NHPC LIMITED
(A Govt. of India Enterprise)
CIN: L40101HR1975GOI032564

CORRIGENDUM NO.2

Name of the Work	**:**	**Restoration of Civil works for dam, Desilting Chamber, Silt Flushing Tunnel & Part HRT (up to Adit–I of HRT) of Teesta-V Power Station, Sikkim**
Tender ID No.	**:**	2023_NHPC_781108_1
Tender Specification No.	**:**	NH/CCW/CC-IV/CO-279/PR-11123/202
Corrigendum Date	**:**	**22.11.2023**

1. Section-II, Information for Bidders (IFB) has been modified and enclosed.
2. Section-VIII, Technical Specifications (TS), Following Chapters of Technical Specifications (TS) have been modified and enclosed:
   - i. A.2-Site Installations, Services and Environmental obligations
   - ii. A.4-Surveying and Setting out work
   - iii. A.5-Quality Assurance
   - iv. A.6-Commissioning
   - v. B.1-Dewatering during Construction
   - vi. B.2-Surface Excavation
   - vii. B.4-Rock Supports
   - viii. B.6-Embankment Construction and Backfill
   - ix. B.7-Drilling, Grouting and Pressure Relief Holes
   - x. B.9-Concrete
   - xi. B.9A-Reinforced/ Plain cement Concrete cutting and Demolition & Dismantling
   - xii. B.9B-Repair/ Rehabilitation and modification of Concrete
   - xiii. B.15-Building and Architectural Works
   - xiv. B.17-Slope and Riverbed Protection Works
   - xv. B.18-Monitoring Instruments
   - xvi. B.20-Electrical and Mechanical Works
   - xvii. B.21-Road works

All other terms and conditions of the Bid document shall remain unchanged.

General Manager (CC-IV),
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1.0 Introduction

1.1 General description of the project

Teesta-V Hydro Electric Project, now referred as Teesta -V Power Station, is situated in East Sikkim district of Sikkim (India) and was commissioned in March 2008. The Sikkim state has an average annual rainfall of about 650mm to 2500mm and fall of the order of 3600m over a length of 175Km making an ideal condition for hydro power generation as rivers has substantial flow even during lean season. The power station is constructed to harness power potential of river Teesta in cascade development scheme. Installed capacity of the Power Station is 510 MW (3 x 170 MW) designed to generate 2573 MUs annually.

Teesta-V power station is providing clean and cheaper energy to the state of Sikkim and other States and has reduced demand of petroleum and wood based energy as these were conventional methods used in Sikkim.

1.2 Access

1.2.1 Road to Dam

Project dam site is accessible through BRO road from Singtam situated on NH-31A. Singtam-Mangan-Lachen road via Dikchu is a state highway and is vital and all time requirement for access to dam and power house as well as to the adits. Power house and dam site are located on the Singtam-Dikchu road at 7 km and 35 km respectively from Singtam. An all weather road of 2 km length exists from Dipudara to power house for transportation of heavy machineries and access to project headquarter. This road further extends up to adit of surge shaft, bottom pressure shaft and main HRT. For emergency, a helipad has been constructed in front of Power house on right bank of river at $27^0 14' 56.5"$N and $88^0 27' 25"$E.

1.2.2 Nearest Town and Railway station.

Singtam is nearest township located at 7km from Project headquarter at Balutar. However, nearest main market that fulfills need of important items is Gangtok (35km approx.) and Siliguri (110km approx.). Nearest Rail head and airport is approx. 130 km & 140 km away at Siliguri/ New Jalpaiguri and Bagdogra (West Bengal) respectively from the dam location.

1.3 The main components of the project:

- 2 nos. 12.2 m diameter Horse shoe shaped diversion tunnels of length 473 m & 610m.
- A 88.6 m high concrete gravity dam (from the deepest foundation level).
- 3 nos. intakes of size 6.5 m x 6.5 m located at the left bank.
- 3 nos. desilting chambers of size 250 m (L), 19.7 m (W) x 24.5 m (H).
- 1 no head race tunnel, 9.5 m diameter, 17.1 km long having 5 nos adits with gated plug.
- 3 nos steel lined pressure shaft of 4.7 m diameter.
- Underground power house cavern 118.5 (L) x 23m (W) x 47.5m (H) housing 3 nos. main units of 170 MW each.
- Transformer cavern, 100.5m (L) x 14.5m (W) x 10.7m (H) located u/s of power house cavern.
- 3 nos. 6.5 m diameter, D-shaped TRT.

1.4 Description of dam & appurtenances.

A Concrete Gravity Dam with FRL at EL 579.00 m, MDDL at EL 568.00 m and top of dam at EL 583.20 m with gross head of 215.33 m has been constructed with central ogee shaped spillway. It is flocked with two non-overflow blocks on right bank and four non-overflow blocks on left bank. The total length of the dam at its top is 176.50 m. Height of the dam over deepest foundation level and above river bed level is 88.6 m and 53.20 m respectively. For energy dissipation, a flip bucket and plunge pool on the d/s has been provided.

The appurtenant structures of dam comprise of 3 nos. intake of size 6.5m x 6.5m, 3 nos. underground desilting basins each 250 m long, 19.7 m wide and 24.5m deep and silt flushing tunnels.

1.5 SALIENT FEATURES OF TEESTA-V POWER STATION

LOCATION:

- State — Sikkim
- District — East Sikkim

HYDROLOGY:

- Catchment area — 4307 sq.km
- Design flood — 14596 m^3/s (PMF)
- River diversion design flood — 3251 m^3/s

RESERVOIR (Post 2014 Survey):

- Maximum reservoir level — EL 580.72 m
- Full reservoir level — EL 579.00 m
- Minimum draw down level — EL 568.00 m
- Gross & Live storage — 9.61 million m^3 & 5.44 million m^3
- Length along the river — 5.1 km (approx)

CONCRETE DAM:

- Max. height above river bed level — 52.20 m
- Max. height from deepest level — 88.60 m
- Dam top elevation — EL 583.20 m
- Length at dam top — 176.50 m

SPILLWAY:

- Energy Dissipation Device — Low level ogee shaped spillways with radial gates and flip bucket
- Design flood — 14596 m^3/s
- Crest of spillway — EL 540.00 m
- Number and size of sluices — Five (Each 9.0m wide, 12.0m high)
- Max Tail pool Level (at PMF) — EL. 550.00

DIVERSION TUNNEL

- Number & Shape — Two nos., Horse –shoe shaped
- Diameter (finished) — 12.2m
- Length — 473 m & 610 m

INTAKE STRUCTURE:

- Number & size of inlets — Three nos. of 6.5m x 6.5 m
- Design discharge — 350.84 m^3/s
- Invert level — EL 554.00/556.50 m

DESILITING CHAMBER:

- Type — Dufour shaped

- Length 250 m
- Number and size Three; 19.7m x 24.5 m
- Minimum particle size to be Removed 90 % of 0.2 mm or above

HEAD RACE TUNNEL:

- Shape Horse-shoe
- Diameter (finished) 9.5 m
- Length 17.1 Km
- Design discharge 292.37 m^3/s
- No. of adits/gated adit 5 Nos./ 4 Nos.

SURGE SHAFT :

- Type Semi underground (restricted Orifice)
- Height & Internal diameter 92.5 m & 30.0 m
- Area of orifice (gate groove) 24.95 Sq. m
- Thickness of RCC lining 1.0 m
- Maximum upsurge EL 625.80 m
- Maximum down surge EL 542.00 m

PRESSURE SHAFT:

- Number and type Three nos., steel lined
- Diameter (internal) 4.7 m
- Height 174.0m

UNDERGROUND POWER HOUSE:

- Installed capacity 510 MW (3 units of 170 MW each)
- Dimensions of machine hall 118.5m (L) x 23m (W) x 47.5 m (H)
- Dimensions of transformer cavern 100.5m (L) x 14.5m (W) x 10.7 m (H)
- Switchyard type Indoor GIS with roof top pothead yard of size 100m x 30m
- Type of turbine Francis, vertical axis
- Spacing of unit axis 22.5m
- Peaking Capacity 4.30 hrs
- Max. Tail water level EL 360.00 m (with 3 units)

- Min./Extreme min. tail water level — EL 359.00 m / EL 358.50 m
- Gross head/Rated net head — 215 m (approx.)/ 196.15 m
- Rated discharge — 97.46 cumecs per unit

TAILRACE TUNNELS:

- Tunnel shape — D-shaped, 3 nos
- Diameter (finished) — 6.0 m
- Length — 165 m, 175 m, 185 m

POWER GENERATION FIGURES:

- Installed capacity — 510 MW
- Annual energy (in 90%dependable year) — 2573 GWh

1.6 Damages in civil structures:

On 4th October 2023 due to flash flood, damages occurred to concrete dam and associated structure of Teesta-V Power Station. Based on preliminary inspection and assessment, it has been observed that extensive damages has been occurred to concrete dam, spillway glacis, piers, buckets, Power pack room and dam control room etc. Reinforcement is also exposed at various locations in spillway glacis, pier and buckets, Desilting chamber, HRT, silt flushing tunnel seems to be had been filled with logs, debris etc. also access to dam top from upstream and downstream has been cut off and shall require its restoration.

Site cleaning works and construction of access roads shall be carried out to facilitate the restoration of the main dam ,intake ,HRT & associated structure.

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HM components like all 5 nos radial gates and associated parts, hydraulic power pack, hydraulic cylinder, stop log unit, gantry crane, DC EOT crane, stop log and radial gate sill beam etc have been found missing and some parts in damage condition.

Detailed inspection shall be carried out after cleaning of DC, SFT, HRT etc to assess the damages to the civil structure and their repair/restoration.

SECTION A.2

SITE INSTALLATIONS, SERVICES AND ENVIRONMENTAL OBLIGATIONS

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SECTION A.2

SITE INSTALLATIONS, SERVICES AND ENVIRONMENTAL OBLIGATIONS

2.1 SCOPE OF WORK

1) The Contractor shall be responsible for providing plant, equipment, materials and labour for the provision of all necessary Temporary works, site installations and services required for the realisation of the Works under this Contract.

2) The Contractor shall design, furnish, set-up, maintain and operate at the Site all Temporary Works, site installations and Contractor's Equipment for his own use as specified in this Section, or required by the Contractor, including camps, workshops, warehouses, storage and assembly areas, all machinery, vehicles, scaffolding, equipment, water and power supply, etc.

3) Temporary Works and services provided and operated by the Contractor shall conform to the applicable Indian laws, regulations, standards, codes and sanitary requirements stipulated for such purpose. In addition, they shall comply fully with all Indian laws and regulations relating to environmental protection, mitigating measures for reducing environmental impacts and remedial works on completion of the Works.

4) The design, construction, operation and maintenance of the Contractor's Temporary Works and services may be subject to inspection by the Engineer-in-Charge.

5) All plants, camp facilities, installations and services provided by the Contractor shall at all time remain his property, except when otherwise specified hereinafter. Should, after the Completion of Contract, the Contractor wish to sell his plants, facilities and equipment in India, he shall pay all taxes and duties required by law as stipulated in the Conditions of Contract, and have to obtain relevant permission from the Government for such sale.

6) The temporary site roads which the Contractor shall construct, and maintain for the various working areas, camps, facilities and other temporary works are covered in the Section "Roadwork".

2.2 SUBMITTALS

1) Within 21 days from the date of issue of the Notification of Award, the Contractor shall submit to the Engineer-in-Charge updated layout plans showing, at adequate scale, the locations and arrangement of all Temporary Works and facilities. These plans shall be consistent with the plan submitted by the Contractor with his Tender as well as with any amendments and additions subsequently agreed to by the Engineer-in-Charge and the Contractor, and shall include:

   a) Camps for Contractor's employees,

b) Offices, parking areas, warehouses, storage areas, and medical care services,

c) Water supply, sewerage, sewage treatment and disposal, power supply and illumination, telephone service (radio and cable),

d) Temporary roadwork, including public road diversions,

e) Equipment pools and mechanical workshops,

f) Spoil areas, borrow, quarry and stockpile areas,

g) Concrete and materials processing plants, including cement storage,

h) Materials testing laboratory,

i) Explosives magazines,

j) Underground ventilation system,

k) Security and safety arrangements,

2) Within 28 days from the date of issue of Notification of Award, the Contractor shall submit to the Engineer-in-Charge the following:

a) Detailed drawings at scale 1:500 showing the camp layout, buildings, roads, recreation areas, all utilities, etc., and drawings at scale 1:50 showing typical building construction details,

b) Drawings and specifications for the establishment of an infirmary and first aid stations, and details of the ambulances,

c) Detailed design for industrial and potable water supply to the camps and working areas as well as sewerage systems, sewage treatment and disposal with and estimate of number of people to be supplied with water,

d) Detailed layout drawings for electrical installations and distribution systems at the Site, showing voltages, outlets, and routing of power lines,

e) Detailed design and drawings including manufacturer's drawings for concrete and materials processing plants in accordance with the requirements of the pertinent Sections of these Specifications,

f) Detailed break-up of all equipment to be used for material testing and in the field laboratory in accordance with the requirements of the pertinent Sections of these Specifications,

g) Details of the drilling and grouting equipment,

h) Details of the underground ventilation system.

i) Details of the dewatering system

3) Within 28 days from the date of issue of Notification of Award, the Contractor shall submit to the Engineer-in-Charge an environmental monitoring and protection plan which will describe all measures to be taken by the Contractor to comply with the requirements of § 2.18 of this Section. This plan will cover all measures to be taken by the Contractor to prevent, minimize or make good all possible environmental effects of the construction work, in particular:

a) Deterioration of the quality of water in rivers and streams, and of ground water.

b) Accumulation of and pollution by solid and liquid waste material anywhere in the project area.

c) Undesirable levels of noise, air pollution and dust both at the construction site as well as along the access road, in quarries and borrow areas.

d) Occurrence amongst site workers and their families of water-borne and other communicable illnesses, and the deterioration of levels of hygiene in the camps and construction areas.

