirements.

i) The sedimentation system shall be provided as close to the portal area as possible with at least two settlement ponds divided by the biological filters or as recommended/instructed by the local authorities/GoN.

Gas (Symbol)	Density (kg/m^3)	Physical Properties	Harmful Effects	Primary Source	TLV-TWA*[1] (ppm)
Carbon Dioxide (CO_2)	1.53	colourless, odourless, slight acid taste	asphyxiant, increased respiration	strata, breathing, oxidation processes	5,000
Carbon Monoxide (CO)	0.97	colourless, odourless, tasteless	toxic, explosive	fire, explosion, IC engines	25
Hydrogene Sulfide (H_2S)	1.54	colourless, rotten egg odour, acid taste	toxic, explosive	strata, stagnant water	10
Sulphur Dioxide (SO_2)	2.26	colourless, irritating, acid taste	toxic	oxidation of sulphide ore IC engines	2
Nitrogen Dioxide (NO_2)	1.59	irritating odour, red-brown colour bitter	toxic	blasting, IC engines	3
Nitrogen Monoxide (NO)	1.04	irritating odour, red-brown colour bitter	toxic	blasting, IC engines	25

*[1] : ***TLV-TWA (Threshold Limit Value - Time Weighted Average); it is the time weighted average concentration for a normal 8-hour workday without adverse effect【Source - American Conference of Governmental Industrial Hygienists (ACGIH)】***

ii) All ground water emanating from tunnel excavation shall be discharged into these settlement ponds, to remove oil, sand, silt and other suspended matter.

iii) A neutralizing agent and a sedimentation accelerating agent, either in liquid form or in powder form, shall be added to the contaminated water before discharging into the settlement ponds. The chemicals to be used shall conform to the laws and regulation of the relevant local authorities/GoN.

iv) The inlet to the ponds shall be designed so that water discharged into the pond will not stir up sediment previously deposited in that pond. Provision shall be made for the ability to repair or clean the pond during the progress of the Works.

v) The outflow from each settlement pond shall be so arranged as to prevent any floating oil from leaving the pond, irrespective of the volume of water entering the pond. The settlement pond shall be constructed using suitable watertight materials, and lined with PVC membrane or similar material to prevent leakage. Wire mesh fencing of 2 meters minimum height shall be installed around the perimeter of the ponds to prevent unauthorized access.

vi) The outflow channel from the pond shall be designed and constructed to the satisfaction of the Engineer and in such a manner that soil erosion is prevented.

vii) To ensure the continuing satisfactory operation of the system, the Contractor shall remove accumulations of sand, silt, oil and sludge must be removed and disposed of at the locations approved by the Engineer.

viii) Natural ground water and storm water from areas outside the immediate area of the Contractor' activities must be prevented from flowing into the pond. The Contractor shall ensure that any diversion berms or drain protecting ponds constructed below ground are adequately maintained.

ix) Temporary drains or pipelines leading from the tunnel portal to the sedimentation ponds shall be designed to adequately handle the expected maximum initial flow of tunnel. In no case shall be less than 2.5 cubic meter per minute.

x) The Contractor may, upon approval by the Engineer, employ mechanical facilities to treat water, in lieu of settlement ponds at no additional cost to the Employer.

ANNEX F : TECHNICAL REQUIREMENTS PLANT AND SYSTEMS (ESE) GENERAL TEST CRITERIA FACTORY AND SITE ACCEPTANCE

ROCKFALL PROTECTION ALONG SIDDHABABA SECTION OF SIDDHARTHA HIGHWAY
Ch. 28+200 km – Ch. 30+600 km

TENDER DOCUMENTS

VOLUME 3 – ANNEX F

TECHNICAL REQUIREMENTS
PLANT AND SYSTEMS (ESE)
GENERAL TEST CRITERIA
Factory and site acceptance

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INDEX

1. INTRODUCTION

This annex describes the general test criteria that shall be applied to the Plant and System works – Exploitation and Safety Equipment (ESE) as defined in the Sub-Clause 1.1.5.9 in Volume 2 of the Tender Documents and shall be used by the Contractor as a base to produce the complete detailed test list which needs to be included in the Technical Document Register (TDR) for each system of the tunnel. The document shall be prepared at the end of the executive design phase and submitted to the Contracting Authority for approval.

The test criteria required during operation and maintenance for each system of the tunnel are not covered by this annex. These criteria shall be provided by the contractor and included into the TDR accordingly to the specific vendor requirements.

2. APPLICABLE CODE AND STANDARDS

Accordingly to the framework conditions and assumptions already defined in the ESE technical report and design basis (Annex C, Volume 3 of the Tender Documents), the project shall refer in order of priority to (in case of different requirements, the most stringent applies): the Nepalese National Standards and regulations (where available), the applicable international standards and the Directives ("Richtlinie") and technical specifications ("Fachhandbuch" / "Technische Merkblätter") of the Swiss Federal Road Administration (FEDRO) which apply to the ESE within the body of the standards valid for the swiss national road.

The following FEDRO technical specification sets are not system related and shall therefore be considered for any of the ESE works:

- ESE Technical specifications 23001 – 121xx, Components
    - 12110 – Normalized cubicles and cabins
    - 12120 – Material selection and corrosion protection
- ESE Technical specifications 23001 – 122xx, Topics
    - 12210 – Environmental conditions
    - 12220 – EMC
    - 12230 / 12231 – Labelling system (AKS CH)

Concerning the labelling system of the components, the project *can reference*, among others, the following FEDRO related directive:

- ESE Directive – 13013, Labelling system (AKS CH)

Moreover, all the applicable Swiss norms (SN), including the SIA (Swiss Society of Engineers and Architects), the SEV (Swiss Association for electrotechnics) and the VSS (Swiss Association of road and traffic experts) standards shall also be considered.

For the electrical installations of the buildings and the low voltage distribution, the Contractor shall reference to the related Nepalese national regulations, where available. In any other case are valid the relevant international / European standards, mainly IEC 60364, low voltage installations and EN 60204 safety of machinery - electrical equipment of machines.

3. GENERAL TEST CRITERIA

Each system of the tunnel shall be tested for compliancy against the related executive project submitted by the Contractor. The general criteria included in this section shall be used by the Contractor as a basis for developing the detailed test procedure that will be effectively used for the acceptance of the tunnel systems after construction by the manufacturer (FAT - Factory Acceptance Test) and on-site during commissioning (SAT - Site Acceptance Test).

3.1. Criteria valid for all systems

This paragraph includes the general criteria which applies to all systems, i.e. which are not system specific. These general criteria refer to the test of the electrical cabinets required by each system.

3.1.1. Cabinet FAT test criteria

- Visual check of the cabinets for execution quality and general layout of the components
- Availability of the cabinets manufacturing certificates according to EN 61439, i.e. declaration of conformity, design and individual verifications
- First independent check of the low voltage cabinets to be executed by an external accredited controller in compliance with the required national and/or international standards and regulations, i.e. in order to receive the certification that allows the electrical operation of the cabinets.
- Availability and compliance of the labelling system used for the identification of components and cables
- Correspondence between the cabinet and the executive electrical drawing
- Verification of the protection equipment parameter settings against the application required values which shall be available in the electrical drawings
- Trip test of the protection switches

- Cabinet I/O interface signal check (e.g. hardwired system automatic reaction signals, if any) at the related terminal interface

3.1.2. Cabinet SAT test criteria

- Final independent check of the low voltage installation of the system and achievement of the required certification issued by an independent accredited controller to allow the system electrical operation accordingly to the relevant national and/or international standards, see FAT first independent check.
- Voltage and frequency measurements at the cabinet inlet supply terminal
- Phase rotational checks (400 VAC)
- Check of the protection switches settings depending onto the connected supplied circuits
- Proper connection to the earth and equipotential system
- Cabinet I/O interface signal check (e.g. hardwired system automatic reaction signals, if any) at the related terminal interface

3.2. Low voltage energy supply system

This paragraph specifies a list of criteria that shall be applied for the testing of the low voltage (230/400 VAC, 50 Hz) distribution system for both the normal and the emergency network.
The design of the system shall refer and comply in order of priority to (in case of different requirements, the most stringent applies): the Nepalese National Standards and regulations (where available), the applicable international standards and the related FEDRO specifications which in turn include a list of the relevant Swiss national and international standards:

- 23001 ESE Technical specifications – 111xx, Energy supply systems
    - 11140 – Low voltage (50 V to 1 kV AC)
    - 11150 – Extra low voltage (below 50 V AC, below 120 V DC)
    - 11160 – Emergency network

3.2.1. Factory acceptance test (FAT) criteria

During the factory acceptance tests the following checks shall be performed on representative components of the system (not exhaustive list):

- Cabinet FAT test criteria (see 3.1.1)
- System specific controller (PLC) FAT test criteria (see 3.8.1.1)

- Test of the low voltage system related I/O interface signals with the auxiliary system (see 3.6.3.1), simulation mode

3.2.2. Site acceptance test (SAT) criteria

During the site acceptance tests the following checks shall be performed on the complete installed system (not exhaustive list):

- Cabinet SAT test criteria (see 3.1.2)
- System specific controller (PLC) SAT test criteria (see 3.8.2.1)
- Check of the electrical measurements (voltage, current, power etc.) provided by the related measurement devices (electrical network analysers), where installed
- Test of the low voltage system related I/O interface signals with the auxiliary system (see 3.6.3.2), real mode

3.3. Lighting System

This paragraph specifies a list of criteria that shall be applied for the lighting system testing.
The design of the system shall refer and comply in order of priority to (in case of different requirements, the most stringent applies): the Nepalese National Standards and regulations (where available), the applicable international standards and the related FEDRO directive and specifications which in turn include a list of the relevant Swiss national and international standards:

- ESE Directive – 13015, Lighting systems
- ESE Technical specifications 23001 – 112xx, Lighting systems
    - 11260 – Road lighting

Whenever the generic term “lighting element” is used within this paragraph, it means that the related criteria applies to all the different lighting elements required by each lighting sub-systems, i.e. crossing, reinforcement and street lighting, fire emergency lighting, optical guide, emergency exit lighting, escape route lighting and rock-shed lighting.

3.3.1. Factory acceptance test (FAT) criteria

During the factory acceptance tests the following checks shall be performed on representative components of the system (not exhaustive list):

- Index of protection (IP) of the lighting element for compliance with environmental conditions and type of use
- Construction materials and mechanical strength of the lighting element

- For crossing and reinforcement lighting, easy handling of the lighting element even for people wearing gloves during installation or maintenance
- For crossing and reinforcement lighting, solid mechanical construction of the lighting element with no jutting part and tied components to avoid accidental loss during installation or maintenance
- Functionality of each lighting type element
- For crossing and reinforcement lighting, testing of the dimming functionality implemented via dedicated lighting interface communication bus (DSI, DALI etc.)
- For crossing and reinforcement lighting, automatic 4 levels adjustment (emergency, maximum / event, night, day) of the light intensity accordingly to the luminance probe measurements and actual conditions (e.g. event or probe fault), based on simulated values; alternative level adjustment based on internal calendar chart (ephemeris)
- Operating logic required for the other lighting sub-systems, i.e. street lighting, fire emergency lighting, optical guide, emergency exit lighting, escape route lighting and rock-shed lighting, based on simulated values
- Cabinet FAT test criteria (see 3.1.1)
- System specific controller (PLC) FAT test criteria (see 3.8.1.1)

3.3.2. Site acceptance test (SAT) criteria

During the site acceptance tests the following checks shall be performed on the complete installed system (not exhaustive list):

- Visual check of the assembled system and scope of supply
- Check of assembly and fastening of the lighting elements
- Electrical connections to each lighting element
- Position check of the lighting elements
- Check of the wirings to the luminance sensors
- Check of the expected luminance values required for the tunnel operation by measurements, i.e. the compliance of the intensity of light generated by the crossing and reinforcement lightings.
- For crossing and reinforcement lighting, automatic 4 levels adjustment (emergency, maximum / event, night, day) of the light intensity accordingly to the luminance probe

measurements and actual conditions (e.g. event or probe fault), based on measured values, alternative level adjustment based on internal calendar chart (ephemeris),

- Operating logic required for the other lighting sub-systems, i.e. street lighting, fire emergency lighting, optical guide, emergency exit lighting, escape route lighting and rock-shed lighting, based on measured values
- Cabinet SAT test criteria (see 3.1.2)
- System specific controller (PLC) SAT test criteria (see 3.8.2.1)

3.4. Ventilation System

This paragraph specifies a list of criteria that shall be applied for the ventilation system testing.
The design of the system shall refer and comply in order of priority to (in case of different requirements, the most stringent applies): the Nepalese National Standards and regulations (where available), the applicable international standards and the related FEDRO directive and related specifications which in turn include a list of the relevant Swiss national and international standards:

- ESE Directive 13001 – Road tunnels ventilation systems
- ESE Directive 13002 – Egress safety tunnels from road tunnels ventilation systems
- ESE Technical specifications 23001 – 113xx, Ventilation systems
    - 11310 – System controller
    - 11315 – System controller functions
    - 11318 – Ventilation availability requirements
    - 11319 – Signals exchange with the tunnel fire detection system
    - 11320 – Sensors, i.e. AVD anemometers and air quality monitors for CO concentration and turbidity
    - 11330 – Longitudinal ventilation

3.4.1. Factory acceptance test (FAT) criteria

- Type check of the Ventilator and fan housing
    - Size check (as per DIN 2768)
    - Weld seam inspection

- Thickness of the anti-corrosion layer (corrosion protection test)

- Dimensioning of the jet fan motors as per EN 60034
- The fan motor should be tested 6 times per hour without suffering any destruction
- In case of motorized butterfly valves/flaps (axial fans)
  - Size check
  - Functionality test
  - Corrosion protection test
  - Leakage test
- For fan blades (axial fans) that are set to heavy use following proofs should be provided
  - Hardness test as per Brinell (where applicable EN ISO 6506 1)
  - Strength tests (Tensile, Stretch, Fracture)
- Bearings should be tested for the lifespan at full load
- Bearings with lifetime lubrification by means of synthetic long-term grease and re-greasing facilities in order to allow the maintenance of the component without dismounting the ventilator, if the case
- Test protocol for electric motors stating the isolation check, resistance measurement, efficiency at different loads
- Noise emission tests (e.g. installation of sound attenuators so that the emission should not be above 104 dB(A) as per DIN 45635 – max deviation of 3 dB(A))
- Vibration check with different load conditions
- Material quality certification for all the individual parts
- Listing of all the material and the required description must be provided
- Type check of the mechanical components used for ventilator fastening. The fastening should be separately galvanized to avoid the risk of corrosion propagation when anchored in tunnel walls
- Ventilator performance measurement values against guaranteed values (e.g. thrust, electrical power, shaft power noise emissions etc.)

- Fire resistance test for smoke extraction of the ventilator at required condition (120 min @ 250 °C) accordingly to relevant standard (DIN EN 12101-3)
    - The fire test should be performed on a similar device
    - The test should be certified from a neutral fire safety test centre
- Cabinet FAT test criteria (see 3.1.1)
- System specific controller (PLC) FAT test criteria (see 3.8.1.1)
- Test of the traffic detection and counting dependent logic, simulation mode
- Test of the smoke control logic based on air-velocity and direction (AVD) anemometer values, simulation mode
- Ventilation strategies accordingly to the operating conditions and in case of event, simulation mode
- Test of the egress tunnel ventilation equipment logic as required, i.e. variable speed drive (VSD) activation, flow meter to check related fan operation when switched on, limit switch monitored shut-off damper to close in case of fan switched off and limit switch monitored pressure relief damper to close as soon as emergency door opens, simulation mode

3.4.2. Site acceptance test (SAT) criteria

- Vibrations measurement for each ventilator during operation (Vibration speed should not exceed 2.8 mm/s as per DIN 2056 anywhere on the fan housing installed at the tunnel roof)
- Test for measuring the oscillation and vibration transfer from equipment to the construction elements
- Functionality test of the flaps and butterfly valves
- Air velocity / flow measurements for each ventilator during operation
- Noise emission measurement for each ventilator during operation
- Start-up current absorption for each ventilator
- Terminal box placement should be checked
- Each jet fans should be checked for the followings:
    - Visual inspection of labelling plates

- Controlling the correct start
- Controlling the blowing directions
- Electrical current and power demand for both flow directions
- Measurement and logging of vibration in 3 axis

- Oscilloscope electrical measurements (wave components) for jet fans start-up current, switching etc.
- Cabinet SAT test criteria (see 3.1.2)
- System specific controller (PLC) SAT test criteria (see 3.8.2.1)
- Air-velocity and direction (AVD) anemometer ultrasonic probes measurement test
- Air quality meter probes (turbidity and CO combined) measurement test
- Test of the traffic detection and counting dependent logic, real mode
- Test of the smoke control logic based on AVD anemometer values, real mode
- Ventilation strategies accordingly to the operating conditions and in case of event, real mode
- Test of the egress tunnel ventilation equipment logic as required, i.e. variable speed drive (VSD) activation, flow meter to check related fan operation when switched on, limit switch monitored shut-off damper to close in case of fan switched off and limit switch monitored pressure relief damper to close as soon as emergency door opens, real mode
- Complete integration tests
- System behaviour in case of different faults (control system, supply and mechanics)
- Measurement of the environmental conditions (wind velocity, temperature, humidity and pressure) at both ends of the tunnel during the measurement tests
- Relevant operation measurements (noise emission, air velocity, pressure difference between main and egress tunnel etc.) for each operating condition and ventilation strategy

3.5. Signage System

This paragraph specifies a list of criteria that shall be applied for the signage system testing.
The design of the system shall refer and comply in order of priority to (in case of different requirements, the most stringent applies): the Nepalese National Standards and regulations (where available), the applicable international standards and the related FEDRO directive and

specifications which in turn include a list of the relevant Swiss national and international standards:

- ESE Directive 13010 – Signs for the safety systems in road tunnels
- ESE Technical specifications 23001 – 114xx, Signage systems
    - 11410 – System controller
    - 11412 – Local controller
    - 11420 – Static signage
    - 11430 – Blinker, traffic light
    - 11432 – Traffic guides
    - 11434 – Prismatic variable signage
    - 11450 – Traffic detection systems

3.5.1. Factory acceptance test (FAT) criteria

- Cabinet FAT test criteria (see 3.1.1)
- Prismatic variable signage cabinet FAT test criteria (see 3.1.1)
- Prismatic variable signage functional control, type test
- System specific controller (PLC) FAT test criteria (see 3.8.1.1)
- Communication (cellular data network) between system controller and local controller (variable signage) including interface modules, test configuration
- Test for the manual and/or automatic selection of all the required tunnel operating conditions (OC), simulation mode
- System check against compliancy with the interlock matrix defined for OC selection
- System check against the selection of not permitted (inconsistent) signal states
- Test of the traffic detection and counting dependent logic, simulation mode

3.5.2. Site acceptance test (SAT) criteria

- Cabinet SAT test criteria (see 3.1.2)

- Prismatic variable signage cabinet SAT test criteria (see 3.1.1)
- Prismatic variable signage functional control, real test
- System specific controller (PLC) SAT test criteria (see 3.8.2.1)
- Communication (cellular data network) between system controller and local controller (variable signage) including interface modules, real configuration
- Test for the manual and/or automatic selection of all the required tunnel operating conditions (OC), real mode
- System check against compliancy with the interlock matrix defined for OC selection
- System check against the selection of not permitted (inconsistent) signal states
- Calibration and Test of the traffic detection and counting stations
- Test of the traffic detection and counting dependent logic, real mode

3.6. Surveillance Systems

This paragraph specifies a list of criteria that shall be applied for the surveillance systems testing. The design of the system shall refer and comply in order of priority to (in case of different requirements, the most stringent applies): the Nepalese National Standards and regulations (where available), the applicable international standards and the related FEDRO directive and specifications which in turn include a list of the relevant Swiss national and international standards:

- ESE Directive 13004 – Tunnel fire detection systems in road tunnels
- ESE Directive 13005 – Video surveillance systems
- ESE Technical specifications 23001 – 115xx, Surveillance systems
    - 11510 – Tunnel fire detection system
    - 11530 – Auxiliary system

The surveillance systems include the following independent systems:

- Tunnel fire detection system (PLC based, SCADA integration)
- Video surveillance system (server based, SCADA monitoring)
- Auxiliary system (PLC based, SCADA integration)

The test criteria for each of these systems are described separately in the following sub paragraphs.