4) This environmental plan will also describe the procedures to be adopted by the Contractor for reporting on the environmental protection programme and for informing and communicating with government institutions. The plan will also give details of arrangements made by the Contractor with local land-owners for the leasing of land for site installations, camps etc., and will include drawings detailing the areas in question.

2.3 SITE OFFICES, STORES, WAREHOUSES, MATERIALS YARDS

1) The Contractor shall provide and equip, for his own and his subcontractors' use, main and secondary offices, warehouses, materials storage areas, fuel storage areas and explosives magazines, all of which shall be maintained in good conditions until the Completion of Works.

2) Listed hereunder are the buildings, shops and warehouses expected to be constructed and equipped by the Contractor for use in the performance of the Work under this Contract, in addition to facilities explicitly specified elsewhere in these Specifications:

a) Mechanical repair shop,

b) Electrical repair shop,

c) Metalwork and wood fabrication shop,

d) Main warehouse and parts store,

e) Bulk cement silo,

f) Bagged cement store,

g) Spare parts store,

h) Gasoline and oil stations.

i) Explosive Magazine.

3) The Contractor is required to have at the Site at least one month's minimum reserve of materials both for construction activity and other requirements. For the monsoon months, from May to October, when transport to and from site may be made difficult, his reserve requirements may need to be increased.

2.4 CONCRETE AND MATERIALS PROCESSING PLANTS

The Contractor shall install and erect all necessary concrete and materials processing plants of sufficient capacity to meet the planned peak requirements during construction. The plants shall be subject to approval by the Engineer-in-Charge and shall be well designed and fabricated and kept in good running order to ensure compliance with the materials quality specifications. All control and measuring equipment shall be regularly serviced and calibrated.

2.5 MATERIALS TESTING LABORATORY

1) The Contractor shall build and equip an adequate field laboratory for the sampling and for testing of materials for concrete, steel reinforcement, earth, rock or any other materials as specified in the pertinent Sections of these Specifications.

2) The laboratory shall be located in a dust-free building properly equipped with electricity, water, etc., and shall have enough room for storing the samples tested as required.

3) The equipment to be supplied and the methods of testing shall be in accordance with the relevant Indian Standards or with requirements of the US army corps of engineers (USACE), or USBR Concrete Manual and USBR Earth Manual. All apparatuses and equipment shall be brand new, of the latest design, manufactured by a reputed manufacturer, and properly calibrated with calibration certificate from Indian or International Authority. The proposed type and number of items of laboratory equipment shall be presented to the Engineer-in-Charge prior to purchase.

4) The Contractor shall operate and maintain the laboratory until the Completion of Works and make all facilities and services available to the Engineer-in-Charge as required. All sampling and testing to be undertaken shall be under the direct supervision of the Engineer-in-Charge. The laboratory shall be run by Contractor's personnel experienced in sampling and testing of materials, and quality control.

5) Specialised testing which may be required and which cannot be performed in the Contractor's laboratory due to lack of time or equipment shall be assigned to an independent organisation. The Contractor shall accept all results, instructions or restrictions stipulated by the Engineer-in-Charge based on such tests.

6) Upon the Completion of Works, all laboratory equipment shall remain the property of the Contractor. However, Employer reserves the right to purchase some or all of the equipment.

2.6 COMMUNICATION SYSTEMS

2.6.1 Site Communications

1) The Contractor shall supply, install, operate and maintain a telephone switchboard, and wireless mode as alternative communication system, complete with standby power supply, to connect his offices with the Engineer's-in-Charge,

campsite, laboratories, workshops, stores, aggregate plants, quarry/borrow areas, batching plants, ice plant, adit portals, tunnel portals, tunnel headings, dam~~barrage~~ site, infirmary and first aid stations and all other work areas within the Site.

2) The Contractor shall furnish a directory of the telephones installed at the Site and make it available to the Engineer-in-Charge.

2.6.2 Communication System in Surface & Underground Works

1) The Contractor shall install and maintain operational a communication system by telephone or preferably an underground radio system approved by the Engineer-in-Charge between each heading face and entrance to the tunnel.

2) An intermediate intercom station shall be located at least every 500 m along the tunnel.

3) This communication system shall have its source of energy independent of the main energy supply for underground works.

4) The availability of the communication with open air shall be ensured at all times throughout the whole duration of underground construction.

2.6.3 Outside Communications

1) The Contractor may install, operate and maintain a radiotelephone system(s), UHF and/or microwave, at the Site to provide the access to the National and International telephone grid.

2) Any permission of Indian Government or State Government, if required, shall be arranged by the Contractor. However, Employer will endorse the necessary license applications of the Contractor.

3) Upon the Completion of Works, the Contractor shall dismantle and remove from the Site the installed outside communications. However, Employer reserves the right to purchase some or all of the equipment.

2.7 SERVICE & INSPECTION VEHICLES

The Contractor shall operate and maintain sufficient service vehicles for use by its own staff and employees in the management for the supervision and performance of the work.

2.8 CAMPS FOR CONTRACTOR'S EMPLOYEES

1) The Contractor shall design, construct, provide furnishings, maintain, and operate two separate construction camps; one for Contractor's Indian and expatriate staff of mid and upper level, employed at site and the other for Contractor's labour.

2) The construction camps shall provide for the housing, feeding and recreation of the Contractor's employees and those of his subcontractors as per Indian labour

law and other relevant regulations. The camps shall be large enough to accommodate the anticipated peak work force.

3) The Contractor shall be responsible for the acquisition of, and the expenses for the required land, if not provided by the project.

4) The Contractor shall be responsible for the necessary topographical surveys, clearing, and earthwork required for the landscaping and to provide satisfactory foundations for buildings, streets and auxiliary facilities.

5) Food handling, preparation and serving shall be arranged by the Contractor in properly equipped canteen buildings for all his and his subcontractors' employees.

6) The Contractor shall be responsible for keeping the camp and the buildings in good hygienic conditions. The standards and regulations presently in force in the project area with regard to personnel treatment, sanitary conditions, and fire and accident prevention shall be duly taken into account.

7) The prices charged by the Contractor for food, beverages, etc., available in the camp shall be calculated on a non-profit basis.

2.9 COMMERCIAL CONCESSIONS

1) Commercial concessions such as for laundry, catering, shops, etc. granted to a third party by the Contractor for the use of the employees and residents at the Site, shall be subject to approval by the Engineer-in-Charge. Any concession shall be revoked if the concessionaire violates the law or the provisions governing the granting of the concession. Concessions shall automatically terminate upon Completion of the Works or in the event of the termination of the Contract.

2) No concession shall be granted for activities that are contrary to statutory regulations or law of the land or are declared by the Engineer-in-Charge to be offensive to the community.

3) Concessionaires will be regarded as subcontractors of the Contractor.

2.10 MEDICAL CARE FACILITIES

1) The Contractor shall comply with laws and health standards presently in force in India. In the event of illness of an epidemic nature breaking out, the Contractor shall carry out and comply with all orders, arrangements or regulations which may be issued by the Government or local authorities.

2) The Contractor shall construct, equip, and maintain at the Site, the following medical care facilities:

   a) One clinic and infirmary with ambulance and driver within his main camp,

   b) One first aid station at each work front.

3) The construction of these facilities shall be such as to provide reasonable quiet, privacy, communications, adequate ventilation, heating, light, hot and cold water, toilet facilities, electrical outlets, and impervious floors, walls and roofs.

2.11 POWER SUPPLY AND ILLUMINATION

1) The Contractor shall provide, install and keep operational throughout the time for completion, own generating facilities as a back-up arrangement at his own cost, of such capacity necessary to supply all requirements at the Site and in the camps. The power generating sets shall be installed in separate concrete or steel structure buildings on concrete foundations. The power supply to the construction sites, camps etc. shall be designed for continuous operation, 24 hours a day, with sufficient capacity to satisfy peak and emergency demands.

2) The Contractor shall install, operate and maintain electrical distribution systems which shall include all other necessary transformers, circuit breakers, disconnect and safety switches, voltage regulators, transmission lines, poles, pole hardware, conductors, meters and other equipment necessary for power distribution throughout the Site and temporary facilities.

3) Local standby generating units to prevent the interruption of work during the failure of the primary power source and capable of maintaining minimum services such as illumination, water supply, dewatering, etc., safety and security shall also be provided by the Contractor at his own cost.

4) The Contractor shall ensure adequate illumination for all his operations at the Site and at the camp, including illumination of the streets. The minimum intensities for illumination in general shall be as follows:

	Area of Operation	**Luminous Intensity**
a)	Excavation and spoil areas, and outdoor access ways	35 Lux
b)	General construction areas, outdoor concrete placement, active storage areas, loading, platforms, refuelling, and field maintenance areas	55 Lux
c)	Indoor construction areas	110 Lux
d)	Tunnel and general underground work areas	55 Lux
e)	Tunnel headings during drilling, mucking and scaling	110 Lux
f)	General construction plant and shops, e.g. batching plants, mechanical and electrical, equipment rooms, carpentry shops, active storerooms, barracks or living quarters, lockers or dressing rooms, mess halls, and indoor toilets	110 Lux
g)	First aid stations, infirmaries, and offices	550 Lux
h)	General interiors warehouses, corridors, hallways and exit ways	55 Lux
i)	Welding	330 Lux

5) Contractor shall maintain illumination up to the luminous intensity as specified above and will not withdraw the same till completion of all the works but not earlier than commissioning/taking over of first unit with written permission of Engineer-In -Charge.

2.12 WATER SUPPLY

1) The Contractor shall design, install, operate and maintain two separate water supply systems at the Site:

   a) Industrial water: for general construction use, treated to the extent necessary to meet specified requirements. (e.g. for concrete),

   b) Potable water: for supply to all buildings and plants requiring high quality water meeting statutory requirements for drinking water.

2) Water shall be supplied by the Contractor from suitable natural sources available within the Project area. The water shall be free of contamination and unaffected by the Site construction work. In isolated areas with no natural sources, the Contractor shall provide sufficient number of water carts to cover the requirements on both the industrial as well as potable water.

3) The Contractor shall furnish, install, operate and maintain all pumps, piping, fittings, valves, storage tanks, purification plant and chlorination for the water supply and distribution systems, adequate in quantity and pressure. Industrial water shall be used for construction purposes only if it meets specific requirements. There shall be no cross connections of any kind between the industrial and potable water supply systems. Only potable water shall be piped into buildings.

4) Throughout the duration of the construction, the Contractor shall take regular samples from all water supplies to examine it for suitability and treatments required, and make the bacteriological tests periodically from potable water systems.

2.13 SANITATION AND SEWERAGE

1) All offices, workshops, laboratory and other occupied work buildings shall be provided with toilets connected to properly constructed and regularly maintained septic tanks approved by the Engineer-in-Charge.

2) The campsites shall be provided with a complete, properly maintained and operated sewerage system, including septic tanks, sewage treatment and disposal facilities. Facilities for washing clothes shall also be provided and linked to the sewerage system.

2.14 WASTE AND GARBAGE DISPOSAL

1) The Contractor shall collect waste material and garbage from camp, offices and workshops on a daily basis and transport it to an area approved by the Engineer-in-Charge where it shall be incinerated and buried.

2) The Site shall be kept clean and free of refuse at all times. No waste shall be dumped in areas other than those approved by the Engineer-in-Charge for waste disposal. No waste of any kind shall be deposited in any watercourses.

3) The Contractor shall observe the norms prescribed by the Government for keeping all areas clean.

2.15 FENCING AND SITE SECURITY

1) The Contractor's offices, workshops and storage compounds, campsites and all construction areas where exclusion of unauthorised personnel is necessary for safety and security, shall be adequately fenced, gated and guarded.

2) The Contractor shall employ an adequate force of properly trained security guards at the work site and at the construction camp on 24-hour duty including Sundays and holidays. Storage areas shall be fenced, lighted and regularly patrolled by security guards. Warehouse buildings and explosive magazines shall be kept locked and keys accounted for at all times.

3) All employees engaged in the execution and maintenance of the Works shall wear identification badges when at the work site.

4) The Contractor shall be responsible for the losses occurring in his installations and those of Employer resulting from carelessness on the Contractor's part.

2.16 INSPECTION BY THE ENGINEER-IN-CHARGE

The Owner and the Engineer-in-Charge have the right at any time to inspect any part of the Contractor's temporary facilities, without advance notification, and to require immediate rectification of any contravention of the specified requirements.

2.17 FINAL CLEAN UP

1) Upon the Completion of Works, or when any plant has completed its functions the Contractor shall dismantle and demobilise all temporary facilities erected by himself or his subcontractors, and remove all debris, objectionable material, and all other refuse which may have been deposited on Site till completion of Works. Such materials may be deposited only in areas approved by the Engineer-in-Charge.

2) All excavated areas shall be filled, graded and dressed in a clean and orderly condition acceptable to the Engineer-in-Charge. As far as possible, such areas should conform to the natural appearance of the landscape.

3) No demobilisation or removal of temporary facilities and equipment shall be made without prior approval of the Engineer-in-Charge.

2.18 ENVIRONMENTAL OBLIGATIONS

1) The Contractor shall, during the whole period of the Works comply fully with all Indian laws and regulations relating to environmental protection, mitigating measures for reducing environmental impacts and remedial works on completion of the Works. This obligation shall extend to the construction sites, all the Contractor’s site installations, all quarries, borrow areas and pits.

2) Notwithstanding any specific obligations as these may be specified in prevailing laws and regulations in force in India, the Contractor shall at all times comply

with the following particular requirements for the protection of the environment, the local population and the workers at the construction site:

a) Collect, treat, remove from site and dispose of in accordance with the regulations and to the satisfaction of the Engineer-in-charge all domestic and industrial waste and excess construction materials (both solid and liquid), fuel, chemicals and other matter.

b) Make every effort to minimise the harmful effects of transport to and from the site, in particular vehicle emissions and noise and the control of dust on roads.

c) Provide its work force with fuel for cooking and heating and ensure that workers on the site do not cut wood or other vegetation as firewood.

d) Take measures and construct works, on the instructions of the Engineer-in-charge, to prevent soil erosion from slopes in the construction area.

e) Not clear any areas of forest or woodland without the authority of the Engineer-in-charge and statutory authorities.

3) In order to reduce adverse effect on public health resulting from the influx into the project area on construction workers, the Contractor will be obliged to undertake during the whole construction period the following preventive measures:

a) Ensure that all construction staff and workers, prior to being accepted to work on site, submit certificates of good health and, till completion of the works, ensure that all employees are given a periodic physical examination (at least once a year and following any serious illness) by a qualified medical practitioner.

b) Ensure that workers suffering from noticeable contagious illnesses are removed from the site for treatment and are not permitted to return to the site without an updated medical certificate.

c) Carry out regular spraying of all parts of the site and site installations to control mosquito vector diseases, using approved insecticides.

d) Implement a control programme to ensure the maintenance of satisfactory sanitary conditions on the site and in the living areas, and report to the Engineer-in-charge all cases of serious enteric and/or water-borne illness.

4) The Contractor will send representatives to constituted project environmental monitoring committees, as instructed by the Engineer-in-charge, and will at all times comply with the requests of said committees with regard to the need for environmental or health protection measures. He will also maintain close contact with local authorities and government institutions in addressing issues arising from the construction activities. Such issues needing particular attention are the following:

a) Pollution caused by construction work.

b) Disputes related to the leasing of land for construction activities and/or site installations etc.

c) Disputes arising from traffic congestion and restrictions on the use of the main project access road and roads in the project area.

d) All matters relating to road safety and measures to minimize the risk of traffic accidents.

5) The Contractor will submit to the Engineer-in-charge monthly reports on environmental performance and control. These reports will give details of all environmental protection measures taken during the months, as well as:

a) Any environmental problems encountered during the month.

b) Details of health conditions, in particular any occurrence of contagious illness and any accidents.

c) Any notices received from government or state institutions relating to environmental matters, and the action taken by the Contractor as a result.

6) In view of the limited space available for the site accommodation facilities and in order to avoid problems of assimilation with the present population of the project region, the Contractor will be obliged to keep the number of workers imported from other areas to the minimum required for him to complete the Works on time and in accordance with the specifications. The Contractor will co-operate with the local authorities at all times to prevent migration to the area, of unauthorised persons not involved directly in the construction work. To this end, he will at all time strictly control the movement of persons into and out of the construction areas and camps.

2.19 PAYMENT FOR SITE INSTALLATION AND SERVICES

The initial mobilisation costs such as purchase and transport of Contractor's Equipment and materials to the Site, planning, designing, installing, operating, maintaining and removing of all Temporary Works, site installations, services and facilities specified in this Section, making submittals to the Engineer-in-Charge, recruiting and transferring staff, obtaining rights of way, statutory permits and clearances, clearing, grading and excavating in areas for temporary facilities, and any other costs involved in preparation for constructing Permanent Works will not be paid separately and the entire cost thereof shall be included in the Unit Prices for other items of the Works.

No separate measurement for payment or payment shall be made for complying with any environmental obligations required by national and state laws and regulations, and/or as described in this Section, and all such costs incurred by the Contractor to this end shall be considered as being included in the Contractor’s Unit Prices.

Contractor if fails to comply with the environmental obligations, the Engineer-in-Charge shall get the required compliance done from third party at Contractor’s risk and cost.

END OF SECTION A.2

SECTION A.4

SURVEYING AND SETTING-OUT WORK

List of Contents

SECTION A.4

SURVEYING AND SETTING-OUT WORK

4.1 EXISTING SURVEY CONTROL POINTS

1) Basic survey network consisting of fixed triangulation polygon points and benchmarks exists in the project area. In addition, these data have been supplemented by surveys carried out by the Survey of India. All coordinates and elevations shown on drawings are based on basic survey grid. These data will be at the Contractor's disposal to serve as a base for the setting-out and checking work.

2) Prior to commencing any construction work, the Contractor shall undertake survey for the purpose of checking these reference data and in order to satisfy himself as to their accuracy. Should he have any objections to these data and the relevant drawings; he shall inform the Engineer-in-Charge in writing within two weeks of receiving them from the Engineer-in-Charge.

4.2 OBLIGATIONS OF THE CONTRACTOR

4.2.1 General

1) The Contractor shall perform all calculations, surveys and setting-out necessary to establish the accurate location of the structures as shown on the Construction Drawings and shall carry out all necessary surveys to verify the topographical data used by the Engineer-in-Charge for the project design and measuring purposes.

2) Within 28 days from the date of issue of Notification of Award, the Contractor shall submit his proposed survey plan to the Engineer-in-Charge. The proposed plan shall indicate the order of accuracy for all surveys.

3) In advance of any setting-out work associated with all principal project features, the Contractor shall submit to the Engineer-in-Charge for approval a description of the method and procedures he intends to use in establishing bench marks and base lines.

4) If the Contractor chooses to use triangulation points or bench marks other than those furnished by the Engineer-in-Charge, he shall do so at his own expense and risk.

5) The Contractor shall carry out topographical surveys of the original ground surface in each sector of the Works where surface excavation will be necessary, and produce sufficient and adequate cross-sections which will permit later to evaluate the volume of excavation for the measurement purposes and payment of excavation.

6) Prior to handing over site to Contractor, a joint survey of already constructed structure shall be carried out which will form basis for future measurements and payments.

7) The Contractor shall entrust the surveying works only to persons who by their training and experience have sufficient qualifications and knowledge to ensure proper fulfilment of the survey tasks assigned to them. For the performance of the survey, the Contractor shall use a sufficient number of reliable and accurate instruments including Total Station (Lieca 1200++ or higher version).

4.2.2 Bench Marks and Triangulation Stations

1) Existing survey control point bench marks and base lines shall be verified with respect to permanent control points at Powerhouse/Dam~~Barrage~~ site and corresponding bench marks and base lines established afresh as necessary to construct each portion of the Works.

2) Permanent survey control points shall be established prior to starting the work and such permanent points shall be preserved during construction.

3) If not already in existence, a minimum of 2 permanent bench marks shall be established for all adit portals, major structures and referenced to data established by survey control points. Benchmarks shall also be provided at intermediate locations between adit portals for checking and carrying purposes. The location of such points with horizontal and vertical data shall be recorded on the construction record drawings by the Contractor.

4) From the primary survey control points the construction surveys shall be performed as required to locate, layout and construct each portion of the Works.

5) Complete and adequate logs of all control and survey work shall be maintained as it progresses. Such logs shall be available for the Engineer-in-Charge's inspection at all times.

6) The Contractor shall protect, preserve and keep accessible the bench marks and triangulation stations of the basic survey and those provided by himself. Any damage or removal of benchmarks and stations, including such of other parties shall be prevented. Any accidental damage shall immediately be brought to the attention of the Engineer-in-Charge. **It is expressly stated that the Contractor will be made responsible for the damage and its consequences.**

7) Benchmarks shall be of stainless steel or cast iron. In softer soil, the steel bolt shall be embedded in a block of concrete of suitable size, and absolutely stable. Inscriptions shall be durable and clearly legible. Underground benchmarks shall be installed at suitable locations and adequately protected.

8) Subordinate points may be marked by steel pipes or pegs, subject to the approval of the Engineer-in-Charge. Every newly fixed point shall be checked, as far as possible through other elements than those, which served to establish the point.

4.2.3 Accuracy of Surveying

1) Horizontal distances shall normally be measured with optic or electronic distance measuring instruments. Chaining with metallic tape shall be restricted to measuring of short distances and will be rejected for use in survey of traverse nets.

2) Elevations shall be determined by differential horizontal levelling.

3) Angles shall be measured by Total Station.

4) Traverse nets shall be executed with the precision and as per Survey of India practice and as per IS codes.

5) Levelling shall be checked by closing the loop to the initial benchmark.

4.2.4 Auxiliary Works

1) The Contractor shall perform auxiliary works with regard to surveying which include, but not be limited to, the following:

   a) Perform all necessary calculations with clear presentation of calculations and results in order to facilitate verification,

   b) Expose covered bench marks,

   c) Provide bench marks in lieu of and/or in addition to those in existence,

   d) Remove machinery and obstructions from the required sight-lines,

   e) Provide adequate ventilation in tunnels to ensure the necessary clear view,

   f) Provide adequate lighting or shut off sources of interfering light to ensure the necessary clear view,

   g) Provide adequate labour, and materials as deemed necessary and suitable by the Engineer-in-Charge for the control and auxiliary surveys,

   h) Remove all obstructive accumulation of water,

   i) Carry out additional topographical surveys in cases where the existing topographical data is, in the opinion of the Engineer-in-Charge, insufficient for accurate measurement of the Works,

   j) Carry out all necessary topographical surveys for the incorporation of measuring equipment and instrumentation located in the Permanent Works,

   k) Carry out all necessary topographical surveys for the observation of the behaviour of structures during construction.

2) All the above shall be done in close co-ordination with the Engineer-in-Charge.

4.2.5 Accuracies and Tolerances

(1) Accuracies

Accuracy of Survey works shall be within the following tolerances:

Triangulation	
Allowable error of closure	
-Average not to exceed	5 seconds
-Maximum not to exceed	10 seconds
Traversing	
-Allowable error of closure	1/3000
-Allowable error of distance	1/5000
Levelling	
Allowable error for each 1 km	
Measured forward and backward	10 mm
Allowable error of closure	10*S^0.5

(where S is total distance of Levelling in 1 km)

(2) Tolerances

a) The tolerances given below shall be the maximum permissible deviations from the specified dimensions, levels, alignments, positions, etc. as shown on the construction Drawings of the structures or structural elements.

b) In addition, at the interfaces with mechanical components, concrete surfaces shall be finished flush and shall also meet any additional tolerances required by the mechanical designs or works, respectively.

Determination of center lines for alignment of tunnels, adits, etc. shall meet the following criteria:

Plan position of center line	±10 mm
Elevations	± 10 mm
Slope protection	

Benchmarks and subsidiary monuments intended to observe slope movements shall be placed with tolerances not exceeding ± 5 mm

Rock bolts and prestressed anchors	
Position	± 150 mm
Deviation from direction	± 5°

4.2.6 Damage to Crops and Vegetation

1) No trees or crops of economic value existing at the Site shall be damaged or removed by the Contractor during survey and cross-sectioning works prior to their enumeration and evaluation.

2) Throughout the surveying and setting-out the Contractor shall work closely with the authorised local appraisers of crops and vegetation in

question and shall provide them with facilities necessary for the expeditious performance of their duties.

3) As soon as a section of work has been defined and valued, the Contractor shall delineate the boundaries of the areas to be cleared by approved markings.

4.3 CHECKING OF CONTRACTOR'S WORK BY THE ENGINEER-IN-CHARGE

4.3.1 Regular Checking

1) All elements of the Contractor's survey work associated with the setting-out of principal project features will be regularly checked by the Engineer-in-Charge during the course of the work, and the Contractor shall provide assistance at any time as required in the performance of such control work.

2) The Contractor may be required to provide the Engineer-in-Charge with any information, readings or computations for checking.

3) The regular checks will usually be made during work breaks, but in case of urgency, the Contractor shall restrict or stop the affected work.

4) Any checks by the Engineer-in-Charge shall not relieve the Contractor of his full responsibility for the accuracy of structures and parts of them with regard to their position and dimensions.

4.3.2 Confirmation Survey of the Surface & Underground works

1) In addition to the regular check surveys described above, the Engineer-in-Charge, or an independent survey organisation nominated by the Engineer-in-Charge, may perform confirmation survey of the surface & underground works in course of excavation progress. Starting from the duly surveyed fix points at the portals, a traverse net (combination of traverse and gyroscopic measurements) and a levelling will be carried out in each case.

2) The first confirmation survey may be performed after the first 100 m of tunnel have been excavated. The following controls will be carried out after every 500 m of excavation. Each confirmation survey will require approximately 2-3 days.