3.6.1. Tunnel fire detection system

3.6.1.1 Factory acceptance test (FAT) criteria

- Cabinet FAT test criteria (see 3.1.1)
- System specific controller (PLC) FAT test criteria (see 3.8.1.1)
- Configuration of the smoke control unit
- Communication with the smoke control unit connected to selected smoke detectors
- Smoke detectors fault test
- Test of the smoke detectors monitoring values, simulation mode
- Test of the smoke detectors pre-alarms / alarms thresholds, simulation mode
- Configuration of the fire control unit
- Communication with the fire control unit connected to sample temperature linear probe
- Temperature linear probe fault test
- Test of the linear probe temperature monitoring values for selected sectors, simulation mode
- Test of the linear probe temperature pre-alarms / alarms thresholds for selected sectors, simulation mode
- Test of the data recording feature (SCADA system) in case of event, simulation mode

3.6.1.2 Site acceptance test (SAT) criteria

- Cabinet SAT test criteria (see 3.1.2)
- System specific controller (PLC) SAT test criteria (see 3.8.2.1)
- Communication with the smoke control unit connected to all installed smoke detectors
- Smoke detectors fault test
- Test of the smoke detectors monitoring values, real mode
- Test of the smoke detectors pre-alarms / alarms thresholds, real mode

- Communication with the fire control unit connected to the tunnel temperature linear probe
- Temperature linear probe fault test
- Test of the linear probe temperature monitoring values for each sector, real mode
- Test of the linear probe temperature pre-alarms / alarms thresholds for each sector, real mode
- Test of the data recording feature (SCADA system) in case of event, real mode

3.6.2. Video surveillance system

3.6.2.1 Factory acceptance test (FAT) criteria

- Cabinet FAT test criteria (see 3.1.1)
- Video camera parametrization check on sample units
- Configuration of the video control server, test scope
- Configuration of the data server, test scope
- Communication between each video camera and control server, test network
- Communication between each video camera and data server, test network
- Graphic user interface of the video control server, including remote access via web browser, test network
- Video streaming quality check (frame resolution and rate) on control server, sample units
- Check files recording on data server (availability, format and storage), sample units
- Check on-event recording feature on data server, including pre- / post time intervals, simulated event
- Configuration of the VMS server, test scope
- Communication between video camera and VMS server, sample units
- VMS server functionality check, i.e. video streaming routing from multiple sample camera to multiple monitors accordingly to user selection
- Test of the video surveillance system related I/O interface signals with the auxiliary system (see 3.6.3.1), simulation mode

3.6.2.2 Site acceptance test (SAT) criteria

- Cabinet SAT test criteria (see 3.1.2)
- Video camera parametrization check on all tunnel installed units
- Configuration of the video control server, final scope
- Configuration of the data server, final scope
- Communication between each video camera and control server, tunnel network
- Communication between each video camera and data server, tunnel network
- Graphic user interface of the video control server, including remote access via web browser, tunnel network
- Video streaming quality check (frame resolution and rate) on control server, all units
- Check files recording on data server (availability, format and storage), all units
- Check on-event recording feature on data server, including pre- / post time intervals, real event
- Configuration of the VMS server, final scope
- Communication between video camera and VMS server, all units
- VMS server functionality check, i.e. video streaming routing from multiple camera to multiple monitors accordingly to user selection
- Test of the video surveillance system related I/O interface signals with the auxiliary system (see 3.6.3.2), real mode

3.6.3. Auxiliary system

3.6.3.1 Factory acceptance test (FAT) criteria

- Cabinet FAT test criteria (see 3.1.1)
- System specific controller (PLC) FAT test criteria (see 3.8.1.1)
- Test of the video surveillance system related I/O interface signals, simulation mode
- Test of the SOS emergency stations related I/O interface signals, simulation mode
- Test of the radio diffusion system related I/O interface signals, simulation mode

- Test of the other auxiliaries related I/O interface signals (low voltage energy supply system and medium voltage main switches status, technical rooms air conditioning, fire detection in buildings, pumping stations etc.), simulation mode

3.6.3.2 Site acceptance test (SAT) criteria

- Cabinet SAT test criteria (see 3.1.2)
- System specific controller (PLC) SAT test criteria (see 3.8.2.1)
- Test of the video surveillance system related I/O interface signals, real mode
- Test of the SOS emergency stations related I/O interface signals, real mode
- Test of the radio diffusion system related I/O interface signals, real mode
- Test of the other auxiliaries related I/O interface signals (low voltage energy supply system and medium voltage main switches status, technical rooms air conditioning, fire detection in buildings, pumping stations etc.), real mode

3.7. Communication network system

This paragraph specifies a list of criteria that shall be applied for the communication network system testing.

3.7.1.1 Factory acceptance test (FAT) criteria

- Cabinet FAT test criteria (see 3.1.1)
- Configuration of the main switches, test network
- Communication between the main switches including ring topology, test network
- Configuration of the Network Management System (NMS), test scope
- NMS environment for monitoring network status (current traffic, hardware monitoring, address management) and network related alarms, test scope
- Communication between NMS and SCADA, test network
- Network status and network related alarms available on SCADA from NMS, test network

3.7.1.2 Site acceptance test (SAT) criteria

- Cabinet SAT test criteria (see 3.1.2)
- Configuration of the main switches, tunnel network

- Communication between the main switches, tunnel network
- Configuration of the Network Management System (NMS), real scope
- NMS environment for monitoring network status (current traffic, hardware monitoring, address management) and network related alarms, real scope
- Communication between NMS and SCADA, tunnel network
- Network status and network related alarms available on SCADA from NMS, tunnel network

3.8. Control system

The control system of the tunnel is implemented at two main different levels:

- System level – Technologies for which a system specific PLC based control is foreseen, i.e. lighting, ventilation, signage, tunnel fire detection and auxiliaries (integration of the video surveillance system, the SOS emergency stations, the radio diffusion system, the low / medium voltage energy supply system, the technical rooms air conditioning, the buildings fire detection and the pumping stations) together with other installations which require a dedicated control server, i.e. the video surveillance system, the communication network (directly integrated into the SCADA system), the SOS emergency stations and the radio diffusion system.
- Tunnel level – The SCADA control system provided for the entire tunnel which communicates with each system controller and server.

The control system test criteria for the systems that do have a system specific PLC based control and therefore are integrated into the SCADA are listed here below together with the test criteria for the radio diffusion system, the SOS emergency stations and the SCADA system itself.

Other control system test criteria that are system specific or apply to systems that do have a dedicated control server are instead included into the system related paragraph.

The design of the radio diffusion system shall refer and comply in order of priority to (in case of different requirements, the most stringent applies): the Nepalese National Standards and regulations (where available), the applicable international standards and the related FEDRO directive which in turn includes a list of the relevant Swiss national and international standards:

- ESE Directive 13006 – Radio diffusion systems in road tunnels

3.8.1. Factory acceptance test (FAT) criteria

3.8.1.1 System specific controller (PLC)

- Check of system PLC hardware / software configurations

- Check of the system operator panel hardware / software configurations
- Test of system I/O signals, simulation mode
- Check of the communication between the system PLC and the operator panel, test network
- Graphic user interface of the system available on the operator panel, simulation mode
- Testing of selected system functionalities from the operator panel, simulation mode

3.8.1.2 Radio diffusion system

- Cabinet FAT test criteria (see 3.1.1)
- Graphic user interface of the radio diffusion server, including remote access via web browser, test network
- Operating modes of the system, test configuration: normal broadcasting of external radio signals, automatic broadcasting of related pre-recorded messages for the tunnel users in case of event, broadcasting of live operator messages for the tunnel users on request.
- Test of the radio diffusion system related I/O interface signals with the auxiliary system (see 3.6.3.1), simulation mode

3.8.1.3 SOS emergency stations

- Cabinet FAT test criteria (see 3.1.1)
- Graphic user interface of the SOS emergency stations server, including remote access via web browser, test network
- Functionality of the implemented telephone exchange and call recorder, test configuration
- Test of the radio diffusion system related I/O interface signals with the auxiliary system (see 3.6.3.1) including the status of the telephone call lever and of the fire extinguisher, simulation mode

3.8.1.4 SCADA control system

- Check of the communication between the SCADA server interface and the system PLC
- Graphic user interface of the system available at the SCADA level, simulation mode
- Check of the system use modes (isolated, local, remote) and operating modes (manual, automatic, maintenance) as implemented, simulation mode

- Testing of selected system functionalities from the SCADA level, simulation mode
- Testing of the system automatic reactions accordingly to the related matrix, simulation mode

3.8.2. Site acceptance test (SAT) criteria

3.8.2.1 System specific controller (PLC)

- Check of system PLC hardware / software configurations
- Check of the system operator panel hardware / software configurations
- Test of system I/O signals, real mode
- Check of the communication between the system PLC and the operator panel, tunnel network
- Graphic user interface of the system available on the operator panel, real mode
- Testing of all system functionalities from the operator panel, real mode

3.8.2.2 Radio diffusion system

- Cabinet SAT test criteria (see 3.1.2)
- Graphic user interface of the radio diffusion server, including remote access via web browser, tunnel network
- Operating modes of the system, real configuration: normal broadcasting of external radio signals, automatic broadcasting of related pre-recorded messages for the tunnel users in case of event, broadcasting of live operator messages for the tunnel users on request.
- Test of the radio diffusion system related I/O interface signals with the auxiliary system (see 3.6.3.1), real mode

3.8.2.3 SOS emergency stations

- Cabinet SAT test criteria (see 3.1.2)
- Graphic user interface of the SOS emergency stations server, including remote access via web browser, real network
- Functionality of the implemented telephone exchange and call recorder, real configuration

- Test of the radio diffusion system related I/O interface signals with the auxiliary system (see 3.6.3.1) including the status of the telephone call lever and of the fire extinguisher, real mode

3.8.2.4 SCADA control system

- Check of the communication between the SCADA server interface and the system PLC
- Graphic user interface of the system available at the SCADA level, real mode
- Check of the system use modes (isolated, local, remote) and operating modes (manual, automatic, maintenance) as implemented, real mode
- Testing of all system functionalities from the SCADA level, real mode
- Testing of the system automatic reactions accordingly to the related matrix, real mode

3.9. Cabling System

This paragraph specifies a list of criteria that shall be applied for the cabling system testing.
The design of the system shall refer and comply in order of priority to (in case of different requirements, the most stringent applies): the Nepalese National Standards and regulations (where available) and the applicable international standards. The design *can also refer*, among others, to the related FEDRO directive and specifications which in turn includes a list of the relevant Swiss national and international standards:

- ESE Directive 13022 – Cabling system for national road
- ESE Technical specifications 23001 – 117xx Cable systems
    - 11710 – Grounding and lightning/surge protection
    - 11711 – Grounding outdoor
    - 11712 – Grounding in tunnel
    - 11713 – Grounding in technical rooms
    - 11730 – Universal structured wiring system
    - 11740 – Cable for SOS emergency telephone

3.9.1. Factory acceptance test (FAT) criteria

- Cable list check for type (e.g. low voltage GKN), construction (e.g. halogen free), performances (e.g. fire resistance) and certifications accordingly to relevant international standard

- Compliance of cable life cycle (e.g. 40 years)
- Compliance of MTBF values

3.9.2. Site acceptance test (SAT) criteria

- Cable ducts
- Cable tubes
- Cable installation, fixing, protection
- Cable bending ray
- Cable connections and terminal
- Cable labelling system

ANNEX G : Warranty, Operation and Maintenance Works

ROCKFALL PROTECTION ALONG SIDDHABABA SECTION OF SIDDHARTHA HIGHWAY

Ch. 28+200 km – Ch. 30+600 km

Table of Contents

1. Introduction

1.1 Aim of the document

In the following, an evaluation of the ordinary maintenance and operation costs of the Siddhababa section of Siddhartha highway Ch. 28+200 km – Ch. 30+600 km, including the Siddhababa tunnel, during the first 5 years of operation after commissioning is provided.

The evaluation is based on guidelines of the Swiss Highway Authority FEDRO and, hence, is based on a database of history cases of Swiss road tunnel. Such procedure estimates maintenance and operation costs in normal conditions as a percentage of the construction costs, taking into account the length and complexity of the tunnel. However, due to the large difference in labor costs between Nepal and Switzerland and in boundary conditions between this special case and standard situation of highway swiss tunnels, such estimation could strongly differ by the real costs in Nepal; for such reason, a description of the activity and required personnel and machinery is also provided in para 6, in order to perform a simplified parallel evaluation adopting estimated local costs for required personnel and renting of machinery. It should be noted anyway that in Switzerland, usually, one technical team serves more than one tunnel at the same time. Therefore – as expected – for Siddhababa Project, where the M&O team is completely dedicated to one single tunnel, the relative costs will be higher, in percentage. In our opinion this latter evaluation is the most reliable for the project.

A clarification on costs included in the provided estimation is given at points 2, 3 and 4, whereas exclusions are clarified at point 1.3.

1.2 Preamble and assumptions

To keep a tunnel in service with proper safety conditions, good operation of electrical and mechanical systems of the tunnel should be guaranteed as well as the fast activation of emergency procedures in case of malfunctioning of some system or any other emergency condition, such as accident in or near the tunnel of fire event.

In order to guarantee what stated here above, two main aspects should be properly addressed and guaranteed:

Maintenance, by means of:

a) A team of technicians always available to provide urgent small repairs, systematic visual checks and systematic cleaning and small maintenance;

b) a proper inspection and maintenance plan, to define frequency & type of inspection and maintenance works

c) a detailed traffic management plan to face the necessary tunnel closure during maintenance of the tunnel and of the road

Operation, both in normal conditions and in case of emergency, by means of:

d) A local tunnel control and traffic management team, checking 24/24 h 7/7 d the surveillance system (SCADA) and properly trained to act in case of any emergency/malfunctioning. The team must have the necessary reserves for absences due to illness, holidays, etc. As a rule, the control room must constantly be manned by two people.

e) A fast and redundant connection system between tunnel control team and police (mobile, radio,…)

f) An emergency plan, defining proper procedures to be followed in case of unexpected events (accident, fire, malfunctioning of any equipment)

g) An operation plan, to define responsibilities and activities to be performed in normal conditions;

h) Definition of minimum operating requirements

All documents and procedures listed in points b, c, e, f, g and h are not treated in the present document and should be properly addressed and defined partly by the Client with the support of the Contractor and partly by the Contractor with the support of the Client during construction and commissioning period (before putting the tunnel in operation) in order to provide the instruments to properly manage the tunnel. These requirements for the Contractor will be evaluated, together with DoR, in the coming weeks and added to the tender documents.

In the present document, a brief description of what should be expected to occur in normal operation and what should be foreseen as normal and planned maintenance is provided, in order to clarify what is considered included in the maintenance and operation costs here estimated.

1.3 Costs not included in the provided estimation

As previously stated, only normal operation costs and normal and planned maintenance costs are here considered and addressed.

Any unexpected extraordinary maintenance, that could be needed due to malfunctioning of some system or of parts of the tunnel structures, has not been considered here.

Moreover, any cost related to activation of police, ambulances and fire fighters in case of accident or fire are not considered, as well as possible adjustments that should be needed to guarantee fast intervention on side (additional personnel and means), since such needs depends on the actual conditions of the local emergency services and they are considered as apart from the direct costs of the tunnel and highway infrastructure. As for an emergency, in the present document, only the costs related to the local personnel required to check the type of emergency and to activate the proper emergency service are considered.

2. Tunnel operation & maintenance organization (in normal conditions)

Although the tunnel safety equipment will be provided with alarms and warnings in the SCADA to warn in case of malfunctioning or anomalous conditions in the tunnel, technical personnel should be always present in the tunnel control room to keep control on the tunnel systems and, in particular, to check in case of alarm if there is a real problem and, following the emergency and operation plans, inform who should be informed and activated. Moreover, a manager (and a deputy) shall be foreseen, in order to checks and supervises correct application of all operation and emergency procedure and that is responsible to guarantee continuous coordination with the police and sanitary emergency services and to keep control of the financial aspects related to the operation and maintenance costs and contracts.

Finally, during the first years of operation, after commissioning, a training program to local personnel shall be performed by the Contractor in order to transfer to the Client, after the first

5 years of operation managed by the Contractor, the trained personnel and keep it in operation under the organization by the Client.

In conclusion, the following personnel shall be foreseen:

1 experienced tunneling manager (international), full time, for the first year, 50% the second year to train the selected future local tunneling manager;

1 local manager, selected to be the tunneling manager, 75% time

1 deputy local manager, selected among tunnel operators, 25% time

5 experienced tunnel operators (international), full time, for the first year, to train selected local tunnel operators (5 operators are needed to guarantee presence of 1 operator 24h each day of the year, assuming: 8 working hours per day, 5 working days per week, 20 holiday days per year, 5 festive days).

10 local tunnel operators as tunneling operators to be trained, full time, to guarantee presence of 2 tunnel operators continuously (24h each day of the year); the number of required tunnel operators should be adjusted based on local working conditions

(number of daily working hours, holidays…) in order to guarantee continuous presence of 2 operators

5 experienced mechanical equipment technician (international), full time, for the first year, to train selected local mechanical equipment technicians (5 operators are needed to guarantee presence of 1 operator 24h each day of the year, assuming: 8 working hours per day, 5 working days per week, 20 holiday days per year, 5 festive days). Please note that the night shift is intended as "on-call, with availability on site in 15 minutes", therefore the assumed utilization rate has been reduced accordingly)

5 local electrical technicians to be trained by the international technician above as mechanical equipment technician and 5 local civil works technician; these 10 technician form a maintenance team always available (2 technician, one electrical and one for civil parts, 24/24h and 7/7 days) to perform urgent maintenance operation on need or ordinary maintenance (cleaning, weekly checks,...) in the spare time; the number of required technician should be adjusted based on local working conditions (number of daily working hours, holidays,…) in order to guarantee continuous presence of 2 technicians. An optimization of the number of technicians could be evaluated assuming to guarantee presence on site during the day (for standard maintenance) and only on call during the night (availability on site within 10-15 minutes only in case of unexpected urgent needs. Please note that – as per their international counterpart, the night shift is intended as "on-call, with availability on site in 15 minutes", therefore the assumed utilization rate has been reduced accordingly)

Moreover, the following vehicles/equipment shall be provided continuously to the tunneling operators in order to be able to perform proper preliminary inspections in case of malfunctioning or other emergencies:

No.2 Pick-up truck or small van, to move along the tunnel and be able to position temporary signaling;

No.2 Mobile platform on wheels to perform any inspection to the tunnel crown and to work on suspended equipment (fans, lighting, sensors, etc.).