3) The Contractor will be notified in writing in advance about the date of such confirmation survey and of the appointment of an independent surveyor who will perform the survey. The Contractor shall co-operate with such surveyor and provide any assistance as required.

4) The Engineer-in-Charge and the Contractor in cooperation with other contractors for HM and E&M works will mutually arrange to carry out

such confirmation survey at a time and in such a manner, so as to limit as far as possible any delay or inconvenience to underground work. But notwithstanding the above, the Engineer-in-Charge may arrange such superior control to be performed at any time and notify the Contractor accordingly.

5) Such work will have to be temporarily halted which may, in the opinion of the Engineer-in-Charge, cause excessive vibration or noise such as drilling, mucking, hauling persons, materials or rock spoil in or out of the tunnel, installing permanent or temporary support or any similar work.

6) The Engineer-in-Charge will normally give the Contractor written notice of such stoppage at least 48 hours in advance and will state the approximate time at which work must cease and the approximate duration of such stoppage. The Engineer-in-Charge will also indicate what work, if any, may continue. The Contractor must promptly acknowledge receipt of any such written notice and confirm this acknowledgement in writing.

7) Irrespective of the times given by the Engineer-in-Charge, he shall not be bound to adhere strictly to these times but will attempt to do so in so far as it is feasible. While the Engineer-in-Charge will endeavour to co-operate with the Contractor in planning such temporary stoppages, the Engineer's-in-Charge decision in all cases will be final.

4.4 MEASUREMENT AND PAYMENT

4.4.1 Survey Work Performed by the Contractor

No extra measurement for payment or payment will be made for Contractor's survey and setting-out work including the assistance in check/confirmation surveys, and the entire cost thereof shall be included in the Unit Prices for relevant items of the Works.

4.4.2 Temporary Suspension of Works in Surface & Underground Works

No extension of time for the Completion of Works will be granted to the Contractor due to temporary suspension of work required for the performance of the confirmation surveys of the surface & underground works by the Engineer-in-Charge. The Contractor shall take into account the number and time of these surveys indicated above in his construction time schedules and includes all expenses, delays, disruptions, loss of production and inconvenience resulting from such temporary stoppage in the Unit Prices for other items of the Works.

END OF SECTION A.4

SECTION A.5

QUALITY ASSURANCE

List of Contents

SECTION A.5
QUALITY ASSURANCE

5.1 QUALITY ASSURANCE IN EXECUTION OF WORKS

1) The Contractor shall establish staff, equip and operate a comprehensive quality assurance set-up at the site during the full period of the Works. The principal responsibility and duty of this set-up shall be to ensure that all work carried out and materials produced or supplied by the Contractor comply fully with the Specifications as well as with all relevant Indian or other standard.

2) With his tender, the Bidder shall submit his detailed proposal (in terms of experienced supervisory staff, trained workmen, procedures of work, equipments, obtaining support from outside agencies) for achieving quality in respect of the minimum following:

   a) Surface & Underground excavation particularly quality control in blasting and minimisation of overbreaks and damage to surrounding rock.

   b) Maintaining clean working environment inside underground work with particular reference to lighting, ventilation and dewatering.

   c) Rock support installations particularly the grouting of rock bolts / rock anchors / tendons in surface and underground works.

   d) Workmanship in shotcrete placement.

   e) Workmanship in concrete placement in surface and surface & underground works.

   f) Grouting activities particularly the mix designs and selection of mixes for particular application.

   g) For construction of coffer dyke including seepage cut off measures.

   h) Final clean up.

   The Bidder's proposal shall be specific enough to assure that all works are executed in a professional manner and Bidder has included in his bid the provision of employment of the best international practices of construction in the implementation of the work.

3) At the time of award of work, the Bidder's proposal at the time of tender proposal at the time of tender shall be confirmed again and shall be improved, if so required.

4) Immediately after the award of work, during mobilization phase, the Contractor shall take systematic steps to implement all the proposals given by him for achieving the desired quality in construction.

5) During course of execution, the quality of the work in progress shall be reviewed at least once in 3 months in the Quality Assurance meeting specifically called by the Engineer-in-Charge and participated by Contractors Project organisation. In case Engineer-in-Charge is not satisfied with the resources

employed *vis-à-vis'* the commitments made in the proposal, the contractor shall take additional steps to supplement his efforts.

5.2 CONTROL OF PROGRESS OF THE WORK

1) Close progress control, and the preparation of corresponding progress reports, shall be an important part of the Contractor's quality control responsibilities. The contractor must at all times provide the Engineer-in-charge with up to date information on the progress of work and must without delay bring to the attention of the Engineer-in-charge all delays or occurrences which could lead to delay or additional costs.

2) The Contractor shall submit detailed monthly progress reports to the Engineer-in-charge, in which the contractual programme for the works is updated and information is given on the quantitative completion of civil works (in the form of tables indicating the quantities of completed work).

3) The monthly progress reports shall give full details of any delays to work in progress or planned delays in transport to/from the site, together with detailed proposals for overcoming or preventing delays, and for regaining any lost time.

4) The Contractor shall at any time, at the request of the Engineer-in-charge, submit detailed reports on particular matters relating to the execution and progress of the works, if such reports are required in order to assess the quality or progress of specific activities or works.

5.3 CONTRACTOR'S QUALITY CONTROL STAFF

1) The Contractor shall assign one experienced engineer at site as full-time quality control officer who will be supported by adequate qualified staff and shall be responsible for complying with all requirements of Technical Specifications.

2) The experience and qualifications of quality control engineer shall be given in the contractor's tender and shall be subject to the approval of the Engineer-in-charge.

3) The positions, qualifications and duties, of the contractor's quality control staff shall be indicated in the QC organisation plan, and shall likewise be subject to approval by the Engineer-in-charge. As a minimum, the contractor shall appoint one qualified and experienced engineer to be responsible for quality control of each of following the surface & underground works as under:

   a) Upstream and downstream coffer dykes

   b) ~~Barrage~~Dam Complex

   c) ~~Head Regulator, Desilting Basin,~~ Intake Structure

   d) Head Race Tunnel Excavation

   e) Access adits etc.

5.4 CONTRACTOR'S LABORATORIES

1) The Contractor shall establish, equip and operate on site laboratories for the testing of the following principal construction materials:
   a) Concrete, including also the testing of sand, aggregates, cement, water and admixtures.
   b) Impervious core,filters and rockfill materials,
   c) Any site testing such as pull out test on rock bolt/anchors and/or calibration of monitoring instrument
2) The numbers of samples to be tested, and the timing of testing, shall be as may be given elsewhere in these specifications, or as may be instructed by the Engineer-in-charge.
3) The staff of the Contractor's laboratory shall have proven experience in similar previous work and their qualifications shall be subject to approval by the Engineer-in-charge.
4) Complete records shall be kept of all laboratory tests carried out and shall be available at any time to the Engineer-in-charge on request.
5) The Engineer-in-charge shall be permitted at any time and without notice to observe tests being carried out in any of the Contractor's laboratories, to inspect equipment or to study results.

5.5 MATERIAL DELIVERED TO SITE

1) The Contractor's quality control staff shall keep full records of all materials delivered to site for use in the Works, and of all tests made on such materials either prior to or following delivery to site.
2) These records shall be available at all times to the Engineer-in-charge, together with any factory testing certification.

5.6 MEASUREMENT FOR PAYMENT AND PAYMENT

1) No measurement for payment will be made for any of the Contractor's QC activities required in this Section. All costs of these activities will be included in the Unit Prices for work listed in the Schedule.

END OF SECTION A.5

SECTION A.6

COMMISSIONING

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SECTION A.6

COMMISSIONING

6.1 GENERAL

1) The Contractor will be required to co-ordinate his work with other Contractors (Civil~~Lot 2~~, HM and E&M works) working for the this Project and make due allowance for the installation, testing and commissioning of items of hydro-mechanical equipment and E&M equipments to be supplied under HM & E&M contracts and will be required to co-operate with and assist the sub contractor/joint venture partner in the work.

2) The periods for the installation and testing of these items shall be the Contractual Programme or otherwise intimated to him separately.

3) During the installation, testing and commissioning of equipment the Contractor will allow full access to the staff of the sub contractor/joint venture partner of HM/E&M contractor, and for their equipment and materials, and must make full allowance in his work activities and programme for any delays, restrictions or changes of working methods which may result from this requirement.

4) The Contractor will be expected to agree with the sub contractor/joint venture partner providing him with materials, consumables and electric power as these may be needed during the installation and testing of hydro-mechanical equipment, at costs to be agreed directly between them and at no cost to Employer.

5) The Contractor will be expected to make available to the sub contractor/joint venture partner as available storage space for equipment items and plant during the installation of the hydro-mechanical equipment, again at costs to be agreed directly between them and at no cost to Employer.

6.2 HYDRO-MECHANICAL EQUIPMENT TO BE INSTALLED

1) The principal items of hydro-mechanical equipment constructed in the HM contract, which are to be installed in civil structures shall include but not limited to the following:

   a) Dam~~Barrage~~ Radial gates & Stop Log gates including hoisting equipments and gantry crane.

   ~~b) Head Regulator - Trashrack, Service & Bulkhead Gate.~~

   ~~c)~~b) Intake Structure - Trash Screen.

   ~~d)~~c) Silt Flushing Tunnel – Gates & hoisting equipments at the intake and outlet.

   ~~e)~~d) HRT Adit Inspection gates.

   Any other installation envisaged during construction.

   In addition to above, the contractor shall also have to coordinate his works with and make due allowances for the works being executed in the vicinity by other contractor.

6.3 TESTING OF EQUIPMENT

1) The Civil Contractor will work together as required with the HM Contractor and E& M contractor and any sub-contractors during the testing of all items of newly-installed Hydro-mechanical and Electro-mechanical equipments.

2) Should this testing reveal any defects or inadequacies of the Works carried out by the Contractor, the latter will immediately act to remedy or make good these defects or inadequacies, to the satisfaction of the Engineer-in-charge, in such a way that the testing by the HM Contractor and the E&M Contractor is not delayed.

3) The Contractor shall contribute any data or other information needed by the HM Contractor and the E&M Contractor contractors or the Engineer-in-charge for inclusion in testing report or commissioning certificates.

6.4 INSPECTION OF CIVIL STRUCTURE

On completion of civil works of all components, contractor shall submit (within 7 days) a report for conditions covering the following aspects:

6.4.1 General Requirement for Concrete Structures

Visual Examination for

a) Width and pattern of cracks
b) Spalling, swelling and scaling of concrete surface
c) Honey combing, cold joints, exposed aggregates and reinforcement
d) Water Leakage: Surface dampness, Seepage/leakage through joints or cracks
e) Adverse movements such as deflection, heaving, settlements etc.

6.4.2 Requirement for Individual Structures

The requirements of all the individual structures shall also be fulfilled as directed by Engineer-in-Charge before commissioning.

6.5 DELETED~~COMMISSIONING OF THE PROJECT AS A WHOLE~~

~~The Contractor together with the Civil Contractor of Lot-2, HM Contractor and E&M Contractor shall fully participate (and co-operate with the Engineer-in-Charge) at the time of final commissioning of the Project which shall include reservoir filling, filling of the water conductor system and commissioning of individual units in the Power House.~~

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6.6 MEASUREMENT FOR PAYMENT AND PAYMENT

There will be no payment for any of the activities related to equipment commissioning as well as restart~~commissioning~~ of the project as a whole. All costs related thereto will be covered by the Unit Prices given in the Bill of Quantities.

END OF SECTION A.6

SECTION B.1
DEWATERING DURING CONSTRUCTION
List of Contents

SECTION B.1

DEWATERING DURING CONSTRUCTION

1.1 SCOPE OF WORK

(1) The Contractor shall provide all labour, material, and Equipment necessary to design, build, operate, maintain, and remove the temporary dewatering facilities for protecting the Works under construction and all the existing structures against flood flows in the rivers and creeks, and to design, build, install, operate, maintain and dismantle the temporary dewatering facilities required to remove service water and natural surface flow or groundwater seepage from the working areas on surface as well as from underground.

(2) The Contractor shall be responsible for maintaining work sites free of water at all times. The Contractor shall make good any damage whatsoever caused by flooding of the Work sites due to failure of Equipment, improper maintenance of protective works, and acts of negligence in his performance of the Work. The Contractor shall indemnify Employer against claims made by other Contractors, land holders or other persons arising out of any such failure.

(3)The Contractor shall make the requisite back-up arrangement for the construction power in accordance with the Special conditions of the contract and shall not be entitled to any claim or compensation due to failure or interruption thereof.

(4)The work shall be executed in accordance with the Contractor's design and specifications, and sequences as approved by the Engineer-in-Charge.

(5)Temporary dewatering facilities shall be removed upon Completion of Works.

(6)The Contractor shall not withdraw temporary drainage and dewatering system from any interfacing site till completion of all the works but not earlier than commissioning/taking over of at least first unit with written permission from the Engineer-In-Charge.

~~(6)~~(7) There is limited dewatering envisaged from the surface and underground working area in dam and associated structure. The tentative quantity envisaged is approx. 2,00,000 -KWh from the working area.

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1.2 SUBMITTALS

(1) Within 56 days from the date of issue of Letter of Acceptance, the Contractor shall submit to the Engineer-in-Charge the detail planning of all diversion, protection and dewatering systems and the necessary flow measurements.