Finally, tunnel operation should take into consideration the necessary utilities:

Potable water to be provided to the technical building (in service 24h every day). Medium voltage electricity to the tunnel equipment (to be provided at the tunnel South portal), average estimated consumption of 1'150'000 kWh/year.

Table 1: Personnel for tunnel maintenance and operation (ordinary activities)

Role	N	Year 1	Year 2	Year 3	Year 4	Year 5
Tunnel Manager (international)	1	Full time	Half time	-	-	-
Tunnel Manager (Local, trained)	1	75%	75%	75%	75%	75%
Deputy Tunnel Manager (Local)	1	25%	25%	25%	25%	25%
Experienced Tunnel Operators (international)	5	Full time	-	-	-	-
Tunnel Operators (local, trained)	10	Full time	Full time	Full time	Full time	Full time
Experienced Mechanical equipment technicians (international)	5	Full time (*)	-	-	-	-

Electrical / mechanical equipment technicians (local, trained)	5	Full time (*)	Full time (*)	Full time (*)	Full time (*)	Full time (*)
Civil works technicians (local, trained)	5	Full time (*)	Full time (*)	Full time (*)	Full time (*)	Full time (*)

[*] Night shift is intended as "on-call, with availability on site in 15 minutes", therefore the assumed utilization rate in appendix B has been reduced accordingly)

Table 2: Minimum equipment for maintenance (ordinary activities)

Vehicle / Equipment	N	Year 1	Year 2	Year 3	Year 4	Year 5
Van / Pick-Up	2	Full time	Full time	Full time	Full time	Full time
Mobile Platform	2	Full time	Full time	Full time	Full time	Full time

3. Tunnel maintenance program brief description

In addition to the continuous tunnel operation activities and personnel, aimed to keep continuous control of the tunnel in service and activate proper procedures in case of emergency or unexpected events, periodic inspections and maintenance activities shall be foreseen, in accordance to the inspection and maintenance program, in order to minimize the risk of unexpected malfunctioning of the tunneling systems and equipment.

A check of all exploitation and safety equipment (both electrical and hydraulic, including the check of all the automatic reactions defined in the automatic reactions matrix, document

695013-D-A-E-K-002-C00) shall be foreseen at least every year. On the basis of the characteristics of the products chosen by the general contractor, it may be necessary, for some equipment, to check more frequently; the frequency to be recommended is the lowest (most

stringent) between that provided here and that provided by the general contractor in the final documentation.

At least once a year, the cleaning of the inner surface of the tunnel (white painted walls and carriageway) shall also be performed in order to guarantee proper luminosity within the tunnel. At least every week, a check of the carriage shall be performed in order to remove any dirt present along the tunnel. The operators in the control room will continuously check, by means of video surveillance, that there are no obstacles on the roadway; any obstacles must be removed immediately.

As for the tunnel structure, a detailed inspection of all the tunnel parts shall be foreseen at the end of the first 5 years of operation and every consequent 5 years, by tunneling specialists, in order to check any degradation of the tunnel lining and record it in proper forms, in order to evaluate the need for extraordinary maintenance activities and their urgency, estimating the degradation speed by comparing the different periodic forms. In occasion of this detailed inspection of the tunneling lining, a drainage and sewage piped purging shall be foreseen; such activity shall be repeated in future on need (in case of malfunction or obstruction of some pipes) and in any case at least every 10 years.

A comprehensive list of the needed periodic maintenance and inspection activities is provided in the following table.

The yearly checks shall require the closure of the tunnel and, hence, shall be planned during the night shifts, when traffic is minimum. The signaling system included in the project shall be used in order to inform and stop the traffic at the entrance of the Siddhababa stretch, i.e. in the nearest villages at both sides of the tunnel, to let vehicles easily deviate to other routes.

The verification teams shall be organized in order to perform all inspection within 1 working weeks, so as to minimize the nights with tunnel closure.

As additional resources respect to the staff described in the previous paragraph, and summarized in Table 1, It shall be foreseen the following teams and needed vehicles/equipment for 1 week every year:

Exploitation and mechanical equipment check and restoration: 4 technicians, 1 driver for the mobile platform and availability of spare parts

Civil engineering parts (lining, drainage and sewage system): 2 technicians with needed equipment to open pits and a van, 2 technicians with cleaning vehicle

Type of check	Actions needed / Aim	Minimum frequency
Check of the carriageway	Removal of any dirt on the way	1 / day
Check of the tunnel cleanliness	Cleaning of the walls and carriageway	1 / year
Check of the drainage pipelines	Cleaning/Functionality of the drainage system	1 / year
Check of the sewage pipelines	Cleaning/Functionality of the sewage system	1 / year
Check of the inspection wells/pits	Cleaning/Functionality of the pits	1 / year
Check of the fire system	Check of the functionality of the hydrants	1 / year
Check of the lighting system	Cleaning and predictive maintenance according to the guidelines of the constructor	At least 1 / year
Check of the lighting system	Repairs	According to the document Minimum operating requirements
Check of the ventilation system	Cleaning and predictive maintenance according to the guidelines of the constructor	At least 1 / year
Check of the ventilation system	Repairs	According to the document Minimum operating requirements
Check of the signs	Cleaning/Functionality of the signs and predictive maintenance according to the guidelines of the constructor	At least 1 / 3 months
Check of the signs	Repairs	According to the document

		operating requirements
Check SOS phones	Cleaning and predictive maintenance according to the guidelines of the constructor, test call	At least 1 / year
Check redundancy SCADA System	In case of redundancy of the SCADA System, the switching must be checked.	At least 1 / year
Power supply redundancy check	In case of redundancy of power supplies, the switching must be checked.	At least 1 / year
All electrical/mechanical plants	Check of all the automatic reactions defined in the automatic reaction matrix, document 695013-D-A-E-K-002-C00 (or more updated document released by the contractor at the end of the construction phase)	At least 1 / year
Check of all other electrical/mechanical plants, including the whole cablings	Cleaning and predictive maintenance according to the guidelines of the constructor	At least 1 / year
All electrical/mechanical plants, including the whole cablings	Repairs	According to the document Minimum operating requirements
Check of the integrity of the structure	Visual inspection and restoration/Special measures if needed	1 / year and on event
General inspection	Visual inspection of the tunnel structure by tunneling specialists	1 / 5 years

The yearly inspection should be planned just after the raining period, in order to check any effect

on the hydraulic systems and waterproofing system of the tunnel lining.

After any emergency event (accident and/or fire) a special inspection shall be foreseen on the affected tunnel stretch to check damages both on civil parts and equipment.

After every yearly check and after the general inspection, if any damages have been detected other than usual substitution of consumables in the equipment, extraordinary maintenance intervention shall be planned to restore damaged parts.

Table 3: Minimum Additional Personnel for tunnel maintenance (planned activities)

Role	N	Year 1	Year 2	Year 3	Year 4	Year 5
Technicians for Exploitation and Mechanical verifications	4	1 week	1 week	1 week	1 week	1 week
Technicians for civil works verifications	4	1 week	1 week	1 week	1 week	1 week
Operator for Mobile Platforms	1	1 week	1 week	1 week	1 week	1 week

Table 4: Minimum Additional equipment for maintenance (planned activities)

Vehicle / Equipment	N	Year 1	Year 2	Year 3	Year 4	Year 5
Van / Pick-Up	2	1 week	1 week	1 week	1 week	1 week
Small truck with crane	1	1 week	1 week	1 week	1 week	1 week
Mobile Platform	1	1 week	1 week	1 week	1 week	1 week
Tunnel Cleaning Vehicle	1	1 week	1 week	1 week	1 week	1 week
Equipment for inspection and purging drainage/sewage pit and pipes	1	1 week	1 week	1 week	1 week	1 week

4. Open stretches maintenance program description

Along the whole road stretch included within the project will also needed a maintenance program, in order to keep clean the carriageway and to make the sewage system and hydraulic under-passages working properly. The regular maintenance of the equipment installed in these stretches must also be performed.

A systematic check of the carriageway should be foreseen to remove any rocks or dirt that would fall on the carriageway. Moreover, every year a check of all hydraulic under-passages, of the pipes and pits of the carriageway sewage system shall be performed in order to check presence of any material that could obstruct the passage of water.

As for the rock-fall protections a yearly check should be also foreseen to verify if some material has been accumulated behind the rock-fall nets and should be removed or if some damage to the adherence nets has been occurred.

Finally, regarding the rock shed, a systematic visual inspection shall be performed, as along the road, to check for presence of objects to be removed and yearly inspection of the drainage system as well as above the rock shed to check if any rock has been fallen and shall be removed. Every 5 years (hence, at the end of the first 5 years after commissioning), a detailed inspection by structural engineer shall be foreseen to check and register the conservation state of the concrete structure and drainage system shall be performed.

In addition to the periodic checks and based on the results of such verifications, systematic small maintenance activity should be expected by the local team of technician, such as cleaning, grass cutting and visual checks of the carriageway should be foreseen.

A comprehensive list of the needed periodic maintenance and inspection activities is provided in the following table.

Type of inspection	Actions needed / Aim	Minimum frequency
Check of the carriageway	Visual check of the carriageway and its lighting system; removal of any obstacles/objects on the way; cleaning where needed	1 / day
Check of the bicycle path (including rock shed)	Removal of any obstacles/objects on the way	1 / week
Check of the lighting system	Cleaning and maintenance of malfunction and local failure	1 / year
Check of the road drainage pipelines	Cleaning/Functionality of the road drainage system	2 / year
Check of the inspection wells/pits	Cleaning/Functionality of the pits	2 / year
Check of the hydraulic underpasses	Cleaning/Functionality of the underpasses	2 / year
Check of the drainage pipelines in the rock shed	Cleaning/Functionality of the drainage system	2 / year
Check of the rockfall nets	Removal of any deposited material behind the rockfall net/restoration of any damaged part	1 / year
Check of adherence nets	Restoration of any damaged parts	1 / year

Check of integrity of the pavement	Restoration of the pavement where needed	1 / year (*)
Check above rock shed	Removal of any deposited material / restoration of levelled cushion above rockshed	1 / year
Check of the integrity of the structure	Restoration/Special measures if needed	on rockfall event
Check of all electrical/mechanical plants, including the whole cablings	Cleaning and predictive maintenance according to the guidelines of the constructor	At least 1 / year
All electrical/mechanical plants, including the whole cablings	Repairs	According to the document Minimum operating requirements
General inspection	Visual inspection of the tunnel structure by tunneling specialists	1 / 5 years

(*) although restoration of pavement is foreseen yearly where needed, if damages too large to guarantee safe usage of the road occur, a restoration shall be planned immediately after occurrence.

The yearly check shall be planned just after the raining period to check any damages due to heavy rain falls. The bi-yearly check shall be planned just after and just before the rainy season. Moreover, just after any heavy rain the weekly checks shall be carried out.

After every yearly check and after the general inspection, if any damages have been detected other than usual substitution of consumables in the equipment, extraordinary maintenance intervention shall be planned to restore damaged parts.

Employer's Requirements

Technical Specification

Contents

1. INTRODUCTION

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

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

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

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

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

2. GENERAL CONDITIONS

2.1. General

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

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

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

2.1.1. Definitions

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

2.1.2. Unit System

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

2.1.3. Language

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

2.1.4. Codes and Standards

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

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

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

2.1.5. Approval/Review by the Engineer

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

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

2.1.6. Drawings

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

2.1.7. Initial Submittals after Order of Commencement

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

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

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

2.2. The Works

2.2.1. Scope of Works

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

2.2.2. Project Description

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

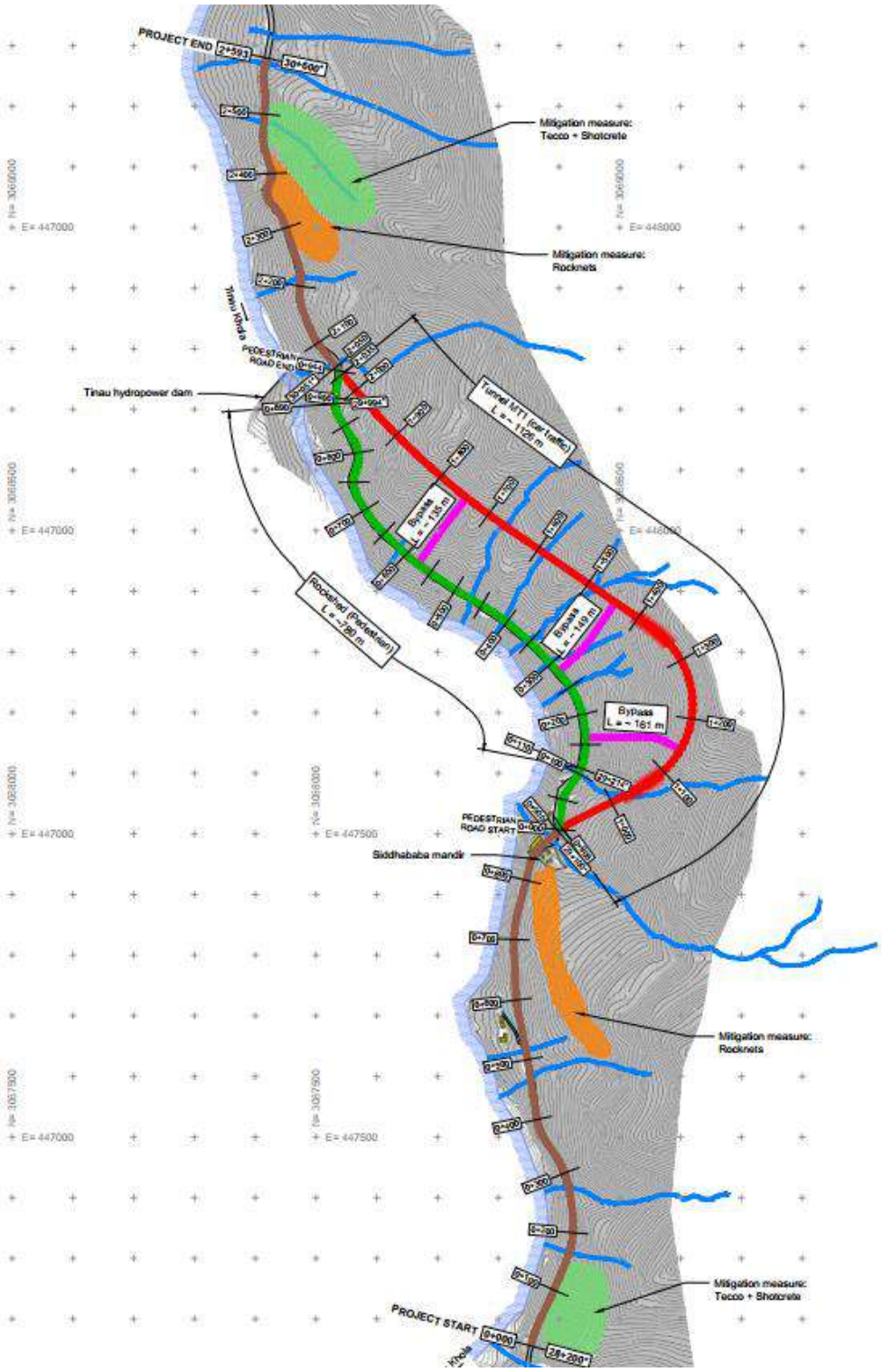

Figure 1: General Plan View of the Project Area

The project foresees an existing track diversion in a new two lanes tunnel for motor vehicles only (one lane for each direction), along the whole high hazard sections, departing from the existing

road near the Siddha Baba Mandir and reconnects to it near the hydropower plant, for a total length of about 1126 m.

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

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

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

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

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

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

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

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

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

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

The main features of the projects can be summarized as:

Road Improvements:

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

Environmental protection measures: Hydraulic regimentation measures

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

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

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

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

- Rocknet with Design Energy between 2000 KJ and 5000 KJ

- Local installation of adherence wiremesh (Tecco type) with bolts on stable outcrops upon the road, where only superficial debris and small blocks are expected, and local stabilisation systems by shotcrete with additional rock bolts, in areas interested by mudstone or other erosive or other erosive , i.e.material subject to erosion due to wash out or other causes.

- Local removal of single unstable blocks that cannot be withstood by the rocknet or to protect thick clay layers within an outcrop, that could otherwise get unstable because of gradual washout of clay during monsoon season.

Road diversion and Road Tunnel for rockfall high risk areas

including all works related to the construction of the rock tunnel and the three emergency escape routes foreseen along its alignment with a maximum distance lower than required 300 m. The tunnel cross-section has been studied in accordance to European and Swiss tunnel guidelines, in order to house: a carriageway width of 7.5 m, sideways on both side with minimum width of 1 m and all necessary hydraulic systems and operational and safety equipment. The operational traffic space considered for design includes not only the necessary space for passing cars and trucks (height up to 4.5 m), but also standard space for signalling, upon the carriageway and on both sides, and for standard safety margins. Thanks to the almost circular section, upon the operation traffic space there is space to house air fans for the longitudinal ventilation system.

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

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

Pedestrian Rockshed for rockfall high risk areas

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

• Inner dimensions, to comply with pedestrian walkaway **(B x H = 5.0m x 5.0m),** with a length of about L = 800m;

• Cushion material, made of Leca 0-30 (or similar) with a medium height of 2m on the top slab of the shed, to protect the structure from falling rocks;

• Roof grade, to be at least 5% to provide drainage of the cushion material and possibly allow falling rock rolling over the rockshed roof.

Special Condition of Condition of 42. Extension of the Intended Completion Date.

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

2.2.3. Site Conditions

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

List of Technical References available to the Tenderers

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

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

Government of Nepal

Ministry of Physical Infrastructure and Transport

Department of Roads

Quality, Research and Development Center

Chakupat, Lalitpur, Nepal

Tel: +977-1-5260505

Email : dorqrdc@gmail.com ; Website: http://www.dor.gov.np

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

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

2.2.4. Ground Conditions

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

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

2.3. Mobilization and Demobilization

2.3.1. General

This Clause of the Specification covers all the operations required for Mobilization and Demobilization of plant, equipment and facilities required for executing the Works. Any additional

requirement not included in this Clause is deemed to be included in the contract prices and will not be paid for separately.

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

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

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

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

2.3.2. General mobilisation

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

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

2.3.3. Development of Contractor’s design

2.3.3.1 General Requirements

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

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

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

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

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

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

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

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

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

Design Standards

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

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

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

Design Programme:

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

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

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

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

Specifications

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

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

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

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

Calculations

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

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

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

Computer Calculations

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

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

- name of the program and the version number;
- description of the program with general assumptions and limitations;

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

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

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

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

Detailed Design Drawings

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

Design of Temporary Works

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

Copies

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

Electronic Data

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

2.3.3.2 Additional Requirements for PLANT and SYSTEMS

Example :

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

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

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

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

695013-D-A-R-D-050	Signage Plan
695013-D-A-E-D-001	Synoptic Plan Of Exploitation And Safety Equipment
695013-D-A-E-D-002	Synoptic Plan Of The Ventilation System
695013-D-A-E-D-003	Layout Of The Ese In The Technical Building At The South Portal
695013-D-A-E-D-004	Layout Of The Ese In The Technical Building At The North Portal
695013-D-A-E-D-005	Tunnel Sections With Ese Layout
695013-D-A-E-K-001	Tunnel Control System Architecture
695013-D-A-E-K-002	Automatic Reactions Matrix”

2.3.4. Construction Site

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

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

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

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

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

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

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

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

……..

……

……

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

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

The vehicles are to be air-conditioned.

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

Equivalent replacement vehicle shall be provided during servicing and repair.

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

2.3.7.1 Design and construction requirements

A) General

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

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

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

Thermal insulation for accommodation units shall meet national standards.

B) Design requirements

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

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

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

- wind
- rainfall
- snow
- flooding

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

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

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

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

C) Fire and Emergency Escape

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

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

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

Buildings to be fitted with smoke detectors.

Carbon monoxide detectors to be fitted where potential sources exist.

D) Electrical supply

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

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

E) Wastewater

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

F) Lifting of accommodation units

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

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

2.3.7.2 Design and construction requirements

A) Sleeping arrangements

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

B) Sanitary Facilities

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

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

Bedrooms to have ensuite facilities and showers.

C) Smoking Designation

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

D) Recreation and Welfare Facilities

Recreational and welfare facilities should be provided which should include:

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

E) Housekeeping and Laundry

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

F) Catering

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

G) Water supply

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

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

2.3.8. Water Supply to the Construction Site

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

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

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

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

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

2.3.9. Fuel Supply to the Construction Site

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

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

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

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

2.3.10. Electric Power Supply to the Construction Site

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

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

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

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

2.3.11. Telephone

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

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

The Contractor shall provide:

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

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

2.3.13. Toilet and Washing Facilities

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

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

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

2.3.14. Security Fencing

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

The fence shall be galvanized steel chain link, secured to 7-gauge coil spring wire at the top and to galvanized rail at the bottom, for a height of 2.5 m, plus 0.50 m height of 3 strands of barbed wire, and buried a minimum of .5m below ground level. The Contractor is to seek advice on providing

other Perimeter Security Measures (Physical or otherwise) to ensure the Camp is fully secure in line with their submitted security plan.

2.3.15. Batching plants

The Contractor shall supply, install and maintain throughout the duration of the Contract, the batching plants necessary for the execution of the Works under the Contract, including, water chilling and flake ice production plants.
Mobilization of batching plants also includes formworks and equipment for transport and concrete casting.

2.3.16. Demobilization

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

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

2.4. Contractor's Organization at Site

2.4.1. General

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

a) Management of the Contract with the Employer and of the Contracts with the suppliers and the Sub-Contractors

b) Management of the Construction activities in the site

c) Development of all required Drawings (shop Drawings of all steel structures and components, detail Drawings, etc.)

d) Development of all construction Engineering including, but not limited to:
   - Method statements for all construction activities
   - Check of lifting gear for all lifts exceeding 20 t and for all lifts requiring multiple cranes
   - Check of Bearing capacity of soil and structures for all heavy vehicle movements

e) Development of all detailed planning of activities in order to control the progress of the works against the Contract Schedule, to update this schedule when appropriate and to identify problems in time to implement corrective measures

f) Development of all Quality Control activities in order to monitor that all works are carried out according to the requirements of this Technical Specification and to timely implement corrective actions should the quality of the works fail to comply with the requirements.

g) Updating "as-made" Drawings

h) On-line computerized survey operations.

i) Capability to process construction site data, including Survey data, on site.

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

2.4.2. Technical Office

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

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

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

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

2.4.3. Planning Office

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

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

- Daily
    a. Activities performed
    b. Workforce (personnel and equipment) subdivided per type of structure
    c. Activities planned for next day
    d. Reporting of vessel and plant transportation movements to/from site
- Weekly
    a. Activities performed
    b. Activities planned for next week
    c. Progress achieved against planned
    d. One week look ahead
    e. One month look ahead
- Monthly
    a. Activities performed
    b. Activities planned for next month
    c. QC update of all materials due on the Project
    d. S-curve of progress achieved against planned
    e. Gantt chart showing original schedule, progress, updated schedule (if applicable)
    f. One month look ahead
    g. Three month look ahead

2.4.4. Quality Control Office

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

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

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

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

2.5. Health and Safety Requirements

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

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

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

2.5.1. Safety

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

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

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

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

2.5.2. Safety Officers

The Contractor shall appoint a responsible person from his staff to undertake the duties of Safety Manager, Safety Officers and Safety Supervisors on Site. The Contractor shall inform the Engineer

in writing prior to commencement of any work on the Contract of the nominated Safety Officer's name for formal approval.

2.5.3. First Aid

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

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

2.5.4. Emergency Arrangements

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

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

2.5.5. Contractor's Health and Safety Plan

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

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

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

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

The Contractor shall:

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

2.6. General Provisions during the Works

2.6.1. General

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

2.6.2. Surveys and Markings

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

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

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

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

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

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

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

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

2.6.3. Survey and Inspection of Completed Works

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

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

2.6.4. Avoiding Damage and Protecting Installations and Structures

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

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

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

2.6.5. Traffic on Existing Roads

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

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

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

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

The Contractor is to satisfy himself with the access roads or public road infrastructure to the Site. The Contractor is required to liaise with all Authorities who own, manage or control the traffic and permissions for the use of roads in the area. This liaison must be continued throughout the Project. The Contractor must allow for complying with the instructions. The Contractor must be mindful of the general public who use the road network and have alternative routes or plans in place for bringing materials, plant and equipment to site.

2.6.6. Compliance with the Environmental Impact Statement Requirements

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

<u>Avoidance of Water Pollution</u>

a) The Contractor shall obtain the standard procedures, if available, of the Environment Authority, and shall on this basis develop a manual indicating his actions in case water pollution occurs.

b) The Contractor shall bear all damages and expenses caused by his negligence.

<u>Avoidance of Air Pollution</u>

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

Solid waste management:

d) Excess material or material unsuitable for re-use within the project should be disposed saffely.

e) If the above conditions cannot be met the excess be disposed of at an officially designated disposal site (Contractor to obtain all necessary license and permits for any such disposal).

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

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

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

2.6.7. Inspection and Testing

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

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

All testing costs shall be borne by the Contractor.

2.6.8. Survey and Inspection of Completed Works

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

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

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

2.6.9. Maintenance of Public Roads

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

Asphalt pavement maintenance repair shall be carried out as follows:

a) sawing of the perimeter of the surface to be repaired

b) removal of the damaged asphalt layers

c) compaction of the existing sub-grade layers

d) spraying with a bituminous emulsion 1 kg/m2

e) laying and compaction of bituminous concrete to the required thickness;

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

a) removal of the shoulder material down to the sub base layer

b) compaction of the sub base surface to 100% Modified AASHO

c) laying and compaction of shoulder material with a thickness of 30 cm

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

2.6.10. Keeping Site Clean

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

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

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

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

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

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

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

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

2.7. Project Management

2.7.1. Construction Programme

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

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

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

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

2.7.2. Method Statement

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

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

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

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

2.7.3. Daily Turns

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

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

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

2.7.4. Weekly Progress Meetings

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

- a schedule of the main work items completed in each section of the works, showing quantitative progress during the previous week and cumulative progress;

- detailed programme of work for the present week;
- record and notification of any QC activities and testing in the past week or in the upcoming period;
- summary of plant and equipment planned to be used in the present week;
- comments.

2.7.5. Monthly Progress Report

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

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

2.7.6. Progress Photographs

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

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

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

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

3. DEMINING AND UXO CLEARANCE

3.1. General

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

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

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

4. SECTION 300: SOIL IMPROVEMENT

4.1. General

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

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

5. SECTION 400: FENCING

5.1. General

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

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

6. SECTION 500: QUALITY CONTROL

6.1. General

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

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

7. SECTION 600: MATERIALS AND TESTING OF MATERIALS

7.1. General

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

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

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

8.1. General

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

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

9. SECTION 800: TRANSPORTATION OF MATERIAL

9.1. General

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

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

10. SECTION 900: EARTHWORKS

10.1. General

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

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

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

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

10.2.1. Shotcrete type

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

10.2.2. Shotcrete execution

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

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

10.2.3. Preliminary tests

Preliminary tests shall be provided by the Contractor.

For each shotcrete production cycle, at least 10 cylindric samples (ϕ50 mm, height 50 mm) shall be tested: 5 compressive strength tests after 7 days and 5 compressive strength tests after 28 days.

10.2.4. Contractor Qualification and Obligations

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

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

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

10.3. Wire mesh for Shotcrete - external areas

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

10.3.1. Wire mesh type

ϕ 6 mm, pattern 10 cm x 10 cm.

K283 Ruwa Matten or similar.

10.3.2. Material Types

Min. B500 A (according to European standards).

10.3.3. Contractor Qualification and Obligations

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

10.4. Permanent rock bolts - external areas

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

- Support measures for excavation at the tunnel portals;
- Support measures for excavations at the mountain side of the existing road;
- Support measures of existing rockwalls above existing road along mudstone or other erosive or other erosive layers
- Foundation micropiles and horizontal supports of retaining walls at the river side of existing road

10.4.1. Bolts type

Type Permanent GEWI Bar 25 or equivalent

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

Type Permanent GEWI Bar 28 or equivalent

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

Type Permanent GEWI Bar 32 or equivalent

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

Type Permanent GEWI Plus 43 or equivalent

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

Length of bolts varies, according to design drawings. The application of the difference bolt types follow indications provided in design documents attached to the tender and shall be updated accordingly to construction design by the Contractor.
For all these bolts, the double corrosion protection shall be provided (in accordance to swiss norm **SIA267** type of corrosion protection 2a) by a corrugated plastic sheating, with at least 2 cm thick injection between the sheating and the bar; moreover, borehole diameter shall be enough large to

guarantee at least 2 cm of grouting between the sheating and the rock. Both preinjected plastic sheating and plastic sheating injected on site can be used, but in latter case, injection procedure shall be agreed in advance by the Engineer.

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

10.4.2. Cement based grout

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

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

10.4.3. Tension / Pull-out tests

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

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

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

- Tension tests: on 2% of all realized bolts.

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

10.4.4. Corrosion resistance tests

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

10.4.5. Other components

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

10.4.6. Contractor Qualification and Obligations

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

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

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

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

10.5. Temporary active anchors

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

10.5.1. Anchor type

Pretensioned grouted anchors made by strands

Characteristic	***Requirements***
Strands Material	Harmonic steel
Strands diameter	0.6”
Strands number	5
Nominal Strand area	140 mm2
Ultimate load (Ftk)	260 kN/strand
yelding load (Fyk)	234 kN/strand
Prestress load	70 kN/strand
Free length	10 m
Anchored length	10 m
Drilling diameter	≥ 200 mm
Steel Grade	S1670/1860

10.5.2. Cement based grout

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

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

10.5.3. Tension / Pull-out tests

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

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

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

- Detailed tension tests: on 2% of all realized anchors.

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

10.5.4. Other components

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

10.5.5. Contractor Qualification and Obligations

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

- Drilling record, with indication of length, diameter, drilling system and type of excavated material;

- Injection record with description of injection system, adopted pressure and injected cement volume;

- Tensioning record, following eurocodes procedure

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

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

11. SECTION 1000: SUBGRADES

11.1. General

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

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

12. SECTION 1100: ROADWORKS OVERALL REQUIREMENTS

12.1. General

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

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

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

13.1. General

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

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

14. SECTION 1300: BITUMINOUS SURFACE AND BASE COURSE

14.1. General

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

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

15. SECTION 1400: KERBS AND FOOTPATHS

15.1. General

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

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

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

16.1. General

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

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

17. SECTION 1600: PILING FOR STRUCTURES

17.1. General

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

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

18. SECTION 1700: WELL FOUNDATION

18.1. General

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

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

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

19.1. General

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

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

20. SECTION 1900: BEARINGS AND EXPANSION JOINTS

20.1. General

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

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

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21. SECTION 2000: CONCRETE FOR STRUCTURES

21.1. General

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

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

22. SECTION 2100: PRE-STRESSING

22.1. General

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

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

23. SECTION 2200: STRUCTURAL STEEL WORK

23.1. General

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

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

24. SECTION 2300: TIMBER CONSTRUCTION

24.1. General

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

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

25. SECTION 2400: RIVER TRAINING AND PROTECTION WORKS

25.1. General

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

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

26. SECTION 2500: BRICKWORKS FOR STRUCTURES

26.1. General

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

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

27. SECTION 2600: MASONRY FOR STRUCTURES

27.1. General

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

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

28. SECTION 2700: REPAIR OF STRUCTURES

28.1. General

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

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

29. SECTION 2800: BIO ENGINEERING WORKS

29.1. General

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

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

30. SECTION 2900: MAINTENANCE OF ROADS

30.1. General

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

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

31. SECTION 3000: SUB-SURFACE GEOTECHNICAL INVESTIGATION

31.1. General

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

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

32. SECTION 3100: MISCELLANEOUS WORKS

32.1. General

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

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

33. CIVIL WORKS FOR ROADS

33.1. General

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

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

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

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

33.2. Pre-cast and cast in situ structures

33.2.1. General

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

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

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

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

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

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

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

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

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

33.2.2. Approval

33.2.2.1 Documentation

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

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

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

33.2.3. Requirements for concrete mixes

33.2.3.1 General

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

LEAN AND STRUCTURAL CONCRETE:

	CONCRETE STRENGTH CLASS	MINIMUM CHARACTERISTIC CUBIC STRENGTH R_{ck} (MPa)	EXPOSURE CLASS	MAXIMUM NOMINAL AGGREGATE SIZE (mm)	CONSISTENCE CLASS	MINIMUM CONCRETE COVER (mm)
LEAN CONCRETE	C12/15 (M15/20mm)	15	X0	20	S2	-
TUNNEL LINING	C30/37 (M40/32mm)	37	XC4, XD1, XF1	32	S4	50
ROCKSHED AND TECHNICAL BUILDINGS (FOUNDATIONS)	C25/30 (M30/32mm)	30	XC2	32	S4	50
ROCKSHED AND TECHNICAL BUILDINGS (EXTERNAL WALLS)	C30/37 (M40/32mm)	37	XC4, XD1, XF1	32	S4	50
ROCKSHED AND TECHNICAL BUILDINGS (TOP SLAB)	C30/37 (M40/32mm)	37	XC4, XF3	32	S4	50
TECHNICAL BUILDINGS (INNER WALLS AND SLABS)	C30/37 (M40/32mm)	37	XC3	32	S4	50
BURIED CULVERTS	C25/30 (M30/32mm)	30	XC2	32	S4	50
RCC WALLS AND EXTERNAL CULVERTS	C30/37 (M40/32mm)	37	XC4, XD1, XF1	32	S4	50
TIE BEAMS FOR EXCAVATIONS WORKS	C30/37 (M40/32mm)	37	XC4, XD1, XF3	32	S4	50

Figure 2: Concrete requirements

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

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

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

a) Materials only of the same origin and quality used for the approved preliminary tests shall be used.

b) The approved mix proportions shall be used unchanged except for adjustments due to different moisture content of aggregates and ambient temperature. Compacting conditions, cement content and water cement ratio of fresh concrete shall remain constant.

c) The Contractor may propose, during the execution of the works, alternate source, mix proportions or aggregate grading, provided that he shows by carrying out new preliminary tests and trial casting, as detailed above, that the proposed changes comply with the requirements of the Specification, and provided that the proposed changes do not interfere with the progress of work. No changes shall be made in the use of materials or mix proportions without the Contractor obtaining the prior approval of the Engineer.

33.2.5. Concrete placing – Formwork

33.2.5.1 General

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

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

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

33.2.5.2 Number of Forms

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

33.2.5.3 Tolerances

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

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

Tolerances for formworks:

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

All other tolerances shall be as indicated in the drawings.

33.2.6. Concrete Placing

33.2.6.1 General

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

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

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

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

33.2.6.2 Placing Methodology

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

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

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

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

<u>Compaction by Vibration</u>

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

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

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

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

33.2.6.3 Construction Joints

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

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

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

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

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

33.2.6.4 Expansion Joints

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

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

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

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

33.2.6.5 Permission to Cast

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

33.2.7. Protection and Curing

33.2.7.1 Horizontal Surfaces

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

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

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

33.2.7.2 Forms Removal

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

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

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

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

33.2.8. Concrete Quality Control &Tests

33.2.8.1 General

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

33.2.8.2 Specimens

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

- Compressive strength shall be tested by 150 x 150 x 150 mm cubes
- Splitting tensile strength shall be tested by 150 x 300 mm (d x h) cylinders
- Flexural strength shall be tested by 150 x 150 x 600 mm prisms

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

33.2.8.3 Temperature Measurements

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

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

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

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

33.2.8.4 Quality Control

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

Tab. 33.1: Number of specimens and frequency of sampling

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

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

33.2.9. Compliance with specifications

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

33.2.9.1 Compressive Strength

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

At the beginning of casting operations (first 15 samples)

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

were:

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

Continuous production (after the first 15 samples)

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

were:

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

33.2.9.2 Flexural and splitting tensile strength

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

33.2.9.3 Unit Weight

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

33.2.9.4 Temperature Gradient

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

33.2.9.5 Cracking Allowances for castings

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

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

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

33.2.9.6 Cracking Reparations and Corrective Actions

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

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

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

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

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

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

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

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

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

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

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

If the cracks are systematically present on all the castings, the Contractor shall submit to the Engineer a bundle of corrective actions to improve the quality of the cast; the corrective actions could involve curing methodology, concrete placing, cooling and transportation, mixing modifications and consequent new pre-trail and trail tests on concrete. Any corrective action to be implemented shall be previously formally approved by the Engineer.

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

33.3. Reinforcing steel

33.3.1. General

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

33.3.2. Material Types

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

33.3.3. Material Production and Testing

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

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

33.3.4. Fabrication

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

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

Reinforcing steel shall be fabricated without laminations or burrs.