(2) This design shall be consistent with the outline description submitted by the Contractor with his Tender, and shall include the following:

a) Design assumptions and calculations,

b) Layouts of diversion and drainage facilities,

c) Layout and capacity of pumps and pipes, sumps, drains, both open and covered, well points, etc., including efficiency and heads, piping arrangement and discharge points,

d) Details of standby dewatering arrangements,

e) Proposal for treating polluted water either by settling basins, filters, traps for separating silt or any other suitable method,

f) Any other arrangements or installations the Contractor may propose for temporary protection of the Works and dewatering of the working areas both in the open air and underground.

(3) At least 28 days prior to scheduled construction of the particular work the Contractor shall submit to the Engineer-in-Charge full details of Equipment to be installed and all necessary construction details required for the dewatering purposes.

(4) The Engineer-in-Charge reserves the right to require any additional information deemed necessary to be included in submitted documents.

1.3 EXECUTION

1.3.1 General

(1) Electrically operated dewatering systems of adequate capacity shall be provided by the Contractor for carrying out dewatering of surface as well as the underground construction sites. The cost thereof shall be deemed to have been included in his unit price of dewatering item. The Contractor shall supply, install, maintain, and operate all dewatering pumps, pipes, supports, channels, troughs, electrical installations, and necessary accessories, and other consumables required to maintain the different work sites free of water during construction.

(2) The Contractor shall provide additional standby power supply unit commensurate with the capacity of the pumps as to cope with the water inflow into construction sites during periods of breakdown and maintenance of his main power supply units.

(3) Dewatering of the surface as well as the underground sites shall be undertaken by gravity whenever possible. Only where dewatering by gravity is not practical, pumping shall be resorted to after this mode has been approved by the Engineer-in-Charge.

(4) The Contractor shall propose the permanent sumps locations for approval of the Engineer-in-Charge. The energy meters for the purpose of measuring energy consumed in dewatering for payment shall be installed at those locations.

(5) Where, in the opinion of the Engineer-in-Charge existing or potential water inflows into excavations can be reduced or controlled by grouting, the Contractor shall perform grouting in accordance with Section "Drilling, Grouting and Pressure Relief Holes".

(6) The pumped water carried in pipes or flumes shall be discharged at point sufficiently away from the edge of the excavation. Care shall be taken to ensure that there is no seepage or backflow to the working areas.

(7) The Contractor shall ensure that all drainage water will be disposed of without causing interference to his own or other Contractors operations elsewhere at the Site and that no drainage water runs into adjacent works or other areas. Water discharged from work areas shall not be polluted or endanger the environment. Any polluted water coming from the working sites shall be treated prior to its discharge from the Site. Particular attention shall be paid to possible pollution

from oil or solvents coming into contact with the water prior to its discharge from the Site. Oil separators shall be provided within the drainage system as necessary.

(8) The dewatering systems shall not adversely affect any of other project activities and structures or works of other agencies. Where more than one agency are working in the same or adjacent area, the Contractor who has already provided the drainage facility, shall extend this facility to other agencies also. In case of dispute the apportioning of such expenditure shall be decided by the Engineer-in-Charge, whose decision shall be final. In no case shall the Contractor stop the drainage activity.

(9) In case the flow from the Contractor's site is passing through the site of other Contractors or agencies, the drainage shall be attended by the Contractor in whose site the origin of the water is located.

(10) If at any time during construction, in the opinion of Engineer-in-Charge, dewatering pumps in addition to the installed dewatering capacities are required in any working area, the Contractor shall provide and install such additional capacity of dewatering system as necessary.

1.3.2 Dewatering of Surface Construction Sites

(1) The Contractor shall perform all works necessary to drain the surface construction sites of rain, groundwater and service water. The dewatering works shall be required during second and third stage of diversion and any other works as directed by Engineer-in-Charge. The work shall include, but not be limited to the following:

a) Design and construction of drainage, ditches, pits, pump sumps and settlement ponds with oil separators,

b) Design, furnishing, operation and maintenance of dewatering equipment,

c) Relocation of dewatering facilities required for the performance of other works,

d) All auxiliary works required for safe and continuous dewatering of the construction sites.

(2) The Contractor shall design and install complete facilities at the surface construction sites. All the components of the dewatering systems shall be installed and operated in accordance with the agreed method and the construction time schedule or approved modification thereof.

(3) Dewatering near the river or stream shall be done down to natural water level by gravity. Suitable drainage shall be made joining the course downstream of the construction site to provide required gradient to facilitate proper and efficient dewatering. Below the natural water table dewatering shall be done by pumping water collected in the sumps and discharging the same into the river course downstream of the construction site.

(4) The Contractor shall provide, install, maintain, and operate adequate pumping and other equipment, including standby units, to handle all water entering into any of surface construction sites. In addition, he shall provide sumps and pumps and/or well points in the immediate vicinity of the structure foundations using

such water conductors as are necessary to conduct the water away from the excavation and concrete placement operations in an approved manner, so that such operation shall be kept free from standing or running water.

(5) The Contractor shall provide the necessary power and energy for operating the pumps and well point system, if any. The standby power supply shall undergo weekly trial runs lasting at least 30 minutes.

(6) The dewatering systems shall be designed and installed in such a way that modifications and extensions to the systems are possible while they are in full operation.

(7) Drainage ditches shall be excavated along the top of excavated slopes and on the berms. Such ditches shall be kept well back from the excavation edges in order to prevent saturating the upper part of the slopes. The ditches shall have sufficient longitudinal gradient and shall be regularly cleaned by the Contractor out of all accumulated silt and other matter so that water may flow freely at all times.

(8) The Contractor shall take measures to ensure that the foundation surfaces remain free of standing water and undamaged by the passage of construction traffic. All ditches shall be outside the foundation areas.

(9) Where excavation is to be made below the groundwater table in loose material, the Contractor shall lower the water table sufficiently below any working surface in advance of the excavation by means of properly screened wells and pumps. Where excavation extends below the water table in rock, the Contractor shall drill holes 6 m deep below the final grade, not farther than 100 m apart, and measure the piezometric head in the hole for 2 days prior to blasting any rock. Excess hydrostatic pressure in the rock shall be relieved in approved manner to prevent upheaval of, or any other damage to the foundation.

(10) Where concrete is to be placed, the water table shall be maintained below the lowest part of the finished excavation for minimum one day following the raising of structure above the natural groundwater table, and for such additional time as may be necessary to preclude damages to structure foundation.

(11) Upon completion of dewatering, temporary pipes and pump sumps beneath permanent structures shall be closed off and completely filled with grout, mortar or concrete as required by the Engineer-in-Charge.

1.3.3 Dewatering of Underground Construction Sites

(1) The Contractor shall perform all work necessary to collect and drain the service and infiltrating groundwater, convey it to main conduits, and lead it out from underground works, such as tunnels, adits, etc.

(2) The work shall include, but not be limited to, the following:

a) Design and construction of pits and trenches,

b) Design, supply, operation, and maintenance of dewatering Equipment,

c) Relocation of dewatering facilities required for the performance of other tunnelling work,

d) Design construction and operation of settlement ponds with oil separators at the portals,

e) All auxiliary work required for the safe and continuous dewatering of the underground sites.

(3) Pilot holes will be drilled if required by the Engineer-in-Charge, to provide information on the inflow of water into the tunnels or shafts as the excavation proceeds. Where the indications are that flows are likely to be large, grouting to seal off the water flows and drilling of drainage holes may be ordered.

(4) The Contractor shall design and provide a complete dewatering system for both the descending and the ascending headings. Dewatering of the ascending heading shall be by gravity alone. The Contractor shall design and construct corresponding drainage trenches in the tunnel inverts with or without lining as appropriate.

(5) After break-through in the tunnel, the drainage water from the descending heading shall be taken over by the upgrade drainage system of the ascending heading (dewatering by gravity).

(6) All excavated areas shall be drained of all service and groundwater. In order to keep the construction areas free from water, the dewatering systems must be able to operate at any time during the whole construction period in any part of the Works at the required capacity.

(7) The Contractor shall provide adequate pumping capacity, including a sufficient number of standby pumping units, to handle all water entering into any portion of underground Works. These units shall be connected to the dewatering systems in such a way that proper and uninterrupted drainage will be guaranteed throughout the entire construction period.

(8) The Contractor shall provide the necessary power and energy for operating the dewatering system. The standby power supply shall undergo weekly trial runs lasting at least 30 minutes.

(9) All components of the systems shall always be maintained in ready-for-service condition and all access to pumps and other Equipment shall be kept in good condition under the most adverse conditions.

(10) The dewatering systems shall be designed and installed in such a way that modifications and extensions to the systems are possible while they are in full operation.

(11) All components of the dewatering system shall be installed and operated in accordance with the agreed method and the construction time schedule, or approved modifications thereof.

(12) After the excavated profile has been checked, the ground water which runs or drips into the excavated space shall be diverted into the drainage trench by means of water collectors, plastic foils, and pipes for collecting the seepage water from rock surfaces or steel/concrete lagging. Damp surfaces or seepage areas with low volume in flows can be sealed off with a quick-setting sealing compound.

(13) Particular care shall be exercised where excavation passes through material, which is liable to soften or swell when it comes into contact with water. In such

locations the water entering the excavated space shall be collected as soon as possible and conveyed away in a pipe or other impervious channel in such a way that the water cannot come into contact with such material. Should the Contractor neglect to observe this requirement and a deterioration of the tunnel invert results from water being allowed to flow over or stand upon the sensitive or swelling material, the Engineer-in-Charge may order the removal of the affected material and its replacement with concrete. The Engineer-in-Charge may order installation of additional rock supports in connection with such remedial work.

(14) If any water from another portion of the tunnels or shafts flows into a lower section where concreting is being done, either for the invert or for drainage trench or any other concreting likely to be affected by water, all such water shall be diverted past this area in such a way that no damage occur to the concrete. The length of the affected sections over which water has to be diverted shall be ordered by the Engineer-in-Charge.

(15) The Contractor shall perform regular checking and cleaning of the drainage trench and all dewatering Equipment and accessories during the whole construction period.

(16) The dewatering facilities shall be kept in operation according to the agreed schedule which shall be related to the progress of the work. No pumps may be stopped, no pipes, ducts, trenches, etc., shall be taken out of service without the permission of the Engineer-in-Charge.

(17) Any openings such as pipes, boreholes, ducts, pump sumps etc., used for temporary drainage purposes in any part of the Works shall be completely sealed by filling with grout, mortar or concrete when no longer required, unless the contrary is directed by the Engineer-in-Charge in writing. The Contractor shall notify the Engineer-in-Charge in writing before any such openings are permanently closed.

1.4 MEASUREMENT AND PAYMENT

1.4.1 Dewatering of Surface Construction Sites

(1) Measurement for payment or payment for the dewatering of surface construction sites will be based solely on the energy consumed in pumping water ~~as~~ based on actual basis as per the unit consumed in pumping of water. The unit rate of dewatering shall be derived based on the anticipated quantity of dewatering 2,00,000 KWh and the Lump sum price quoted by the bidder in the BOQ.

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(2) Payment will be made at the Unit Price per kilowatt-hour (kWh) entered in the Bill of Quantities, which shall include the entire cost of:

a) Supply, transportation, installation, operations including cost of electricity, maintenance, testing, and removal of pumps, pipelines with all accessories, and other dewatering Equipment for pumping water, regardless of the amount of water,

b) Design of all dewatering systems,

c) All costs and labour for excavation, construction and protection of drainage ditches, wells, pits, pump sumps, and settlement ponds,

d) Multistage pumping,

e) Capturing and conveying the water into the drainage system,

f) Moving of the pumps and pipes as necessary between different locations,

g) All auxiliary work required.

(3) The stipulated Unit Price for dewatering will be payable to the Contractor for the measured actual energy consumed in dewatering. However, in case of multistage pumping employed for dewatering, energy consumed in intermediate dewatering in stages from one sump to other shall not be measured for payment. The Unit Price shall hold good for any quantity of dewatering required to be done by Contractor without any variation/deviation limit.

(4) The Contractor shall ensure that dewatering pumps supplied by him perform in accordance with the manufacturer's specifications. In the event of any of dewatering pumps provided by Contractor consume energy in excess of the values specified by manufacturer, the same shall be repaired and replaced by Contractor at his own cost, without delay and to the entire satisfaction of Engineer-in-Charge.

(5) Each pump installed shall undergo a trial testing at least once a week or as and when directed by the Engineer-in-Charge to demonstrate that it is actually discharging the water at its rated capacity and head. If significant deviations (more than 10% below) are discovered the Unit Price for pumping through that pump will be proportionally reduced for the period of the past 7 days or until the time of the last pump testing, whichever may apply. Where several pumps are installed at the same site, the weighted average of the capacity of all installed pumps shall be calculated and the Unit Price proportionally reduced. The pump capacity will be measured at the outlet of the installed pipeline.

(6) The meters and other electrical connections shall be installed by the Contractor at his own expense. Meters shall be tested by the electrical department of Employer before installation. Approved test report of the meters shall be submitted to the Engineer-in-Charge before installation. In case Employer does not have the facilities for such testing, the same shall be got done by the Contractor at his own cost at a standard test house approved by Engineer-in-Charge or at the facilities of the electrical department of the Indian National and/or state government in the presence of the representative of the Engineer-in-Charge. In either case the test report shall be approved by the project electrical department of Employer. Meters shall be calibrated and tested before installation and the test reports shall be submitted to the Engineer-in-Charge prior to installation.