33.3.5. Supply and storage of steel reinforcement

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

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

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

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

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

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

33.3.6. Placing and Fastening

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

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

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

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

33.3.7. Splicing

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

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

33.3.8. Cutting, Bending and fixing of steel reinforcement

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

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

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

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

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

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

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

33.3.9. Concrete cover and spacers

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

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

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

33.3.10. Inspection

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

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

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

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

33.4. Additional provisions

33.4.1. Waterstop for construction joints

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

33.4.1.1 Materials

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

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

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

33.4.1.2 Material Storage

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

33.4.1.3 Placement

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

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

33.4.2. Waterstop for expansion joints

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

33.4.2.1 Materials

PVC waterstops shall have the minimum physical properties shown below:

- Water Absorption: 0.15% (ASTM Method D-570)
- Tear Resistance: 53.5 kN/m (ASTM Method D-792)
- Specific gravity: 1.40 ± 0.05 (ASTM Method D-792)
- Hardness Shore A: 80 ± 5, 10 sec delay (ASTM Method D-2240)
- Tensile Strength: 13.8 MPa (ASTM Method D-638)
- Elongation: 350% (ASTM Method D-638)
- Brittle point: No failure at -35° F / -37° C (ASTM Method D-746)
- Stiffness in flexure: 4.1 MPa (ASTM Method D-747)
- Ozone Resistance: No failure (ASTM Method D-1149)
- After accelerated extraction (ASTM Method CRD-C572):
    - Tensile Strength: 11.0 MPa (ASTM Method D-638)
    - Elongation: 300% (ASTM Method D-638)
- Effects of Alkalies after 7 days (ASTM Method CRD-C572):
    - Weight Change: -0.10% /+0.25 % (ASTM Method CRD-C 572)
    - Change in Hardness, Shore A: ± 5 (ASTM Method D-2240)

33.4.2.2 Material Storage

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

33.4.2.3 Placement

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

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

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

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

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

33.4.3. Waterproofing

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

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

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

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

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

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

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

Between the time the concrete is cleaned and prepared for primer and the time the membrane system is placed, no vehicles, including mechanical spreaders, shall be operated on the area

being treated. Only the necessary personnel and equipment to perform the required work will be allowed on the treated surface, and only at such time and in such manner as approved by the Engineer. Care shall be taken to prevent sudden starts, stops, or turns by equipment. All other traffic shall be maintained on portions of the structure that are not being given the membrane protection.

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

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

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

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

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

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

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

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

Prefabricated membranes shall be free of wrinkles, air bubbles, and other placement defects. Any torn or cut areas or narrow overlaps shall be patched using a satisfactory adhesive and by placing sections of the membrane over the defective area in such a manner that the patch extends at least 15 cm beyond the defect. The patch shall be rolled or firmly pressed onto the surface.

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

After completion of the surface course, the waterproofing effectiveness of the membrane pavement system will be determined. The minimum electrical resistance shall be 500,000 ohms

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

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

33.4.4. Construction

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

Conformance Criteria

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

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

Material Storage

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

Excavation and foundation material replacement

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

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

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

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

Foundation preparation

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

Backfill (except for Rockshed Structures)

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

i) Maximum particle size 100 mm

ii) Uniformity coefficient greater than or equal to 4

iii) Elastic Modulus $M_E \geq 50$ MN/m².

iv) Maximum unit weight of 21 KN/m³, and in any case according to the design requirements.

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

Erosion Protection Measure at Culvers

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

i) Rock boulders: 1 - 3 m³

ii) bed of plain concrete 0.50 m thickness

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

33.5. Additional provisions for Rockshed

33.5.1. General

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

33.5.1.1 Qualification

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

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

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

a. Relevant geotechnical investigation for the design of the structure.

b. Geotechnical review of bearing pressures applied to the foundation soils and overall stability, excavation, installation, supply, placement and compaction of the volume of fill.

c. Replacement of the existing soils with a plain concrete, where the structure is not directly lying on rock material, to meet the requirements for stability (overall) and strength.

Design Calculations:

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

33.5.1.2 Materials

Concrete Materials

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

Concrete Reinforcing Materials

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

Backfill Materials

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

i) Maximum particle size 90mm

ii) Uniformity coefficient greater than or equal to 4

iii) Maximum 15% by mass passing the 75µm sieve, if not; 10% passing at 15µm sieve

iv) Well graded material not gap graded

v) Inorganic with no plastic material content

vi) Minimum angle of friction (Ø) of 40 degree measured through direct shear test under drained condition

vii) Maximum unit weight of 20 KN/m^3, and in any case according to the design requirements.

viii) Plasticity index 6 maximum

The Contractor shall furnish to the Engineer a Certificate of Compliance certifying that the select granular backfill materials comply with this section of the Specifications. A copy of all test results performed by the Contractor which are necessary to assure compliance with the Specifications shall also be furnished to the Engineer. Backfill not conforming to this Specification shall not be used without the written consent of both the Engineer and the wall supplier. The frequency of sampling of select granular backfill necessary to assure gradation control throughout construction shall be as directed by the Engineer.

Cushion Layer (Lightweight Expanded Clay Aggregate LECA Type or equivalent)

The cushion top-filling of the rockshed is composed by Lightweight Expanded Clay Aggregate type LECA 0-30mm or similar, placed in stratum 50cm high, compacted by vibrating plate, conform to the following specifications, according to EN 13055-1 "Lightweight aggregates for concrete, mortar and grout":

i) Aggregate Size Distribution (4.3): 0 - 31.5

ii) Bulk Density Of Material (4.2.1): γ = 390 Kg/m^3 ±15%
(density to be accounted for in design = 600 Kg/m^3)

iii) Crushing Resistance (4.10): σ > 1,5 N/mm^2

iv) Water Absorption at 24 Hours (4.8): C_{imb} < 25%

v) Particle Shape (4.5): Spherical

vi) Friction angle: Φ_k >= 40°

vii) Reaction to Fire: Euroclass A1 (Incombustible)

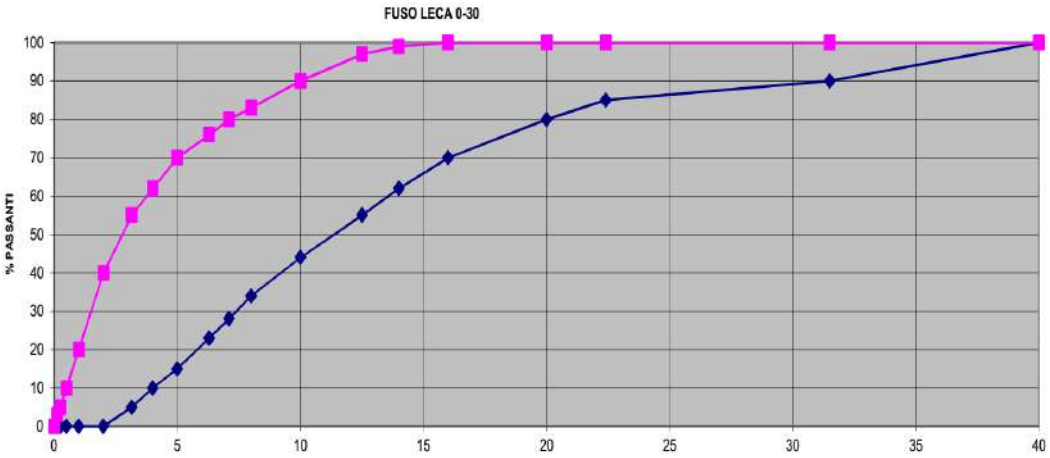


Figure 3: Leca 0-30 / aggregate size / Sieve size vs % passing

33.5.1.3 Construction

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

Conformance Criteria

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

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

Material Storage

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

Excavation and foundation material replacement

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

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

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

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

Foundation preparation

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

Backfill and Topfill

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

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

33.6. Finishing and drainages

All finishing (drainages, painting, filling,..) shall comply with requirements and dimensions provided in the **Employer's Requirement (ERQ), TECHNICAL REQUIREMENTS – Annex A and B and**

Drawing Sections of Contract Document, as well as in “Standard Specifications for Road and Bridge Works – 2073(2075 Amendment) ”, where relevant.

34. UNDERGROUND WORKS

34.1. General

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

34.2. Rock excavations with hammer

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

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

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

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

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

34.2.1. Excavation material management

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

Rock excavation material should be preferably reused or recycled.

34.3. Rock excavations with explosive

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

All works with explosives lie under responsibility of the Contractor.

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

Within first 100 m from the portals, the Engineer could oblige the Contractor to use mechanical excavation (by hydraulic hammer or ripper) instead of explosives, without any additional costs

apart from what is due according to the Contract. Basically, the Contractor must excavate with a full face advance, except for the invert section. In case the Contractor needs to partialize the excavation face, a proper motivation and the relevant excavation scheme shall be provided.

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

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

34.3.1. Excavation material management

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

Rock excavation material should be preferably reused or recycled.

34.3.2. Safety measures

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

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

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

The Contractor must implement all signage works inside and outside the working sites to inform pedestrians and vehicles of the blasting risk in proximity of the working sites.
The Contractor must also implement acoustic and lighting devices to inform peoples in the surrounding area about the beginning of a blasting procedure.

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

34.3.3. Noise reduction measures

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

34.4. Shotcreting (50 to 350mm thick)

34.4.1. Shotcrete type

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

34.4.2. Shotcrete execution

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

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

34.4.3. Preliminary tests

Preliminary tests shall be provided by the Contractor.

For each shotcrete production cycle, at least 10 cylindric samples (ϕ50 mm, height 50 mm) shall be tested: 5 compressive strength tests after 7 days and 5 compressive strength tests after 28 days. Reference shall be made to EN 12 390-3 and EN 12 504-1.

34.4.1. Contractor Qualification and Obligations

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

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

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

34.5. Steel Fibers for Shotcrete

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

34.5.1. Steel fibres type

WIRAND MACCAFERRI FS7 or similar.

Diameter/Length: 0.55 mm/33 mm

L/D aspect ratio: 60

Tensile strength: > 1100 MPa

Elongation at break: < 4%

Dosage: 50 kg/m^3

34.5.2. Contractor Qualification and Obligations

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

34.6. Wire mesh for Shotcrete

34.6.1. Wire mesh type

ϕ 5 mm, pattern 10 cm x 10 cm.

K196 Ruwa Matten or similar.

34.6.2. Material Types

Min. B500 A (according to European standards).

34.6.1. Contractor Qualification and Obligations

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

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

34.7. Steel ribs

34.7.1. Profiles type

HEB 180 profiles are foreseen.

34.7.1. Other steel ribs components

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

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

34.7.2. Material Types

Structural steel S355. Structural steel shall comply with EN10025.

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

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

34.7.1. Contractor Qualification and Obligations

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

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

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

34.8. Lattice girders

34.8.1. Profiles type

JB-3-Gurt Gitterträger or similar:

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

P230-36 or P230-30 or similar

34.8.2. Material Types

Steel grade S500, according to European standards.

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

34.8.3. Contractor Qualification and Obligations

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

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

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

34.9. Swellex rock bolts

34.9.1. Bolts type

Swellex rock bolt Pm 16 type or equivalent

Characteristic Pm16	*Requirements*
Minimum breaking load (expanded profile)	160 kN
Minimum yelding load (expanded profile)	140 kN
Minimum elongation	10%
Profile diameter	36.5 mm
Material thickness	≥ 2 mm
Drilling diameter	≥ 50 mm
Expansion pressure	240 bar

Swellex rock bolt Pm 24 type or equivalent

Characteristic Pm16	*Requirements*
Minimum breaking load (expanded profile)	240 kN
Minimum yelding load (expanded profile)	200 kN
Minimum elongation	10%
Profile diameter	37 mm
Material thickness	≥ 3 mm
Drilling diameter	≥ 50 mm
Expansion pressure	300 bar

34.9.2. Other components

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

34.9.3. Tension / Pull-out tests

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

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

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

- However, at least 3 every 100 m of tunnel for each type of bolt (if applied).

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

34.9.4. Contractor Qualification and Obligations

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

- Drilling record, with indication of length, diameter, drilling system and type of excavated material;

- Expansion procedure record, with description of adopted pressure and injected quantity

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

34.10. Injected rock bolts, incl. injections

34.10.1. Bolts type

Belloli Belcem M33 or equivalent

Characteristic M33	***Requirements***
Minimum breaking load (Ftk)	460 kN
Minimum yelding load (Fyk)	364 kN
Profile diameter	32 mm
Drilling diameter	≥ 60 mm
Steel Grade	B550B or superior

Belloli Belcem M27 or equivalent

Characteristic M27	***Requirements***
Minimum breaking load (Ftk)	350 kN
Minimum yelding load (Fyk)	280 kN
Profile diameter	25 mm
Drilling diameter	≥ 60 mm
Steel Grade	B550B or superior

Belloli Belcem M24 or equivalent

Characteristic M24	***Requirements***
Minimum breaking load (Ftk)	250 kN
Minimum yelding load (Fyk)	200 kN
Profile diameter	22 mm
Drilling diameter	≥ 60 mm
Steel Grade	B550B or superior

Length of bolts range between 4 and 7 m, according to design drawings.
All devices needed to provide a proper injection of the bolts (chamfering, injection pipes, cement itself, pumps and other devices) are to be included in the bolts rate.

34.10.2. Cement based grout

The injection procedure shall be able to guarantee conitnuous and full anchorage between the bolt and surrounding rock. The cement based grout shall comply to the following minimum

requirements. However, independently by compliance to them, the Contractor is required to demonstrate proper anchorage of the bolts by suitable tension tests.

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

34.10.1. Tension / Pull-out tests

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

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

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

- However, at least 3 every 100 m of tunnel for each type of bolt (if applied).

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

34.10.1. Other components

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

34.10.2. Contractor Qualification and Obligations

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

- Drilling record, with indication of length, diameter, drilling system and type of excavated material;

- Injection record with description of injection system, adopted pressure and injected cement volume;

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

34.11. Spiles

34.11.1. Self-drilling bolt type

Minova MAI SDA R51L or equivalent self-drilling cemented bolt

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

34.11.2. Cement based grout

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

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

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

34.11.3. Tension / Pull-out tests

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

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

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

34.11.4. Other components

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

34.11.5. Contractor Qualification and Obligations

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

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

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

34.12. Forepoling umbrella

34.12.1. Steel pipes

Characteristic	***Requirements***
Steel grade	S355
Outer diameter	>100 mm
Thickness	≥ 16 mm

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

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

34.12.2. Cement based grout

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

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

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

34.12.3. Contractor Qualification and Obligations

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

- Drilling record, with indication of length, diameter, drilling system and type of excavated material;

- Injection record with description of injection system, adopted pressure and injected cement volume;

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

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

34.13. Fiberglass dowels/bolts

34.13.1. Fiberglass dowel type

It is foreseen to use fiberglass pipes to be injected from inside. Minimum characteristics as follows.

Characteristic	*Requirements*
Minimum breaking load (Ftk)	800 kN
Outer diameter	60 mm
Inner diameter	40 mm

Length is according to tunnel support classes (see design drawings)

34.13.2. Cement based grout

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

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

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

34.13.3. Tension / Pull-out tests

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

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

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

- However, at least 3 every 100 m of tunnel for each type of bolt (if applied)

34.13.4. Contractor Qualification and Obligations

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

- Drilling record, with indication of length, diameter, drilling system and type of excavated material;

- Injection record with description of injection system, adopted pressure and injected cement volume;

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

34.14. Waterproofing system: composite drainage layer

34.14.1. Description

Groundwater, coming from the surrounding rock mass, is collected at the foot of the tunnel vault, thanks to the drainage and waterproofing layers around the tunnel. The tunnel waterproofing system consists of the following package of layers (in setting sequence, from top to bottom): geocomposite drainage layer; waterproofing layer; protection layer.

34.14.2. Composite draining layer

As drainage layer a geocomposite sheet type Enkadrain shall be used or equivalent, made of two layers of geotextile tissue with interposed a three-dimensional structure to guarantee drainage. Equivalent system can be applied if the Contractor can demonstrate that same drainage properties are guaranteed.

Before to apply the drainage layer, the temporary lining surface shall be accurately checked (visual inspection by Contractor together with representative of the Owner) and smoothened in order to have a regular surface on which to place the waterproofing system. Where smoothening is necessary, it is to be performed by application of an additional shotcrete layer.

34.14.3. Waterproofing layer

Groundwater, coming from the surrounding rock mass, is collected at the foot of the tunnel vault, thanks to the drainage and waterproofing layers around the tunnel. The tunnel waterproofing system consists of the following package of layers (in setting sequence, from top to bottom): geocomposite drainage layer; waterproofing layer; protection layer.

As waterproofing layer, a PVC-P membrane or Spraying Membrane (type SIKAPLAN WP 2110-21HL or equivalent) shall be used, which shall fulfil following minimum requirements:

Characteristics	***Minimum requirements***
Thickness	2 mm
Resistance to punction	≥ 2.85 kN (accor. to Swiss Norm SIA272, SN EN ISO12236)
Tensile resistence	16.5 N/mm2 (accor. to Swiss Norm SIA272, SN EN ISO527)
Max Elongation	≥ 300 %
Shoch resistance	≥ 900 mm (accor. to Swiss Norm SIA272, SN EN ISO12691 system A)

The different strips of PVC membrane shall be welded together by a two parallel continuous welding lines, in order to get a continuous and waterproof membrane. The welding shall be tested by inflating air pressure within the two weld a verifying that a pressure over 100 kPa can be maintained.

No structural or supporting elements that pass through the membrane are allowed. The PVC membrane shall be fixed at the outer lining by proper systems that will be fixe to the membrane itself by welding.

34.14.4. Protection layer

Between the waterproofing layer and the inner lining, a protection sheet shall be placed, in order to protect waterproofing during installation of reinforcement bars and during casting of inner lining.
As protection sheet, an additional protection membrane shall be used (type SIKAPLAN WP Protection Sheet 20H or equivalent).

Characteristics	*Minimum requirements*
Thickness	2 mm
Max Elongation	≥ 150 %
Impact resistance	≥ 900 mm (according to Swiss Norm SIA272, SN EN ISO12691 system A)

34.14.5. Contractor Qualification and Obligations

Contractor shall produce to the Engineer, and get approved before construction, technical sheet of all the elements (composite draining layer, waterproofing layer and protection layer) which shall demonstrate they satisfy all requirements.

The Contractor shall moreover provide for approval to the Engineer before construction the procedure he plan to use to install and weld the waterproofing layer in order to get waterproof connections.

The Contractor shall provide to the Engineer after construction reports of the waterproof tests performed on welded connections.

34.15. Inner lining

34.15.1. Description

The inner lining shall be realized partly by plain concrete and partly by reinforced concrete, accordingly to design and static verifications.

A minimum 50 mm concrete cover must be guaranteed.
Before casting the inner lining, the waterproofing system shall be installed and checked in accordance to Owner's representative.
Casting of concrete shall be made by movable formworks, with length between 10 and 12 m, that allow to cast the lining block in one phase, i.e. without longitudinal construction joints above the final road surface. It is allowed to cast in advance a footing on both sides, in order to provide a support for formwork and a base for the main casting phase.

34.15.2. Concrete

The concrete mixture shall comply with following minimum requirements.