(7) The Contractor shall not be entitled to any claim or compensation due to failure or interruptions in electric supply. In case of diesel dewatering equipment, KW hours shall be worked out on the basis of actual HP of the pump and hours run. The working hours shall be measured by suitable time devices attached to the pumps. A joint record on number of working hours shall be kept for payment.

(8) No measurement for payment or payment shall be made for dewatering surface construction sites by gravity and the entire cost thereof shall be included in the Unit Prices for other items of the Works. Intermediate dewatering in stages from one sump to other shall not be measured for payment.

(9) Payment for grouting and other seepage control and treatment work shall be paid as stipulated in the Section "Drilling, Grouting and Pressure Relief Holes".

(10) Payment for drainage trench excavated along the top of excavated slopes will be made at the appropriate Unit Prices for excavation, concrete, rock paving or others as the case may be. Drain ditches on the berms will not be measured for payment and the cost thereof shall be included in the Unit Prices for surface excavation.

(11) No measurement for payment or payment will be made for the following, and the cost thereof shall be deemed to be included in the Unit Prices for other items of the Works:

a) Excavation of drains and sumps required for dewatering purpose,

b) Piping arrangement, consumables, maintenance and repairs/replacement of dewatering system,

c) Caulking or plugging,

d) Construction, operation and maintenance of the settlement ponds, or other devices for treatment of polluted water,

e) Any dewatering done by pumping in contravention of the instructions given by the Engineer-in-Charge.

(f) Any pneumatic pump if required shall be installed, operated and maintained by the Contractor at his own cost and no separate payment for dewatering with these pumps shall be made to the Contractor.

(12) Any repair work or any liability, which result from non-compliance by the Contractor with any requirements of this Section shall be at the Contractor's full responsibility and at his expense.

1.4.2 Dewatering of Underground Construction Sites

(1) Measurement for payment for dewatering underground construction sites will only be of the energy consumed in pumping water.

(2) Payment will be made at the Unit Price per kilowatt-hour (kWh) entered in the Bill of Quantities, which shall include the entire cost of:

a) Supply, transportation, installation, operations including cost of electricity, maintenance, testing, and removal of pumps, pipelines with all accessories, and other dewatering Equipment for pumping water, regardless of the amount of water,

b) Design of all dewatering systems,

c) All costs and labour for excavation, construction and protection of drainage ditches, wells, pits, pump sumps, and settlement ponds,

d) Multistage pumping,

e) Capturing and conveying the water into the drainage system,

f) Moving of the pumps and pipes as necessary between different locations,

g) All auxiliary work required.

(3) The stipulated Unit Price for dewatering will be payable to the Contractor for the measured actual energy consumed in dewatering. However, in case of multistage pumping employed for dewatering, energy consumed in intermediate dewatering in stages from one sump to other shall not be measured for payment. The Unit Price shall hold good for any quantity of dewatering required to be done by Contractor without any variation/deviation limit.

(4) The Contractor shall ensure that dewatering pumps supplied by him perform in accordance with the manufacturer's specifications. In the event of any of dewatering pumps provided by Contractor consume energy in excess of the values specified by manufacturer, the same shall be repaired and replaced by Contractor at his own cost, without delay and to the entire satisfaction of Engineer-in-Charge.

(5) Each pump installed shall undergo a trial testing at least once a week or as and when directed by the Engineer-in-Charge to demonstrate that it is actually discharging the water at its rated capacity and head. If significant deviations (more than 10% below) are discovered the Unit Price for pumping through that pump will be proportionally reduced for the period of the past 7 days, or until the time of the last pump testing, whichever may apply. Where several pumps are installed at the same site, the weighted average of the capacity of all installed pumps shall be calculated and the Unit Price proportionally reduced. The pump capacity will be measured at the outlet of the installed pipeline.

(6) The meters and other electrical connections shall be installed by the Contractor at his own expense. Meters shall be tested by the electrical department of Employer before installation. Approved test report of the meters shall be submitted to the Engineer-in-Charge before installation. In case Employer does not have the facilities for such testing, the same shall be got done by the Contractor at his own cost at a standard test house approved by Engineer-in-Charge or at the facilities of the electrical department of the Indian National and/or state government in the presence of the representative of the Engineer-in-Charge. In either case the test report shall be approved by the project electrical department of Employer. Meters shall be calibrated and tested before installation and the test reports shall be submitted to the Engineer-in-Charge prior to installation.

(7) The Contractor shall not be entitled to any claim or compensation due to failure or interruptions in electric supply. In case of diesel dewatering equipment, KW hours shall be worked out on the basis of actual HP of the pump and hours run. The working hours shall be measured by suitable time devices attached to the pumps. A joint record on number of working hours shall be kept for payment.

(8) No extra measurement for payment or payment will be made for dealing with water and dewatering of underground construction sites by gravity, and the entire cost thereof shall be included in the Unit Prices for other items of the Works. Intermediate dewatering in stages from one sump to other shall not be measured for payment.

(9) Payment for grouting and other treatment of seepage and fill grouting of drainage system will be made as stipulated in Section "Drilling, Grouting and Pressure Relief Holes".

(10) No measurement for payment or payment will be made for the following, and the cost thereof shall be deemed to be included in the Unit Prices for other items of the Works:

a) Excavation of drains and sumps required for dewatering purpose,

b) Piping arrangement, consumables, maintenance and repairs/replacement of dewatering system,

c) Caulking or plugging,

d) Construction, operation and maintenance of the settlement ponds, or other devices for treatment of polluted water.

e) Any pneumatic pump if required shall be installed, operated and maintained by the Contractor at his own cost and no separate payment for dewatering with these pumps shall be made to the Contractor.

f) Any dewatering done by pumping in contravention to the instructions given by the Engineer-in-Charge.

g) Any remedial work ordered by Engineer-in-Charge, arising out of Contractor's negligence

(11) Any repair work or any indemnities which result from non-compliance by the contractor with any requirements of this section shall be at the contractor's full responsibility and at his expense.

END OF SECTION B.1

SECTION B.2
SURFACE EXCAVATION

List of Contents

SECTION B.2
SURFACE EXCAVATION

2.1 SCOPE OF WORK

(1) This Section covers all surface excavation work to be performed under this Contract, which shall consist of removing all existing material of whatever nature to the lines and grades shown on the Construction Drawings or as otherwise directed by the Engineer-in-Charge. This work shall include the excavation under all conditions of saturation and involve drilling and blasting or any other method of excavation, loading, hauling and disposal of materials in designated spoil, stockpile areas or directly as construction materials.

(2) The Contractor shall also be responsible for excavation which is not specifically required for the construction of Permanent Works, but incidental to the installation of temporary facilities such as site roads, office buildings, campsite, construction plants/Equipments, etc.

(3) Slope protection and stabilisation measures, which may be needed in conjunction with surface excavation work are covered in other Sections of these Specifications.

(4) The approval given by the Engineer-in-Charge to the Contractor's methods and Equipment shall not relieve the Contractor of his full responsibility for the proper and safe execution of surface excavations, or of liability for injuries to, or death of persons, or any obligations under this Contract.

2.2 SUBMITTALS

(1) With his tender, the Contractor will be required to submit a detailed method statement, drawings and work programme for the excavation at sites of various components of the project. This statement must indicate all proposed access and haul roads, stockpiles, spoil tips/ disposal areas for excess material etc. The method statement shall give details on the plant and equipment which the Contractor proposes to use for excavation and haulage, blasting methods, drainage and safety precautions, and procedures for the installation of rock supporting and stabilisation works.

(2) At least 42 days prior to the commencement of any surface excavation, the Contractor shall submit to the Engineer-in-Charge an updated method statement and programme for the activities set out in (1) above, giving full details of the proposed excavation methods and sequences, including necessary site drainage and safety precautions. Any variations from the corresponding data submitted with the Contractor's tender will be explained and justified to the satisfaction of the Engineer-in-Charge. The data shall include the following:

a) Location and area of blasts.

b) Diameter, spacing, depth, pattern and orientation of blasting holes.

c) Type, strength, amount, column load and distribution of explosives to be used per hole, per delay and per blast.

d) The type of detonators, powder factors, and sequence and pattern of delays to be used per blast.

e) Description and purpose of any special methods or Equipment to be adopted by the Contractor.

(3) The method statement shall include the excavation methodology by mechanised means and planning for its movement and access to various components of the Project.

(4) The plans shall be in conformity with detailed requirements of Indian laws and regulation for excavation sequencing, blasting and precautions to be taken in proximity of concrete and grouting operations, public roads, and for the safety of construction workers and members of the public.

(5) Within 14 days of receipt of the overall updated excavation method statement and programme, Engineer-in-Charge will advice the Contractor in writing of his acceptance of, or comments on the submitted plans. The Engineer-in-charge reserves the right to reject the proposed plan if in his opinion undesirable damage to permanent rock surfaces or existing structures would result from performing the blasting as proposed. If rejected, a new plan in whole or in part shall be submitted. Drilling and blasting shall only be carried out in areas for which the plan has been accepted by Engineer-in-Charge.

(6) In addition to preparing a detailed blasting plan, the Contractor shall submit, not later than 24 hours in advance of each proposed blast, a detailed proposal showing the final details of the proposed blast. The Contractor shall not proceed with the blast until permission to load holes with explosives has been given by Engineer-in-Charge.

(7) At least 21 days prior to dumping or stockpiling any material, the Contractor shall submit the layout of spoil or stockpile areas, which will be within the areas designated on the Tender Drawings or as approved by the Engineer-in-Charge. All pertinent data of working methods and provisions for the security, stability and temporary and permanent drainage of the areas shall be included. Details of volumes, material types, heights and grades shall be provided.

(8) Prior to starting any excavation in any particular area, the Contractor shall confirm in writing his agreement with the existing surveys and topographical data showing the original ground surface for the area in question which will be used for measurement purposes. Should the Contractor have any doubts as to the correctness, or sufficiency, of such data, he shall carry out an independent survey on his own and submit his survey to the Engineer-in-Charge for approval. In case of disagreement, the Engineer-in-Charge and Contractor shall mutually review the existing data. The agreement concerning the location of the original ground surface must be reached before commencing excavation work. Contractor's failure to follow the procedure outlined above will forfeit his right to claim any other locations of the original ground surface than that established by the Engineer-in-Charge.

(9) To enable the Engineer-in-Charge to verify all necessary elevations and cross-sections of the original ground surface, prepared by the Contractor, the latter shall notify the Engineer-in-Charge in writing, giving at least 7 days notice

before the commencement of any excavation. The Contractor shall clear, in advance, all vegetation that may interfere with this survey work.

(10) The Contractor shall submit and agree with the Engineer-in-Charge upon a monitoring plan for the excavation to observe potential or actual movement of the slopes excavated in the rock and overburden. This plan shall also give details of the procedures and Equipment to be employed by the Contractor to stabilise or protect as quickly as possible any areas in which it is determined that untoward movement or deformation is occurring or is threatened.

2.3 LINES AND GRADES

(1) The Contractor shall be responsible for setting-out all the structures and slopes as shown on the Construction Drawings, in accordance with the Section "Surveying and Setting-out Work". All extra work and over excavation caused by improper setting-out by the Contractor shall be corrected by himself immediately as requested and as directed by Engineer-in-Charge.

(2) The final excavation grades shall in general be rock of required quality. However, where the final excavation grades are defined by line and grade, the Contractor shall take every precaution, and use the most appropriate method of excavation, to avoid the loosening of material or the breaking of rock beyond the lines and grades shown on the Construction Drawings.

(3) The bottoms of all excavations shall be trimmed to line and grade as directed by the Engineer-in-Charge. The final 200 mm of any loose geological formation in excavations where concrete is to be placed, shall be excavated by hand, when directed, to avoid disturbance of the bottom.

(4) If, for any reason, excavation is carried out beyond the lines and grades shown on the Construction Drawings, the Contractor shall remove the excess material and take the necessary measures to restore the required lines and grades with approved backfill or concrete, as directed by the Engineer-in-Charge.

(5) Should the Contractor wish to excavate beyond the limits given on the Drawings for his own convenience, he may do so only with the prior consent of the Engineer-in-Charge.

2.4 SLOPES, SLIDES, GEOLOGICAL CONDITIONS AND UNSUITABLE FOUNDATIONS

(1) If geological conditions during the performance of the work do not permit excavation of slopes as shown on the Construction Drawings, or where the material is unsuited to form a firm foundation for the structures, the Engineer-in-Charge will modify the drawings accordingly or issue direct order to change the slopes and grades.

(2) Excavation beyond the lines and grades shown the Construction Drawings or as directed by the Engineer-in-Charge, is defined as overbreak.

(3) If overbreak, slides or rockfalls occur, which, in the opinion of the Engineer-in-Charge are due to improper working methods or negligence by the Contractor, and the effective excavated surfaces are beyond the excavation lines shown on the Construction Drawings, the Contractor shall remove all

excessive material and, if required, place approved backfill in the excavated voids as directed by the Engineer-in-Charge..

(4) Geologically accepted overbreak in surface excavation is defined as overbreak which occurs while both of the following conditions are simultaneously fulfilled:

a) The Engineer-in-Charge is informed and given an opportunity for inspection while both the cause and the extent of the overbreak are clearly visible,

b) The overbreak did not occur while, in the opinion of the Engineer-in-Charge, the Contractor was using improper working methods or was otherwise negligent, and it could not have been prevented by prompt and appropriate installation of supports.

2.5 EXECUTION

2.5.1 General

(1) The Contractor shall conduct all excavation procedures and operations so as to produce the required lines and grades.

(2) The surface excavation shall be performed by any approved method using any excavating and hauling Equipment suitable for the work in accordance with the submitted detailed plans and time schedule, or approved modifications thereof.

(3) The surface excavation shall be performed with the provision of benches of sufficient width to accommodate catch water drains and movement of equipments. Adequate slope protection/ stabilisation measure as shown on the construction drawings or as directed by the Engineer-in-charge, shall be taken prior to the excavation to the next bench.

(4) All excavated areas shall be drained to the satisfaction of Engineer-in-Charge. Any surface or subsurface water shall be satisfactorily controlled by methods acceptable to Engineer-in-Charge. When underwater excavation is to be performed, suitable Equipment shall be used.

(5) At all times during construction, Contractor shall adopt excavation procedures such that at no time shall the stability of any slope be impaired. Excavation shall always be started from top and worked down after putting designated supports. In no case should the excavation be carried out from the toe or any intermediate level. The acceptance by Engineer-in-Charge of excavation procedures or equipment shall in no way relieve Contractor of his sole responsibility for safeguarding the stability of all the rock faces and slopes excavated under this Contract.

(6) The Contractor shall carry out periodic cleaning to ensure that no hazardous accumulation of loose material occur on the slopes or on any berm or ledges forming part of the excavation profile. The removal of mud and slush resulting from rain or flooding of the sites shall be performed by the Contractor when, in the opinion of Engineer-in-Charge, it is considered necessary to ensure the safe and effective performance of the work.

(7) Excavation for structure foundations shall be performed under different conditions of saturation. Final surfaces shall be protected against damage by erosion and movement of construction Equipment. Any damage caused shall be repaired by the Contractor at his cost.

(8) Common/Rock excavation at sensitive locations such as Dam area~~Head Regulator, Desilting Basin,~~ Intake (including cut & cover area), tunnel outlet/portals, shall be carefully excavated and preserved during construction. Appropriate excavation method using mechanical means, smooth blasting techniques shall be generally used there. Line drilling may be applied at certain locations. Supports measures shall be installed where indicated on the Construction Drawings, or as directed by the Engineer-in-Charge, to suit the actual geologic conditions encountered.

(9) The Contractor shall exercise particular care when excavating in the vicinity of existing structures or those under construction. He shall be liable for any damage to structures or Equipment caused by his operations. Particle acceleration due to the blasting shall be monitored as specified hereinafter.

(10) The Contractor shall protect the subsoil and particularly the ground water from contamination by fuel or oil from his Equipment.

(11) Water shall be sprinkled on work sites by the Contractor to ensure dust free atmosphere at no extra cost. If the contractor does not heed to the instructions in this regard, the Engineer-in-charge shall be at liberty to get sprinkling done at the cost of contractor.

2.5.2 Classification of Excavation

1) Surface excavation is classified according to the method used to carry out the work, as follows:

   a) Common Excavation,

   b) Rock Excavation,

   c) Dental Excavation,

   d) Loose excavation and Ripping,

   e) Minor Excavation Work,

   f) Additional Excavation,

   g) Borrow and Quarry Excavation.

2) The dismantling of any concrete structure shall be included in the item “Rock excavation”.

3) Excavation of rock by ripping may be used at the Contractor’s discretion, subject to the approval of the Engineer-in charge and providing that the work complies fully with the quality requirements of these specifications for rock excavation by blasting or mechanised means. Any such ripping work will be paid for as rock excavation. The ripping of the river borne material shall be treated as common excavation only.

2.5.3 Common Excavation

(1) Common excavation including riverbed overburden excavation comprises clearing and grubbing, stripping, and all kind of loose excavation other than solid mass of rock under all conditions of saturation.

(2) Clearing shall consist of cutting and disposing of all shrubs, stumps, debris and any other vegetation and organic topsoil, existing structures, foundations of structures (except concrete or masonry in mortar), fences and other materials on the surface of the ground within the areas to be cleared as indicated on the Construction Drawings, or as required by Engineer-in-Charge.

(3) All flammable material resulting from clearing shall be either burnt or disposed of by the Contractor in a manner acceptable to the Engineer-in-Charge. The Contractor shall be responsible for taking all safety measures required for burning of the materials, and he shall be responsible for any damage done by fire resulting from his work. The fire shall at no time be left unattended, until it has been fully extinguished. The Contractor shall have suitable Equipment and supplies for fighting fire during the burning of material and shall take all necessary precautions to prevent fire from spreading. None of the disposed material shall be piled in stream of river or in a location where in the opinion of Engineer-in-Charge it is liable to be washed away by floods.

(4) Stripping consists of removing all rubbish, humus, vegetable material and all or part of the organic topsoil in the areas and to the depth as indicated on the Construction Drawings or as directed by the Engineer-in-Charge.

(5) Common excavation means general excavation of material such as organic topsoil, clay, silt, sand, gravel, and boulders of up to 1 m^3 in volume and soft or disintegrated rock, which can be removed by common earth moving Equipment without ripping or blasting.

(6) Stripping and loose excavation shall be accomplished by proper excavation and hauling Equipment suitable for the work which allows for an efficient work progress adopted to the soil conditions encountered.

(7) When the bottom of excavation as indicated on the Construction Drawings is not rock and the natural foundation material is disturbed or loosened, for any reason, the Contractor shall improve it by compaction or replace it with approved fill and compact as directed by the Engineer-in-Charge.

(8) The contractor shall submit a detailed plan accompanied by the drawings along with the tender document showing detail proposal of excavation, layout of haulage road, intermediate berms for excavation pit, dewatering arrangement, disposal proposal etc. The plan has to be accompanied by equipment and manpower planning and also detailed scheduling of different activities.

(9) The removal of mud and slush resulting from rain or flooding of the sites will be, when ordered by the Engineer-in-Charge, considered as common excavation.

2.5.4 Rock Excavation

2.5.4.1 General

(1) Rock excavation consists of the removal of rock by blasting or mechanised means includes all solid rock in place which cannot be removed until loosened by blasting, barring or wedging, removal of all boulders or detached pieces of solid rock larger than 1 m^3 in volume, as well as any existing structural foundation made of concrete or masonry placed in mortar which cannot be removed during common excavation or by ripping.

(2) Lines shown on the Tender or Construction Drawings such as “Rock Line”, "sound rock", "top of rock" etc., are approximate and for information only. They will not be used for measurement purpose.

(3) All excavation shall be performed using methods and techniques that will produce smooth and sound rock surfaces with minimum overbreak and fracturing beyond the lines and grades or limits of excavation shown on the Construction Drawings, or as required by Engineer-in-Charge, and will preserve the structural integrity of the excavated openings. All precautions shall be taken by the Contractor to achieve this result and also preserve in a soundest possible and undisturbed condition all the materials beyond the limits of the excavation of lines and grades shown on the drawings. Particular care shall be exercised where vertical or near vertical faces are required.

(4) Drilling and blasting shall be done in such a manner as to ensure that the rock will break along the desired lines and grades. Rock shattered by blasting operations outside the established limits of excavation shall be removed and replaced by concrete if necessary. Rock faces and slopes shall be scaled or cleaned of loose or overhanging rock immediately after excavation. Rock surfaces, both temporary and permanent, shall be regularly inspected by the Contractor and rectified whenever necessary.

(5) The diameter and the spacing of the blast holes shall be constantly reviewed with respect to the actual conditions at the Site. The Contractor shall develop the blasting techniques as the work progresses to obtain the best possible excavation surface after blasting. The techniques used shall be at all times subject to the agreement of the Engineer-in-Charge, who may order blasting tests to be undertaken by the Contractor to substantiate his proposed methods of blasting. The Contractor shall engage a qualified professional blasting consultant to assist in establishing satisfactory techniques

(6) Rock excavation close to the final excavated surfaces shall be performed using controlled blasting methods such as "pre-splitting", "cushion blasting", "smooth blasting" as defined hereinafter. Line drilling and broaching shall be used to limit the overbreak and damage of surrounding rock.

(7) Shattering or splitting of rock, or the opening up of seams and joints in the rock, beyond the limits of excavation, shall be avoided. If in the opinion of Engineer-in-Charge such damage occurs due to Contractor's negligence, then additional rock support shall be installed and any resultant shattered material beyond such lines shall be removed and replaced with rockfill or concrete as directed by Engineer-in-Charge.

(8) Immediately following the blasting, and at any time throughout the duration of the Contract, the Contractor shall scale and remove from the excavations all loose material which appears to be unsafe or to endanger persons, work or property. The fact that such scaling and removal may enlarge the excavation

beyond the required excavation lines shall not relieve the Contractor from the necessity of performing such scaling and removal.

(9) After scaling and prior to excavation of the next bench or round, the Contractor shall install rock stabilisation and reinforcement, and provide any surface treatment need, as shown on the Construction Drawings or as directed by the Engineer-in-Charge.

(10) All blasted rock shall be removed from the bench toe before the succeeding bench is excavated. The maximum bench height shall be as indicated on the Drawings and may be changed only with approval of Engineer-In-Charge.

(11) The final excavated surfaces shall have no abrupt changes in slope and sharp projections greater than 500 mm. Projections in excess of 500 mm shall be treated where necessary by supplementary excavation as determined by the Engineer-in-Charge, to produce the desired surface of contact between concrete and rock.

(12) The excavation shall be made to sufficient depths to secure foundations of structures on sound rock free from weathered materials or other objectionable defects, as determined by the Engineer-in-Charge. The exploratory investigations of the foundations are not sufficiently complete to disclose all seams, defects, and other irregularities that may exist in the foundation rock. The lines of excavation shown on the Construction Drawings shall therefore not be interpreted as indicating the final or actual lines of excavation or that no defects exist. The excavations at all elevations shall be so shaped as to produce as uniform and regular a profile as is practicable to obtain using excavation methods described herein.

(13) Whenever, in the opinion of the Engineer-in-Charge, further blasting may injure the rock upon or against which concrete is to be placed, or is otherwise undesirable, the use of explosives shall be limited to light charges or discontinued, and the excavation shall be completed by wedging, barring, line-drilling or other suitable methods approved by the Engineer-in-Charge.

(14) Should the presence of rock appear to make excavation for the foundations of any structures unnecessary to the extent, which is shown on the Construction Drawings, the Contractor shall consult the Engineer-in-Charge before proceeding with such work. The Engineer-in-Charge will issue a direct order in writing on whether to precede with the work as shown or to define the how the work shall be modified.

(15) When the excavation has been completed to the approximate grade, as shown on the Construction Drawings or established by the Engineer-in-Charge, the surface shall be cleaned off by barring, wedging, picking or other approved methods, and with an air and/or water jet under pressure for purpose of inspection. If the foundation is found to be not satisfactory as determined by the Engineer-in-Charge, supplementary excavation shall be made as directed, and the surface again cleaned for inspection. This procedure shall be repeated until a satisfactory foundation is obtained. Just prior to placing the concrete, a final cleanup of the rock surface shall be made. All loose, shattered, or disintegrated material shall be removed, and the final surface cleaned with jets of air and/or water under pressure.

(16) Contractor shall regularly monitor and inspect all excavations made under this Contract, and shall forthwith promptly remove and dispose of any rock which Contractor or Engineer-in-Charge deems loose, unsound or disintegrated, or in any other way unsafe.

(17) Excavation of rock by ripping may be used at the Contractor's discretion, subject to the approval of the Engineer-in-Charge and providing that the work complies with the quality requirements of these specifications for rock excavation by blasting. Any such ripping work will be paid for as excavation by blasting.

2.5.4.2 Control Perimeter Blasting

(1) Bench or open-cut excavation of permanent rock slopes shall be carried out using the cushion blasting or presplitting techniques. However, depending upon the detailed geometry of rock slopes, other techniques, such as line-drilling, may be used with written approval of Engineer-in-Charge. Production holes within 3 m of the perimeter row of holes shall be drilled at a reduced spacing and charged with a reduced load. Perimeter holes shall be drilled in such a manner to meet the following tolerances with respect to length, collar, locations and alignment:

a) The collar of perimeter holes shall be located within 75 mm of the perimeter line,

b) Perimeter holes shall not be longer than 6.0 m unless otherwise agreed by Engineer-in-Charge,

c) All perimeter holes shall be aligned so that each hole terminates within 200 mm of the line, to which the holes are being drilled,

d) Within 1 m of corners, the hole spacing shall be reduced by drilling intermediate holes so that satisfactory and high-quality excavation lines are maintained. The intermediate guide holes may or may not be loaded, depending on the results obtained and as required by Engineer-in-Charge.

(2) Holes for perimeter blasting technique shall be at spacing of 450 mm, 600 mm or 750 mm. The selection of center-to-center spacing of holes for perimeter blasting shall be developed by trial. In initial stages of excavation, perimeter holes shall be drilled at 450-mm spacing and based on results this spacing may be varied.