Characteristic	***Requirements***
Minimum cement or combination [1] content	300 kg/m^3
Maximum water cement ratio [1]	0.45
Maximum size of Coarse Aggregate	≤ 32 mm
Consistency class (EN 206-1)	S4 - S5
Minimum average bulk density of fresh concrete	2400 kg/m^3
Compressive strength class (EN 206-1)	C30/37
Minimum characteristic cube strength	37 MPa
Minimum average Flexural strength (EN 12390-5)	2.4 MPa
Minimum average Splitting tensile strength (EN 12390-6)	2.0 MPa
Exposure class	XC4 / XD1 / XF1
Other requirements	Resistant to AAR

34.15.3. Reinforcement

As concrete reinforcement, ribbed steel bars shall be used satisfying following minimum requirements.

Characteristic	*Requirements*
Steel grade	B500B
Yielding stress (Fyk)	500 MPa

34.15.4. Contractor Qualification and Obligations

As for all other requirements, regarding for example (but not only) concrete production, documentation and testing, formwork and curing, the Contractor shall refer to indications and requirements provided in "Standard Specifications for Road and Bridge Works - 2073", Government of Nepal, Ministry of Physical Infrastructure and Transport - Department of Roads, referred to "concrete for structures – section 2000" and section 1800

34.16. Inner Finishing and drainages

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

34.17. Instrumentation And Monitoring

Instrumentation and monitoring are considered as an integral part of the NATM tunneling for verification of the design assumptions on the interactions between the surrounding ground and the initial tunnel support systems induced during excavation process. Works described herein are subsidiary obligations of the Contractor.

34.17.1. Method of Monitoring

Monitoring of ground movement is the mandatory activities to assure that the tunnel centre remains in the alignment.

The monitoring of the ground movement aims to detect the displacement and settlement of the initial tunnel support systems -- particularly the shotcrete lining -- and the ground surface while they are still small and to enable early support system modifications.

These monitoring shall consists of the following observations/surveys.

(a) **Visual Examination of the Tunnel Opening and Ground Surface**

(i) Geologic mapping of the face after each round.

Geologic mapping of the tunnel face and the round periphery is an important element for determining initial support systems.

Information typically included in these face maps include:

- The station location for the cross-section; the date and time the face mapping was prepared;
- The name of the individual who prepared the face map;
- Classification of each type of material observed; the location of interface boundaries between these materials;
- Rock jointing including orientation of principal joints and joint descriptions;
- Shear zones;
- Observed seepage conditions and their approximate locations on the face, walls, or roof;
- Observed ground behaviour noting particularly the location of any instability or squeezing material at the face;
- The location of any boulders or other obstructions; and
- Any other significant observations.

In rock tunnels where the perimeter rock is left exposed, sketches presenting similar information can be prepared for the tunnel walls and roof. All mapping shall be prepared by an experienced geologist or geological engineer of the Contractor knowledgeable of tunnelling and with soil and rock classification.

Mapping of the face, walls and roof shall occur for every excavation round and formally documented and signed off by both the Contractor and the Engineer in the format acceptable to the Engineer.

(ii) Groundwater inflow, if observed.

The quantity of observed seepage shall be recorded and monitored on a daily basis for all groundwater inflow including seepages in the previous rounds as well. The method of measuring inflow quantity shall be subject to the Engineer's approval.

(iii) Deformation of initial support systems after each round.

Ground movement along the tunnel alignment will be the primary cause of displacement or buckling of initial support systems. Amongst others, displacement, buckling and subsidence (settlement) of steel ribs, integrity of shotcrete with wire mesh/steel ribs and rock face, and potential damage to or loosening of rock bolt components, shall be visually checked by the Contractor's geologist or the geological engineer before using the survey instruments. Information thus obtained shall be recorded and presented to the Engineer for review before next excavation.

(iv) Ground surface settlement along the tunnel centre

The Contractor is required to make close observation on potential anomalies such as surface cracking, tilting of trees, changes in stream water flow direction, displacement of the existing boulders, and other unusual phenomena. The Contractor shall record any such anomalies with each excavation cycle, and submit such records as soon as possible but well before next excavation takes place.

The Engineer may instruct the Contractor to lay surface settlement markers and/or benchmarks for observation of ground movement.

(b) **Lateral and Vertical Displacement**

As for the lateral movement of the tunnel opening, distance between the shotcrete surfaces shall be measured at the points illustrated in Fig-34.17.1 for full-face excavation profile and Fig-34.17.2 for top-heading and bench excavation shown below.

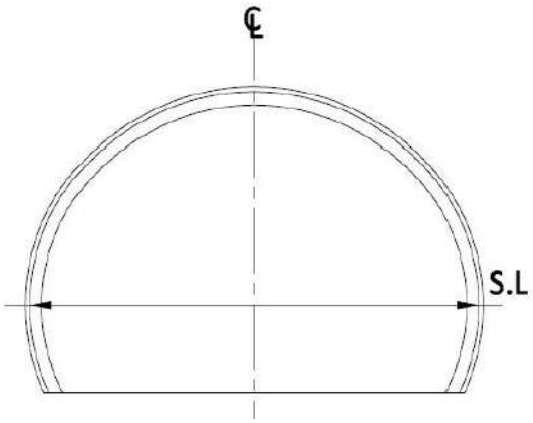


Fig-34.17.1: Full-face excavation

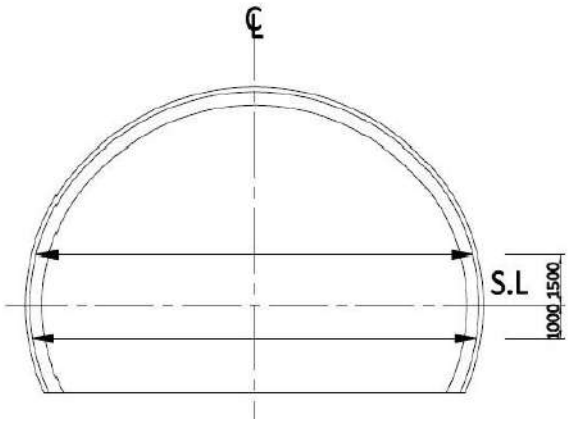


Fig-34.17.2: Top-heading and bench excavation

Vertical displacement of the tunnel cross-section shall also be monitored by surveying level of the crown.

Lateral displacement shall be measured at the spring lines for full-face excavation sections (Fig-34.17.1), and if tunnel is excavated sequentially, i.e. top heading ahead of bench, measurement shall be taken first at 1.5 meters above the spring line (Fig-34.17.2) for every top heading round.

Once bench excavation starts after the top heading excavation, the Contractor shall measure the displacement again at 1.5 meters above the spring line (Fig-34.17.2) and at 1.0 meter below the spring line (Fig-34.17.2) after each bench excavation round.

In unstable ground, which is vulnerable to excavation-induced stress relief such as or tunnel sections near the portals under shallow overburden -- say less than about twice the tunnel width measured along the spring line -- additional measurements shall be taken along a pair of symmetrical lines between the points connecting the crown and points at 1.5 meters above the spring line (Fig-34.17.3).

In tunnel domains where any of or a combination of (i) excavation-induced sharp unsymmetrical pressure, (ii) settlement of steel rib, or (iii) ground heaving is likely to occur, the Engineer may instruct the Contractor to take further measurements along a pair of the symmetrical lines (indicated in dashed lines in Fig.-34.17.3) that connect the point at the crown and points at 1.0 meters below the spring line.

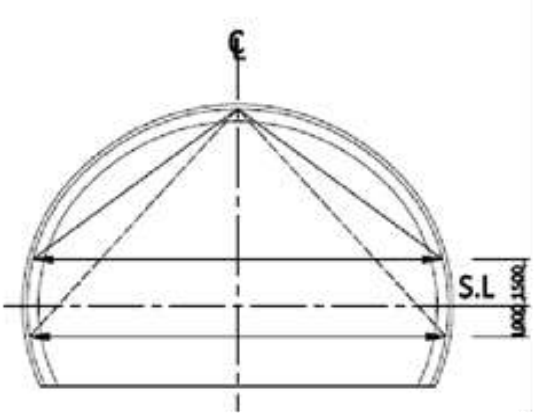


Fig-34.17.3: Lateral Displacement Survey Points for Top Heading & Bench Excavation

In case where the magnitude of the unsymmetrical pressure, settlement of steel ribs, or the ground heaving is considerable in the Engineer's judgement, the Engineer may instruct the Contractor to take readings of the vertical displacement at two off-set points from the crown in addition to the settlement reading of the crown level.

The number of survey points will be determined at the Engineer's discretion and the Contractor shall provide such survey points according to the Engineer's instructions given orally or in writing.

(c) **Surface settlement above the centreline near the tunnel portal**

Geological anomalies observed on the ground surface above tunnels, such as surface cracking, tilting of trees, changes in stream water turbidity and its flow direction, displacement of the existing boulders, and other unusual phenomena, shall be monitored and recorded in a format acceptable to the Engineer.

The Engineer may determine shorter intervals of survey points which are normally selected along the tunnel centre despite the normal intervals given in Table-34.1 below. Survey points may be increased on the ground surface at the Engineer's discretion in case readily noticeable movement is detected.

Table-34.1: Depth of Overburden and Intervals of Survey Points

Depth of Overburden	Intervals
Not exceeding D	5 m
Exceeding D and less than 2D	10 m

D: Tunnel diameter at spring line.

34.17.2. Monitoring Frequency and Interval of Distance

Lateral and vertical displacement of the tunnel opening shall be monitored at the frequencies indicated in Table-34.2, and at the intervals shown in Table-34.3.

Table-34.2: Parameters of Monitoring Frequencies

Monitoring Frequency (*1)	Factors Controlling Monitoring Frequency (*1)	
	Distance from Face	Rate of Lateral/Vertical Movement
2 times / 1day	0 – 0.5 D	Exceeding 10 mm / day
1 time / 1day	0.5 – 2.0 D	5 – 10 mm / day
1 time / 2 days	2.0 – 5.0 D	1 – 5 mm / day
1 time / 1 week	5.0 D or more	Not exceeding 1 mm / day

*(*1): Monitoring frequency will be determined by either the distance from face or rate of movement whichever effectuate higher frequency.*

Table-34.3: Intervals of Survey points

Excavation Profiles	Interval of Survey points (*2)			
	Within 50 m from Portal	50 – 200 m from Portal	Over 200 m from Portal	Overburden not exceeding 2D
All Class	10 m	20 m	30 m	10 m

*(*2): The intervals will be determined by the Engineer based on the ground conditions encountered.*

Surveying Requirements

(a) The Contractor shall use a total station for all surveys for accurate data collection. Thus, the Contractor shall submit to the Engineer for his approval details of the total station he proposes to use.

(b) All survey shall be conducted and controlled by a qualified professional surveyor having a minimum 3 years tunnel survey experiences using a modern total station.

(c) The required surveying accuracy is ± 2 mm for both lateral and vertical directions in any survey unless otherwise instructed by the Engineer. The surveying instruments shall be packaged with the minimum reading function not more than ± 0.1 mm.

(d) The lateral and vertical movement of the tunnel supports (and ground surface as well) shall be surveyed immediately after mucking is completed. It is recommended that the survey is conducted within 3 hours after completion of mucking. For synchronicity of the survey data between ground surface movement and the tunnel supports movement, the Contractor shall simultaneously carry out tunnel survey and ground survey unless otherwise the Engineer agrees.

(e) No excavation will be permitted unless all required survey data is collected.

(f) The data processing software shall be subject to the Engineer's approval.

Survey Reference Points

(a) Permanent reference points shall be continuously located and installed along the tunnel route, no later than one day after installation of the tunnel support system.

(b) The maximum spacing of the reference points shall be not more than 100 meters along straight sections of the tunnel, and no more than 50 meters along curved sections.

(c) The installation of the reference points shall be to the satisfaction of and/or as required by the Engineer. The location of the reference points shall not conflict with other parts of the work, and

(d) Reference points shall be rechecked and verified at one-kilometre intervals in conjunction with the completion of the tunnel support systems.

Longitudinal Profile Survey

The Contractor shall perform (and provide to the Engineer) longitudinal profile survey of the tunnel lining, by means of closed traverse, upon completion of the tunnel works.

Submittal

(a) The Contractor shall submit for the Engineer's approval the following information within 28 days after the date of commencement of the Works.

- Format of geologic mapping, and method of measuring quantity of groundwater inflow,
- Details of the total station, and
- Data processing software.

(b) Other documents (reporting formats) which should be submitted before next excavation are as follows.

- A report notifying geological anomalies observed during visual inspection of tunnel supports and ground surface above the tunnel alignment.

34.17.3. Thresholds

Convergence thresholds (Rock Class upto III):

- Expected maximum vertical displacement 6 mm - 10 mm (lay-by) - 1 mm (bypass);

- Alert threshold, vertical displacement 10 mm;

- Alarm threshold, vertical displacement 15 mm;

- Expected maximum horizontal displacement 2 mm;

- Alert threshold, horizontal displacement 5 mm;

- Alarm threshold, horizontal displacement 10 mm.

Convergence thresholds (Rock Class IV):

- Expected maximum vertical displacement 8 mm;

- Alert threshold, vertical displacement 10 mm;

- Alarm threshold, vertical displacement 15 mm;

- Expected maximum horizontal displacement 2 mm;

- Alert threshold, horizontal displacement 5 mm;

- Alarm threshold, horizontal displacement 10 mm.

Convergence thresholds (Rock Class V):

- Expected maximum vertical displacement 8 mm;

- Alert threshold, vertical displacement 10 mm;

- Alarm threshold, vertical displacement 15 mm;

- Expected maximum horizontal displacement 6.5 mm;

- Alert threshold, horizontal displacement 10 mm;

- Alarm threshold, horizontal displacement 15 mm.

35. ROCKFALL PROTECTION MEASURES

35.1. General

The purpose of this Technical Specification for Civil Works is to recall and extend, where necessary, the general requirements set forth in the "Standard Specifications for Road and Bridge Works – 2073(2075 Amendment)", Government of Nepal, Ministry of Physical Infrastructure and Transport - Department of Roads, with reference to the rock protection measures and earthworks. For all not written in following articles, general requirements by "Standard Specifications for Road and Bridge Works – 2073(2075 Amendment) hold.

35.2. Lightweight Expanded Clay for Rockshed Cushion layer

Within the following articles of this Technical Specification, the minimum technical requirements for Rockshed Cushion Layer

35.2.1. Applicable Codes and Documents

Applicable Code is the latest edition of relevant Eurocode

35.2.2. Contractor Qualification and Obligations

The Contractor shall prove

35.2.3. Articoli specifici

Testo

35.3. Rockfall barriers

Within the following articles of this Technical Specification, the minimum technical requirements for providing and installation of Rockfall Barriers to withstand falling boulders with different levels of impact energy are given: 2000 KJ, 3000kJ and 5000 KJ with wire Ø 3mm, Ring Ø 350mm, Rope Ø 16-22mm, HEA post type with spacing of 8-12m, with barrier ht. ranging between 4 and 5 m as per design and specification including the construction of all required foundations, support system, braking system all complete, and use of helicopter or the crane, whichever is feasible & equivalent to Geobrugg RXE 2000-3000-5000 Rockfall barrier.

35.3.1. Barrier types

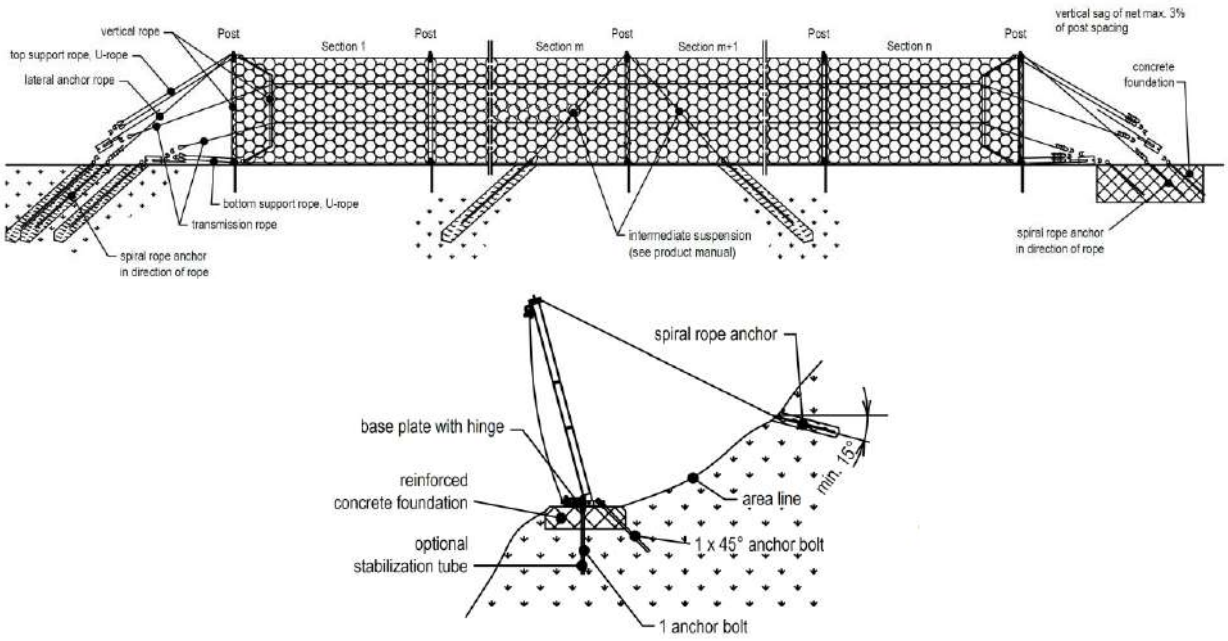
Depending on required energy adsorbion, three types of rockfall barriers has been considered with the following general requirements:

- Design barrier type GEOBRUGG RXE 2000 or similar
  Absorption capacity 2000 kJ
  Energy class EOTA 5
  Height 4 m
  Post spacing 8-12 m (average 10 m)
- Design barrier type GEOBRUGG RXE 3000 or similar
  Absorption capacity 3000 kJ
  Energy class EOTA 6
  Height 4 m
  Post spacing 8-12 m (average 10 m)

- Design barrier type GEOBRUGG RXE 5000 or similar
  Absorption capacity 5000 kJ
  Energy class EOTA 8
  Height 5 m
  Post spacing 8-12 m (average 10 m)

Adequacy of the position, energy absorption and height to the local conditions shall be verified and confirmed or adapted by the Contractor performing an independent rockfall analysis. Exact location of the rockfall barriers shall also be defined based on such analysis.

An example of the rockfall barrier hereby considered is shown in the following figure (Geobrugg AG). See tender drawings for more details.



35.3.2. Technical requirements

The Contractor must refer to the rockfall barriers supplier for all system details.

The reference supplier for the present design is GEOBRUGG AG. Similar suppliers could be chosen by the Contractor.

Structural elements of the barrier shall fulfil the following minimum requirements.

Minimum diameter of a single net wire shall be 3 mm and coating thickness min.150 g/m2 to encounter potential erosion and weathering processes and reduce maintenance. The nets shall be made in such a way that if there is a rupture, the failure area should be closely limited and not propagate through the protection surface.

For safety reasons, brake elements shall be placed at the ends of the corresponding support ropes only.

Brake elements activation force has to be ≥ 50 kN, to avoid activation during installation or triggered by snow other temporary loads.

Hot dip galvanization of energy dissipating (deforming) elements is not allowed to avoid rusting after partial brake elements activation.

All connections of ropes to posts and anchors must be detachable, to allow mesh exchange without taking down support or middle ropes in order to guarantee fast and economical maintenance.

All assembly components shall be hot dip galvanized to provide at least the same corrosion resistance as the main elements (posts, ropes, net).

Anchors shall fulfil the following general requirements:

- Rope anchorage with a flexible head section which allows a movement of min. 30° off the anchor axis without reduction of the nominal load capacity;
- Double corrosion protection at anchor head of rope suspensions.

Moreover, anchorages, depending on the type of rock barrier required at each location, shall satisfy individual minimum requirements as resulting by proper calculations under the effect of the design impact energy and accordingly to the supplier of the adopted system.

All elements of the adopted rockfall barriers shall guarantee a service life not lower than 50 years.

35.3.3. Technical requirements on anchors for Geobrugg RXE 2000 or equivalent

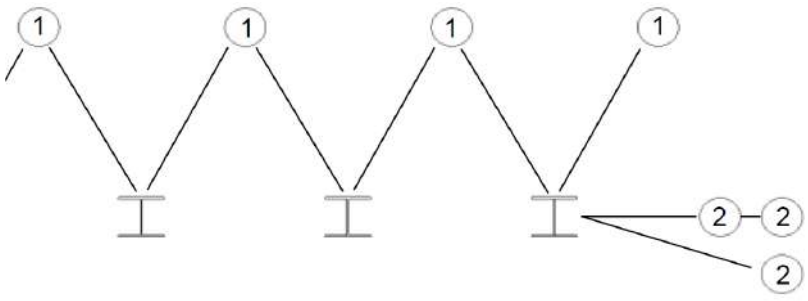
Anchors with following minimum requirements shall be provided (to be verified in accordance with supplier specifications):

- Upslope anchors (1) retaining ropes

Characteristic load	315 kN (tensile)
Anchor type	permanent spiral rope anchor GEOBRUGG type III 18.5 mm or similar
Drilling diameter	≥ 110 mm
Length	≥ 5.5 m

- Lateral anchors (2) support and lateral ropes

Characteristic load	285 kN (tensile)
Anchor type	permanent spiral rope anchor GEOBRUGG type III 18.5 mm or similar
Drilling diameter	≥ 110 mm
Length	≥ 5.0 m

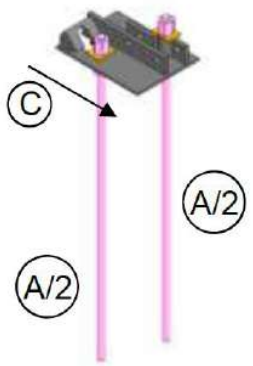


RXE 2000 typical rope scheme

- Posts foundation

Characteristic load 310 kN (A = compression) / 85 kN (C = shear)
Anchor type 2x permanent micropiles GEWI 32 mm or similar (steel grade B500B)

Drilling diameter ≥ 110 mm
Length ≥ 4.5 m



RXE 2000 post foundation

35.3.4. Technical requirements on anchors for Geobrugg RXE 3000 or equivalent

Anchors with following minimum requirements shall be provided (to be verified in accordance with supplier specifications):

- Upslope anchors (1) retaining ropes

  Characteristic load 230 kN (tensile)
  Anchor type permanent spiral rope anchor GEOBRUGG type III 18.5 mm or similar

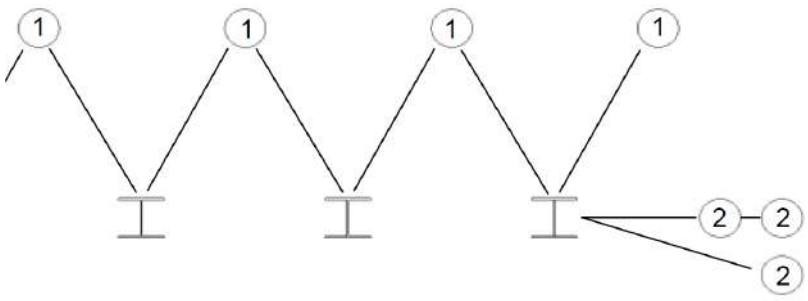
  Drilling diameter ≥ 110 mm
  Length ≥ 4.0 m

- Lateral anchors (2) support and lateral ropes

  Characteristic load 280 kN (tensile)
  Anchor type permanent spiral rope anchor GEOBRUGG type III 18.5 mm or similar

  Drilling diameter ≥ 110 mm
  Length ≥ 5.0 m

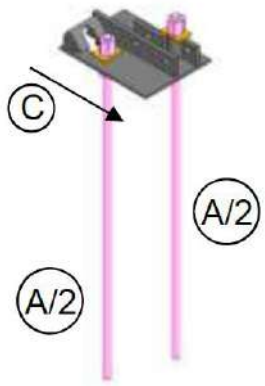
RXE 3000 typical rope scheme



- Posts foundation

  Characteristic load 270 kN (A = compression) / 150 kN (C = shear)

Anchor type	2x permanent micropiles GEWI 32 mm or similar (steel grade B500B)
Drilling diameter	≥ 110 mm
Length	≥ 4.0 m



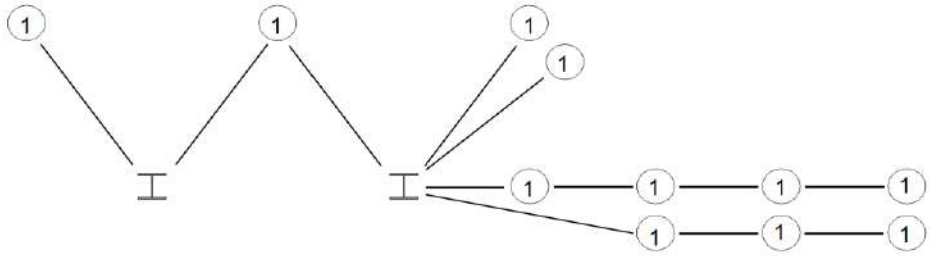
RXE 3000 post foundation

35.3.5. Technical requirements on anchors for Geobrugg RXE 5000 or equivalent

Anchors with following minimum requirements shall be provided (to be verified in accordance with supplier specifications):

- Upslope/Lateral anchors (1) retaining/support/lateral ropes

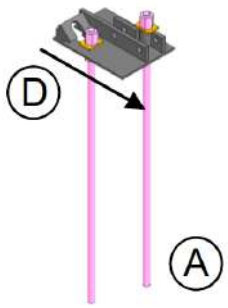
Characteristic load	290 kN (tensile)
Anchor type	permanent spiral rope anchor GEOBRUGG type III 18.5 mm or similar
Drilling diameter	≥ 110 mm
Length	≥ 5.0 m



RXE 5000 typical rope scheme

- Posts foundation

Characteristic load	300 kN (A = compression) / 265 kN (D = shear)
Anchor type	2x permanent micropiles GEWI 40 mm or similar (steel grade B500B)
Drilling diameter	≥ 110 mm
Length	≥ 7.5 m



RXE 5000 post foundation

35.3.6. Onsite tests

In order to verify that spiral rope anchors and micropiles meet the design requirements, suitable pull out/load tests shall be provided before rockfall barriers installation.

In each homogeneous rock formation or ground condition and for each rocknet, at least 3 tests shall be provided for each designed anchor type. The design of the tests (location, pulling and loading system, etc.) shall be provided by the Contractor according to Eurocodes. The tests shall be performed up to a load level useful to guarantee that external resistance is at least equal to characteristic internal characteristic resistance of the anchors. The tests shall be performed before to start construction and the results shall be made available and approved by the Engineer.

35.3.7. Contractor Qualification and Obligations

The Contractor shall demonstrate to make use of specialized personnel with experience in installation of rack barrier of the same supplier as adopted.

The Contractor shall produce a safety plan and a risk assessment for the construction phase, which show all safety measures that he is going to install in order to exclude the risk of falling rocks and materials on the existing road during installation of rocknet. Only after approval by the Engineer, construction can start.

The Contractor shall also prove to have installed the rocknet accordingly to supplier requirements. For this purpose, the Contractor shall produce a certificate provider by the supplier of the system testifying that the rock net has been installed correctly in order to work properly.

The Contractor shall moreover provide the following documentation being crucial for correct installation and guaranteeing results obtained during certification procedure:

- Product manual showing all the barrier's details, installation steps and details of solutions for special cases (e.g. intermediate suspension).
- Maintenance manual explaining inspection procedures, conditions proving correct barrier performance and eventual repair methods.
- Anchor forces table showing characteristic forces (max. forces measured during tests).

The Contractor shall consider as included in his prices all component, activity and safety measure needed to provide and install the adherence mesh in the proper way and position, including all redistribution plates, bolts and wire bolts, drilling activities, use of helicopter, safety measures and protection barrier to allow to keep the H10 in service at least with reduced width (alternate traffic).

35.4. Wiremesh Systems

Supply and installation of Wiremesh system as per design and specification including the construction at site, and use of helicopter or the crane, whichever is feasible & equivalent to Geobrugg TECCO G65/4 high tensile steel wire mesh.

35.4.1. Technical requirements

The Contractor must refer to the adherence wiremesh system supplier for all system details.

The reference supplier for the present design is GEOBRUGG AG. Similar suppliers could be chosen by the Contractor.

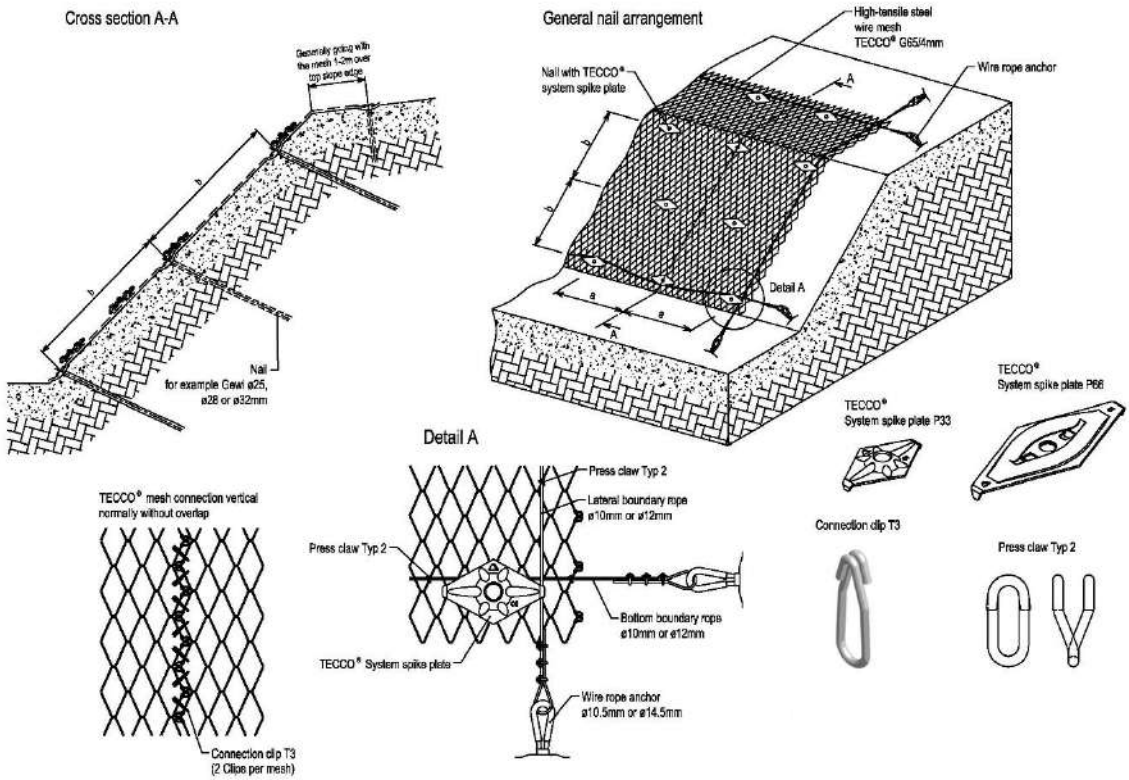
The adopted surface net shall be made of high-tensile steel wire mesh type Geobrugg TECCO G65/4 or similar, with P66 redistribution plates (spike plates, steel quality S355J) or similar. Anchorage of stabilization nets will be provided by grouted bolts GEWI 32 mm or similar (steel grade B500 B), with a pattern with maximum step 2.5 m x 2.5 m, having a minimum drilling diameter equal to 110 mm. As the bolts are used as permanent bolts, a sacrifical steel layer of at least 2 mm around the whole bar shall be assumed as a consequence of rusting during service life. As alternative, bolts with double protection shall be adopted, accordingly to relevant Eurocodes. Minimum requirement on characteristic resistance of the bolt during service life (i.e. considering section reduction due to rusting) is:

- axial resistance ≥300 kN;
- shear resistance ≥ 170 kN.

Along the border of the net, a lateral border rope and wire rope anchors shall be provided as by supplier indications.

All element of the adopted adherence mesh shall guarantee a service life not lower than 50 years.

The above described adherence mesh is shown in the following figure (Geobrugg AG).



35.4.2. Onsite tests

In order to verify that wire rope anchors and micropiles meet the design requirements, suitable pull out/load tests shall be provided before adherence net installation.

In each homogeneous rock formation or ground condition, at least 3 tests shall be provided for each designed anchor type. The design of the tests (location, pulling and loading system, etc.) shall be provided by the Contractor according to Eurocodes. The tests shall be performed up to a load level useful to guarantee that external resistance is at least equal to characteristic internal characteristic resistance of the anchors. The tests shall be performed before to start construction and the results shall be made available and approved by the Engineer.

35.4.3. Contractor Qualification and Obligations

The Contractor shall demonstrate to make use of specialized personnel with experience in installation of adherence net of the same supplier as adopted.

The Contractor shall produce a safety plan and a risk assessment for the construction phase, which show all safety measures that he is going to install in order to exclude the risk of falling rocks and materials on the existing road during installation of rocknet. Only after approval by representative of the Owner, construction can start.

The Contractor shall also prove to have installed the adherence net accordingly to supplier requirements. For this purpose, the Contractor shall produce a certificate provider by the supplier of the system testifying that the rock net has been installed correctly in order to work properly.

The Contractor shall moreover provide the following documentation being crucial for correct installation and guaranteeing results obtained during certification procedure:

- Product manual showing all the net's details, installation steps and details of solutions for special cases (e.g. intermediate suspension).
- Maintenance manual explaining inspection procedures, conditions proving correct barrier performance and eventual repair methods.
- Anchor forces table showing characteristic forces (max. forces measured during tests).

The Contractor shall consider as included in his prices all component, activity and safety measure needed to provide and install the adherence mesh in the proper way and position, including all redistribution plates, bolts and wire bolts, drilling activities, use of helicopter, safety measures and protection barrier to allow to keep the H10 in service at least with reduced width (alternate traffic).

35.5. Permanent Shotcrete with bolts for erosion protection of mudstone or other erosive layers (150 mm thick)

Where erosion of mudstone or other erosive layers with thickness larger than 20 cm can be expected with consequent risk of instability of upper sandstone blocks, a shotcrete layer shall be applied to protect it by erosion and stabilize superficial unstable blocks.

Wherever mudstone or other erosive or other erosive with a thickness ranging between 20 and 50 cm, the following system shall be applied:

- execution of a permanent shotcrete C30/37 layer, 15 cm thick, with a wire mesh ø6/10x10;

- the shotcrete layer shall have a minimum high of 1 m (to cover the whole mudstone or other erosive or other erosive layer and overlap mudstone or other erosive or other erosive for at least 20-30 cm);
- wire mesh shall have everywhere at least 5 cm cover and 30 cm overlapping;
- in the centre of the shotcrete layer, a row of bolts with horizontal step 2 m shall be placed and the heads covered by at least 5 cm concrete, accordingly to design drawings.
- Above shotcrete layers and its bolts, where foreseen, Tecco net will be installed with its own bolts, as by previous point, to keep continuity of the Tecco intervention above and below the mudstone or other erosive or other erosive layer;
- before shotcrete execution, scaling of unstable blocks;
- if a mudstone or other erosive or other erosive layer is eroded (presence of step between sandstone layer above and mudstone or other erosive or other erosive layer), the step shall be filled with shotcrete in order to level it and give a foot to the above sandstone layer, before installing the final shotcrete layer and bolts.

Wherever a mudstone or other erosive or other erosive layer has a thickness > 50 cm, the following measures shall be applied:

- same system with protective shotcrete layer as for thinner mudstone or other erosive or other erosive layers, but with at least 2 rows of bolts fixing the shotcrete layer with horizontal and vertical step not larger than 2 m;
- Above shotcrete layers and its bolts, Tecco net will be installed with its own bolts, as by previous point;
- scaling and filling with shotcrete in case of erosion as for thinner layers of mudstone or other erosive or other erosive .

For relevant requirements regarding shotcrete type, characteristic and admixture, wiremesh type, bolts types and characteristics, execution process, preliminary tests on shotcrete, pull-out, tension and corrosion tests on bolts and Contractor qualifications and obligations, reference shall be made to points 10.2, 10.3 and 10.4 and to “Standard Specifications for Road and Bridge Works – 2073(2075 Amendment)”.

35.6. Scaling of unstable blocks

Within the following articles of this Technical Specification, the minimum technical requirements for scaling procedure of unstable blocks shall be defined.

35.6.1. Applicable Codes and Documents

Relevant document is Employer’s Requirements-Drawing of the contract Documents, where potential unstable boulder are shown as available observed by orthophotos. This document shall be considered as a starting base to evaluate the areas where scaling shall be needed; however, the Contractor shall perform an independent survey to record position of boulders, evaluation of their risk of instability and, hence, update map of boulders to be removed.

35.6.2. Contractor Qualification and Obligations

The Contractor shall provide to the Engineer for approval its own independent evaluation on the areas where scaling is needed and a plan describing them, before to start activity. Moreover, Contractor shall submit for approval to the Engineer, prior to start activity, a proper procedure to proceed on removal of unstable blocks, guaranteeing safety of adjacent areas that shall be kept in service, at least with reduced width (alternate traffic); the procedure shall include all necessary protection to guarantee safety of traffic and pedestrian. Moreover, all activity shall be performed guarantee safety conditions to workers themselves.

After activity has been concluded, the Contractor shall produce a plan where he record all boulders that has been removed and all boulder that has been checked but considered stable in the short and long term.

36. EXPLOITATION AND SAFETY EQUIPMENT (ESE)

36.1. General

The detail-degree of all the systems listed here below has been harmonized with the project phase and with the procedural situation (tender for DB/EPC contract), therefore no executive details are provided where it is not considered essential for the outcome of the works. It was therefore assumed that the executive details will be defined with the general contractor, by the client or by a representative of the same, during the execution phase of the project.

The reference standards and requirements for the following systems have been defined:

- Energy supply system
- Lighting system
- Ventilation system
- Signage system
- Surveillance systems
- Communication network and Tunnel control system
- Cabling system
- Secondary installations

Refer Employer's Requirement (ERQ), TECHNICAL REQUIREMENTS Annex C and D.

37. Installation and pre-commissioning

Once the plants/Equipments have arrived at the site, they can be installed according to the detailed planning provided by the contractor.

The activities will have to be harmonized and optimized to reduce the installation time without this being detrimental to the quality of the work. The installation sequence of the systems must follow a logical order and must be harmonized with the execution of the civil engineering works.

They should be avoided:

- rework

- disassembly of plants or parts of plants already assembled and tested.

Progressively, with the installation of the plants, the general contractor will have to monitor the quality of the execution of the works, and intervene promptly in the event that it is not satisfactory.

The progressively assembled plants, and also their parts, will be progressively tested in their basic functions. These tests will be informal and will be conducted by the general contractor.

The installation period will end with a pre-commissioning phase that will take place on site.

In the pre-commissioning, Contractor shall arrange and carry out all inspections in accordance with the Contract requirement. Where the third party inspection is required, Contractor shall ensure that all third party inspection conform with the Contract requirements and Contractor shall furnish Contracting Authority with the copies of records for all inspections.

Contractor's scope of inspections prior to pre-commissioning shall include, but not be limited to, the following:

- All materials and Works are subject to visual inspection for surface defects.
- Visually inspection and verification that the installations conform with the drawings.
- Conduct inspections of all equipment, check nameplate, check electrical connection data, layout and ensure conformity to specification.
- Inspection on safety features and earthing system of electrical equipment.
- Visual inspection and ensure correct assembly of all equipment.

Contractor shall perform testing and pre-commissioning in accordance with Contract requirement for all Contractor and Contracting Authority supplied equipment and system.

Contractor shall prepare the detailed testing and pre-commissioning procedure and submit to Contracting Authority for review and approval three (3) months before testing and pre-commissioning activities commencement. The procedure shall include, but not be limited to, the following:

- Pre-commissioning execution plan, critical path network, bar charts.
- Pre-commissioning scope of work of each system, equipment testing procedures of each system.
- Check sheets overview, reinstatement test pack, list of equipment to be used.
- Pre-commissioning manpower level and organisation.
- Schedule for equipment vendor representative(s) mobilisation for both Contracting Authority and Contractor supplied equipment.
- Listing of consumables required.

All testing and pre-commissioning shall be thoroughly recorded and documented. These documents shall be approved by Contracting Authority and eventually be included in the Final Documentation.

No testing or pre-commissioning shall be undertaken until the appropriate verification and check have been satisfactorily completed and agreed upon in writing by Contractor.

In all cases, the relevant equipment manufacturer's instruction manual and vendor data must be carefully read and understood before any testing and pre-commissioning started.

Non-conformance of any equipment discovered during testing and pre-commissioning shall be rectified, re-tested and re-commissioned by Contractor to the satisfaction of Contracting Authority at Contractor's own cost.

Contractor shall provide all consumable necessary for the testing, pre-commissioning and operation of the process equipment. Contractor shall use vendor recommended consumable for the equipment and take due cognisance of the manufacturer's recommendations and the overall intent of Works.

Contractor shall provide the services of vendor representatives, as required, for the pre-commissioning period for Contractor supplied equipment at Contractor's own cost.

The PLANT AND SYSTEM SCOPE OF WORK of the present contract will be considered as mechanically complete when the following requirements have been met:

- The PLANT AND SYSTEM SCOPE OF WORK have been constructed, and pre-commissioned in accordance with the approved drawings, specifications, Quality Plan and procedures, including inspection/witnessing and acceptance by Contracting Authority prior to introducing the process and utility feedstock into the system.
- All the installed equipment have been functionally tested, all SPIRs have been submitted by Contractor and accepted by Contractor.
- All utility systems and plant buildings have been commissioned.
- All design modifications have been noted and modifications incorporated into Data and Documentation mark ups with As- Built mark ups within system dossiers. All operating instructions, documentation and drawings necessary for prudent and safe operation of the facility have been submitted and accepted by Contractor.
- Mechanical Completion Certificate have been issued by Contractor, upon fulfilment of all the above stated requirement by Contractor.

38. COMMISSIONING

38.1. General

The additional requirements contained in this section shall apply to PLANT AND SYSTEMS (ESE) works, as defined Employer's Requirement Section.

Contracting Authority is responsible to perform the commissioning

Contractor shall execute all activities required for commissioning and start-up of the Exploitation and Safety Equipment, i.e. checking, putting into operation and operating the utilities systems required for commissioning the process and other facilities, and all verifications required to demonstrate that the Exploitation and Safety Equipment are ready for start-up.

38.2. Commissioning requirement

Contractor shall note that Commissioning shall generally include the following activities and such activities are to be completed prior to opening the tunnel to traffic.

The commissioning phase shall end at least two months before the tunnel is put into service. In the following two months the tunnel shall be allowed to operate without traffic to check for any problems before opening to traffic.
All tests must be documented and signed by those present.

Major commissioning Activities are (non-exhaustive list):

- Testing and certification, in accordance with current legislation, of the entire low-voltage electrical distribution system, including the UPS network and including verification of all grounding and lightning and surge protection. Where required by law, the tests must be accompanied by the necessary certifications
- Testing of all control algorithms of the lighting (lighting level adjusted according to the values of the luminance probes, etc.) and testing of the manual control of all parts of the lighting system.
- Testing of all control algorithms of the ventilation (ventilation level adjusted according to the values of the sensors, etc.) and testing of the manual control of all parts of the ventilation system.
- Test of a software simulated fire and consequent reaction of the ventilation system.
- Testing of all possible signage conditions (all OCs - operating conditions – and transitions between them). In particular, the emergency closure of the tunnel shall be tested.
- Test of the detection carried out by the fire detection system: both thermal detection (fibre-optic cable) and smoke detection (smoke sensors).
- Test live images from all cameras: display in control centre, recording.
- Testing of all auxiliary systems, such as pumping systems.
- Testing and verification of the fibre-optic infrastructure.
- Testing and verification of universal structured cabling.
- Test the Ethernet communication network of the gallery, including the redundancy of the main switches.
- Testing of the entire tunnel control system (SCADA): appearance of the graphic pages, sending of commands, acknowledging the execution of a command, tracking in the system log, alarm messages, control algorithms at SCADA level, control

algorithms at the level of the operator panels and their graphic appearance, control algorithms at the level of the PLCs, etc.
Every single SCADA variable (tag) must be tested. The redundancy of the SCADA server must be tested. All response values (times) of the system must be tracked to future memory. The export of historical data (log) must be tested.
The verification of the graphic aspect of the man-machine interface must take place in the presence of the final operators who will use the systems, who will have the possibility to request modifications or adaptations.

- Testing of the radio system in the tunnel in the presence of emergency services such as police, fire brigades or ambulances. The effectiveness of the radio communication system shall be officially confirmed by the emergency services.
- Testing of the emergency telephone system (calls), including texts of fire extinguisher pick-up.
- Testing of all installations inside buildings, such as electrical sockets, room lighting, fire detection, telephony, etc. Where required by law, the tests must be accompanied by the necessary certifications.
- Accurate testing of all automatic safety reactions (document 695013-D-A-E-K-002, volume 5). The individual events triggering the reactions may be either real or simulated. All implant reactions should be logged and attached to the test documents as proof to future memory.
- Test of the functioning of the tunnel equipment in the presence of two fires. For this purpose, two fires will have to be simulated, at different times, using smoke generators suitably placed inside the tunnel at particularly significant points according to the ventilation designer. The reaction of all tunnel installations should be evaluated according to document 695013-D-A-E-K-002. The reaction of the ventilation system (activation, delays, sense of smoke evacuation, etc.) should be evaluated and confirmed by the ventilation designer. The tests must be carried out in the presence of the emergency services, which may use this opportunity for a drill (arrival at the tunnel, manoeuvres, communication between the services, entrance to the tunnel in the presence of smoke, rescue of people - figurants - involved, clearing of the area, etc.). The text may also serve as an exercise for the operators of the control room. The tests will have to be filmed. All reactions of the installations, tracked in the log of the tunnel control system, must be saved to future memory.

38.3. Contractor Commissioning Responsibility

Contractor's responsibilities include, but are not limited to the following:

- Provision of a team of suitably experienced and qualified personnel including management, supervision, labour, and the necessary assistance by Sub-Contractor's / Vendor's commissioning specialists, for commissioning as per approved plans, schedules and procedures, including the appointment of a Commissioning Manager.

- Preparation of interface and commissioning co-ordination procedures together with supporting documentation. Contractor shall prepare and submit Commissioning Manual to Contracting Authority for approval, six (6) weeks in advance.

- Preparation of safety audits and recording of all approved safety audit items to ensure the required safety.

- Provision of all commissioning spare parts and consumables and ensuring their availability at Site at least two (2) weeks prior to commissioning of facility.

- Maintenance of all documentation and records of Commissioning Activities including execution and documentation of performance tests of commissioning systems.

- Maintenance of records of all design changes for updating the operating manuals.

- Provision of mechanical, electrical and instrumentation test and measuring equipment and special tools and accessories necessary to carry out calibration, testing, trouble shooting and repair to ensure timely completion of commissioning activities.

- Preparation and issue of the Commissioning dossier of the individual systems.

- Identification of commissioning activities including definition electrical and instrumentation test systems, definition of commissioning systems and definition of performance test program.

- Ensuring adequate and timely operator involvement in the preparation of the commissioning activities, and close liaison and co-ordination with Contracting Authority Operations, Maintenance and Safety.

- Provision of a detailed commissioning plan, procedures, schedules and reports which shall be submitted to Contracting Authority for approval. Ensuring documented recording and reporting.

- Submission of operating and maintenance manuals for Contracting Authority approval, six (6) weeks prior to commissioning.

- Obtaining and complying with the necessary permits and approvals.

39. TRAINING OF CONTRACTING AUTHORITY PERSONNEL

The additional requirements contained in this section shall apply to PLANT AND SYSTEMS (ESE) works, as defined Employer's Requirement Section.

With an objective to ensure continuous, efficient and trouble free operation and maintenance of the road tunnel plants and systems, after hand-over to Contractor and before tunnel opening to traffic (desired: 1 month), Contractor shall undertake a training program for Contracting Authority personnel. The training of Contracting Authority operations and maintenance personnel is a key Contractual requirement, which will be fulfilled by Contractor, in agreement and to the satisfaction of Contractor.

Training shall be provided in both, a formal 'classroom' environment and also 'hands on training' at site during installation and commissioning stage.

Training requirements of Contracting Authority personnel shall cover as a minimum:

a) General operation of the road tunnel

b) Operation of the road tunnel in emergency conditions

c) General maintenance requirements of all the equipment.

The training for operation and maintenance shall be carried out at site, by continuous involvement of assigned Contracting Authority personnel, during installation, pre-commissioning and commissioning stage.

Training must also be provided for emergency services (police, fire brigade, ambulance):

- general description of the tunnel and its facilities

- closure of the tunnel

- functioning of the ventilation

- risk factors in tunnel intervention

- the way it interacts with the control room.

In particular, account must be taken of the fact that those who intervene on site in the event of an emergency must be adequately trained to give instructions to the operators of the control room (switch off the ventilation, act on the signs, act on the lighting, etc.).

Contractor shall prepare a detailed training program, in consultation with vendors and submit to Contractor, for approval at least 6 months before the opening of the tunnel to traffic.

The general requirements related to training are as below:

- All training shall be conducted using the Nepalese and English Language and during the normal operational working hours.

- Services of suitably experienced and qualified instructors shall be utilized by Contractor for training. The instructors must have perfect mastery of the tunnel facilities.

- All training equipment including training aids, special training equipment etc shall be organized by Contractor. Also considered here are the equipment necessary for real fire tests (smoke generators, respirators, beakers).

- Reference manuals including vendor data books, training/maintenance/operating manuals and other technical literature, as necessary for the training shall be supplied in the required number of sets in advance by the Contractor. The language of these documents will be English and Nepalese.

- Class-room training shall be followed by field demonstrations.

- Training program shall cover the following aspects :

    - General system familiarization.
    - System/operation
    - System/operation in emergency situations
    - Automatic safety reactions
    - System maintenance
    - Troubleshooting – in operations as well as maintenance
    - Preventive maintenance requirements
    - Periodical cleaning and inspection.

- Contractor shall ensure that the program of vendor representatives' site visit for field assistance, is informed to Contractor, in advance to enable Contracting Authority personnel to participate with Contractor/Vendor's staff during the installation and commissioning of such equipment/system.

- Contractor shall maintain a complete record of training and submit to Contractor, along with one set of complete training literature, manuals etc. on successful conclusion of training program.

- The number of training shall be as per activity schedule.

40. PROJECT DOCUMENTATION

Project documentation requirements for Contract execution, as explained below, shall be complied by the Contractor.

40.1. Documentation During Engineering, Procurement, Construction Phase

The documents and drawings, which are to be submitted to Contractor, for review and approval or review, shall be identified by Contracting Authority as a part of approval of Technical Document Register (TDR), during early part of project. The balance documentation in TDR shall be forwarded to Contractor, for information. Contractor shall submit three (3) sets of the required documentation for Contracting Authority review.

Contracting Authority approval / review cycle shall be 30 calendar days from the receipt of the document. Contractor shall plan and schedule all related project activities, taking into account the 30 calendar days' Contracting Authority approval cycle. Contracting Authority shall, however, endeavour to review critical documents on priority, with shorter approval cycle, to the extent possible.

40.2. Final documentation

After successful completion of the defect liability period, within 1 month, Contractor shall hand-over the Final project Documentation to Contracting Authority as outlined below:

a) The number of sets of Final Documentation to be handed over shall be:

- Hard Copy - 6 Sets
- Electronic Copy - 2 Sets

Hard copies shall be handed over as properly hard-cover bound volumes, with complete documentation index in each volume, in addition to the index of the respective volume.

Electronic copies shall be on DVD or USB pen-drive with proper labels and List of Contents.

b) The Final Project Documentation, shall include, but not limited to, the following:

- Start-up and Operation Manual.
- Maintenance Manual
- Final Vendor Documentation
- As-Built Drawings.
- Project Design Dossier (will cover an updated Design Basis, Design Philosophies, and Calculations, which formed basis for engineering).
- Detailed, definitive and exhaustive wiring diagrams.
- Complete set of Approved SPIRs
- Construction Documentation and Records

- Commissioning Records.

Vendor documentation shall be well organized and compiled. It shall have the following three separate sections:

- Design section – Technical Documents, specifications, data sheets and drawings
- Manufacturing records
- Operation and maintenance manual

Contractor shall transmit this requirement to the vendors during inquiry stage and check vendor's compliance with this requirement upon receipt of the vendor documentation.

Contractor shall include copies of his purchase orders for the tems, in his final documentation.

Un-priced purchase orders for all items and bulk items will also be included in final documentation.

The above purchase orders shall not be subject to any review, audit or reimbursement and shall be submitted for Contractor's future reference only.

c) Final Acceptance Certificate shall be issued by Contractor, only after hand-over of complete Final Documentation by Contractor to Contractor's satisfaction.

SECTION-VI

Bill of Quantities

Notes for Unit Rate Contracts :

Objectives

The objectives of the Bill of Quantities are

(a) to provide sufficient information on the quantities of Works to be performed to enable Bids to be prepared efficiently and accurately; and

(b) when a Contract has been entered into, to provide a priced Bill of Quantities for use in the periodic valuation of Works executed.

In order to attain these objectives, Works should be itemized in the Bill of Quantities in sufficient detail to distinguish between the different classes of Works, or between Works of the same nature carried out in different locations or in other circumstances which may give rise to different considerations of cost. Consistent with these requirements, the layout and content of the Bill of Quantities should be as simple and brief as possible.

Content

The Bill of Quantities should be divided generally into the following sections:

(a) Preamble;

(b) Work Items (grouped into parts);

(c) Day works Schedule;

d) Provisional Sums; and

(d) Summary.

Preamble

The Preamble should indicate the inclusiveness of the unit prices, and should state the methods of measurement which have been adopted in the preparation of the Bill of Quantities and which are to be used for the measurement of any part of the works.

Work Items

The items in the Bill of Quantities should be grouped into sections to distinguish between those parts of the Works which by nature, location, access, timing, or any other special characteristics may give rise to different methods of construction, or phasing of the Works, or considerations of cost. General items common to all parts of the works may be grouped as a separate section in the Bill of Quantities.

Day work Schedule

A Day work Schedule should be included only if the probability of unforeseen work, outside the items included in the Bill of Quantities, is high. To facilitate checking by the Employer of the realism of rates quoted by the Bidders, the Day work Schedule should normally comprise the following:

(a) A list of the various classes of labor, materials, and Constructional Plant for which basic day work rates or prices are to be inserted by the Bidder, together with a statement of the conditions under which the Contractor will be paid for work executed on a day work basis.

(b) Nominal quantities for each item of Day work, to be priced by each Bidder at Day work rates as bid. The rate to be entered by the Bidder against each basic Day work item should include the Contractor’s profit, overheads, supervision, and other charges.

Provisional Sums

A general provision for physical contingencies (quantity overruns) may be made by including a provisional sum in the Summary Bill of Quantities. Similarly, a contingency allowance for possible price increases should be provided as a provisional sum in the Summary Bill of Quantities. The inclusion of such provisional sums often facilitates budgetary approval by avoiding the need to request periodic supplementary approvals as the future need arises. Where such provisional sums or contingency allowances are used, the Contract Data should state the manner in which they will be used, and under whose authority (usually the Project Manager’s).

Summary

The Summary should contain a tabulation of the separate parts of the Bill of Quantities carried forward, with provisional sums for Day work, for physical (quantity) contingencies, and for price contingencies (upward price adjustment) where applicable.

These Notes for Preparing Specifications are intended only as information for the Employer or the person drafting the Bidding documents. They should not be included in the final documents.

Bill of Quantities

1 Provisional Sum

Procument Item Details

SL. No	Item Description	Unit	Quantity	Unit Rate(NPR)	Amount(NPR)
1	Provisional sum [Environmental/Social Mitigation Measures identified and suggested in Environmental and Social study and other unforseen measures during the project period; Reconstruction and Relocation of Public utility services(Water Supply Lines, irrigation channels, Sewer pipes, Electric poles, Railing, Boundry Wall etc.) Cost for Employer Facility as instructed by the Engineer.	PS	1.0	6.861979803E8	686,197,980.30

2 Construction work

2.1 Works for complete or part construction and civil engineering work

2.1.1 Engineering works and construction works

Procument Item Details

SL. No	Item Description	Unit	Quantity	Bidder's Rate (NPR)	Bidder's Rate (in words)	Total Amount (NPR)
1	Planning, Design, Engineering, Procurement, Construction, Commissioning and Five Years of Service Operation & Maintenance of One Double Lane Standard Highway Tunnel, Rock shed Structure, Rock Fall Mitigation and Road Works of Siddababa Tunnel Project on Engineering Procurement Construction (EPC) basis all complete	Job	1.0			

Total of Procument Items

Total Item Price	
VAT	
Grand Total	