(3) Contractor's controlled perimeter drilling and blasting techniques shall be considered acceptable and in conformity with these Specifications for controlling the completed rock surfaces if:

a) At least 50% of the drill hole traces of each round are visible in the final rock surface, distributed uniformly, after the scaling down of all loose and shattered rock that is liable to fall before or during rock reinforcement installation and if all drill hole traces are close to the lines shown in the Construction Drawings,

b) Engineer-in-Charge may modify the above criteria if, in his opinion, the achievement of such results is not reasonably possible because of adverse rock conditions.

(4) Drill holes for controlled perimeter blasting shall be loaded in a manner and detonated in a sequence so as to ensure a minimum of damage to the rock beyond the excavation lines.

2.5.4.3 Line Drilling

(1) Line-drilling shall be used where control perimeter blasting may cause excessive damage to the surrounding rock or where there are structures adjacent to the excavation.

(2) Line-drilling is defined as a single row of unloaded holes drilled along the neat excavation line, spaced no more than two to four times the hole diameter on centres. These will form a surface of weakness to which the primary blast can break. Light blasting with well-distributed charges fired after the main excavation is removed may be permitted in the holes. If, however, in the opinion of the Engineer the blasting may injure the rock, the use of explosives shall be discontinued and the excavation shall be completed by broaching, wedging, or barring.

(3) Line-drilling is anticipated near and around Dam area~~Head Regulator, Desilting Basin,~~ Intake area and cut & cover area, adit/tunnel portals.

(4) Contractor's Line drilling techniques shall be considered acceptable and in conformity with these Specifications for controlling the completed rock surfaces if:

a) At least 50% of the drill hole traces of each round are visible in the final rock surface, distributed uniformly, after the scaling down of all loose and shattered rock that is liable to fall before or during rock reinforcement installation and if all drill hole traces are close to the lines shown in the Construction Drawings,

b) Engineer-in-Charge may modify the above criteria if, in its opinion, the achievement of such results is not reasonably possible because of adverse rock conditions.

2.5.5 Dental Excavation

(1) Dental excavation shall include the removal of unsuitable material from shear zones, clay seams, pockets, joints, or from spaces between boulders beyond the lines of excavation shown on the Construction Drawings or established in the field, which are too small to be excavated by common earth moving Equipment.

(2) Dental excavation, depending on its extent, will require the use of a back-hoe, hand tools, or other small excavating Equipment, as well as the use of a high velocity air-water jet. The methods employed shall be such as to avoid fracturing of the rock adjacent to the material being removed.

(3) Dental excavation shall be performed where directed. The extent to which such material shall be removed, including the depth, direction, and dimensions of the work, will be determined by the Engineer-in-Charge. In general,

however, excavation into cracks or seams shall be to the depth that is a minimum of three times the seam width, and such excavation shall be backfilled with M15A40 concrete or shotcrete. No blasting will be permitted.

2.5.6 Loose Excavation and Ripping

(1) Loose excavation shall include all types of soil, soft and hard moorum, soft rock and such other material, which can be excavated manually by ordinary pick and shovel or barring and wedging or by mechanical Equipment such as tractor blade, ripper, power shovel and dragline but without recourse to blasting. It shall also include embedded boulders, not bigger than one metre in any one direction.

(2) All loose boulders, semi-detached rocks (along width the earthy stuff which might move therewith) not directly in excavation but so close to the area to be excavated, as to be liable in the opinion of the Engineer-in-Charge, to fall or otherwise endanger the workmen, Equipment or the Work, shall be stripped and removed from the areas of excavation. The methods used shall be such as not to shatter or render unstable or unsafe any rock that was originally sound and safe. Any material not requiring removal as contemplated in the Work but which, in the opinion of the Engineer-in-Charge, is likely to become loosened or unstable later on shall be promptly and satisfactorily removed, as directed by the Engineer-in-Charge.

2.5.7 Minor Excavation Work

(1) Minor excavation work consists of excavation, in all materials, of trenches or holes of less than, or equal to, 2 m of width and in other small or restricted areas, which will be carried out manually or using small Equipment.

(2) The Contractor shall excavate to the limits, lines and grades shown on the Construction Drawings.

(3) Bracing, shoring or other methods of supporting the excavation shall be carried out as necessary.

(4) Mechanical excavation of trenches, except those in rock, shall be stopped not less than 100 mm above final bottom level. The remainder of the excavation shall be removed, shaped, and graded manually.

(5) In rock, the trenches shall be excavated to such depth that space for placing of compacted sand bedding at least 10 cm thick shall be provided between the rock and the underside of any Equipment or pipe.

2.5.8 Additional Excavation

(1) The Contractor may be directed by the Engineer-in-Charge to perform excavation beyond the lines and grades of already completed work. Such excavation shall be defined as additional excavation.

(2) Additional excavation may consist of any or all classes of excavation stipulated in this Section.

(3) Excavation outside the excavation limits, which is required by the Contractor for his own convenience may be performed only with agreement by the

Engineer-in-Charge, who may direct the Contractor to refill it with concrete or rockfill in a satisfactory manner at no additional cost to Employer.

2.5.9 Borrow and Quarry Excavation

(1) Materials required for the construction of Permanent Works which are not available from excavation will be obtained from the borrow areas and quarries the location of which are shown on the Drawings and/or described in the Information for Bidders, or from other areas as may be designated in the course of the work. For the sake of clarity these terms have the following meaning:

Borrow excavation will produce construction materials by loose excavation.

Quarry excavation will produce construction materials by blasting.

(2) The Engineer-in-Charge may request execution of exploratory core drillings as specified in the Section "Drilling, Grouting and Pressure Relief Holes" prior or during the quarry operations.

(3) Prior to commencing borrow and quarry excavation, the Contractor shall clear and strip the area and remove all material which is unsuitable for use in the construction of the Works. Topsoil shall be stripped from the excavated areas and stockpiled for future use apart from other excavated material.

(4) The Contractor shall make such tests, use such Equipment, and vary his excavating methods and blasting patterns as necessary to produce the required grading, uniformity or mixture of each material, and shall be fully responsible that those materials meet the specifications, and for adequacy and safety of the quarrying and borrowing operations.

(5) Borrow excavation will produce material for coffer dykes including impervious core, concrete aggregates, base material for roads, etc. If required to prevent excessive moisture, the Contractor shall lower the water table in the borrow area by appropriate means, stockpile the excavated material to permit drying or perform such work as necessary to reduce the moisture content.

(6) Borrow areas shall be kept graded and drained so that surface and ground water will not collect or stand there. Upon completion of the work, excavated surfaces shall be left with stable slopes not steeper than two horizontals to one vertical. Unless specifically waived by the Engineer-in-Charge, the slopes and bottoms of the borrow pits shall be evenly graded to present a neat and orderly appearance. Tracks or marks of heavy Equipment or other disturbed earth shall be smoothed or filled to the surrounding level. The stockpiled topsoil shall be evenly spread over the subsoil exposed by the excavation.

(7) Quarry excavation will produce material for Gabions, concrete aggregates, etc. Unsuitable material or material not required for permanent construction purposes found in the quarry shall be left in place or, with the approval of the Engineer-in-Charge, shall be excavated and disposed of in an approved spoil area. The Contractor shall avoid contamination of construction material by such unsuitable material.

(8) During excavation at the quarry, berms approximately 3 m wide at 15 m vertical intervals shall be provided.

(9) During quarrying operations the Contractor shall take precautions in order not to interrupt the traffic along nearby roads and provide personnel and devices to warn the road users of blasting.

(10) Upon the Completion of Works, rock faces, slopes and bottoms of quarries shall be scaled and cleaned of all loose and overhanging rock. Quarries shall be properly graded for self-drainage and finished with neatly trimmed slopes not steeper than one horizontal to two vertical, unless otherwise directed.

2.6 EXCAVATED MATERIALS

(1) All suitable materials from the excavations shall be utilised to the fullest extent practicable as construction materials in Permanent Works.

(2) The Contractor's blasting and excavating techniques shall be such that as far as practicable, construction materials of satisfactory quality will be obtained. Wherever possible, such materials shall be excavated separately from materials to be wasted.

(3) Whenever possible, excavated material which is suitable for construction purposes shall be transported directly from the excavation area to the designated final locations for its use.

(4) If the immediate placement in the final location is not possible, the materials shall be stockpiled. If the moisture content of excavated materials which would be suitable for backfill is too high after excavation, such material shall be drained and dried in the stockpile until the moisture content is sufficiently reduced to allow for placement.

(5) The Contractor shall remove any cobbles, boulders or rock fragments found in otherwise approved materials which are greater or smaller than permitted for specific embankment zones and place them in other zones or dispose of them appropriately.

2.7 DISPOSAL OF EXCAVATED MATERIALS

(1) Excavated materials which are not suitable for, or are in excess of the construction requirements shall be disposed of in the spoil area shown on the Tender Drawings, or in areas designated as such by the Engineer-in-Charge in the course of the work. The Contractor shall be responsible for the stability of all fills, embankments and stockpiles created by the disposal of excavated materials.

(2) The spoil tips shall be located where they will not interfere with the natural flow of streams or rivers, with construction operations in the borrow and quarry areas, with reservoir operation, with flow of water to or from outlet works, or with accessibility to the Site. Where required, the Contractor shall permanently divert (stage-wise if necessary) the present courses of the streams.

(3) The excavated materials shall be transported to the disposal areas in such a way that spillage onto roads etc. is avoided. In case such materials fall despite taking reasonable care, such areas shall be promptly cleared by the Contractor to keep it in the state of cleanliness and tidiness.

(4) No rock material may be dumped into rivers or creeks. The earth or soil material may be dumped into natural watercourse with the agreement of the Engineer-in-Charge, and if prior written confirmation of this is obtained.

(5) The surfaces of all disposed excavated materials which are to remain permanently exposed shall be finished to prescribed lines and to stable slopes approved by Engineer-in-Charge. Adequate diversion of water courses in such areas and drains shall be constructed to prevent the undesirable accumulation of water in or around the disposal or stockpile areas.

(6) The Contractor shall be liable for any damage to Temporary or Permanent Works or to the property of third parties caused by poor drainage in the spoil or stockpile areas.

(7) The contractor shall comply all environmental safeguards during disposal of excavated material. The contractor shall be liable for any damage for any damage / penalty imposed due to non-compliance.

2.8 PREPARATION AND PROTECTION OF EXCAVATION SURFACES

(1) Excavation surfaces against or upon which concrete, backfill will be placed shall be prepared and protected as specified herein and in combination with specifications contained in the pertinent Sections of these Specifications or as shown on the Construction Drawings.

(2) If, during excavation work, material beyond the limits of excavation shown on the Construction Drawings is loosened or disturbed, the Contractor shall re-compact the loosened material or remove it altogether and replace it with other compacted fill as directed.

(3) If, during excavation in rock for concrete structures or linings, the rock beyond the limits of excavation shown on the Construction Drawings becomes broken or shattered, the Contractor shall remove all loose material and replace it with concrete or shotcrete as directed.

(4) Foundation excavation shall be kept well drained and free of standing water. The Contractor shall provide all necessary drains, ditches and sumps, and use pumps when necessary, in order to ensure that foundation surfaces are not harmed by water. When foundations are damaged, the affected material shall be removed and replaced with approved backfill.

(5) Shotcrete shall be applied to finished excavation surfaces where, in the opinion of the Engineer-in-Charge, it is deemed necessary to prevent air slaking, erosion or other deterioration of the surface. The protective coating shall be applied to excavated surfaces either with or without steel wire mesh reinforcement in accordance with the provisions of the Section "Shotcrete".

2.9 MONITORING AND PROTECTION FROM BLASTING

(1) The Contractor shall adequately protect existing structures from the effects of blasting, both from impact with rock or debris and from excessive shock. Structures at risk shall be inspected both before and after blasting, and shall be monitored during the blasting operations by appropriate means, if so directed by the Engineer-in-Charge.

(2) The Engineer-in-Charge may monitor part or all of the blasting operations utilising velocity transducers, vibrographs or other Equipment. The Contractor shall cooperate with Engineer-in-Charge in placing, operating and recording of monitoring Equipment.

(3) In case of concrete structures and cement grout maximum particle velocities that result from blasting operations shall not exceed the following limits.

a) For concrete and grout in place for more than 60 hours, the maximum particle velocities shall not exceed 5 cm/s,

b) For concrete or grout in place for less than 60 hours, the maximum particle velocity shall not exceed 1 cm/s,

c) For complete or partially complete portions of platforms in fill, peak particle velocity shall not exceed 5 cm/sec and the maximum particle acceleration shall not exceed 1.0 g.

(4) Blasting within 25 m of concrete or grout will be permitted only after concrete or grout is 7 days old and only after submission by Contractor, and approval by Engineer-in-Charge, of a plan showing the relative positions of structures or grouted area and the area to be blasted, Contractor's proposed drilling and blasting plan, together with outline of precautions to be taken. All concrete and other completed work within 25 m of blasting shall be protected by limiting the size of blasts. Blasting will not be permitted within 10 m of structures or installations vulnerable to damage by blasting. Replacement or repair of work damaged by blasting shall be carried out by Contractor at no expense to Employer unless otherwise instructed by Engineer-in-Charge.

(5) The blasting restrictions stated above are given as a guide only and may be revised by Engineer-in-Charge on the basis of seismic measurements and observations during the progress of the work. If results of blast monitoring indicate that Contractor's blasting methods endanger excavation, grout or concrete work, Contractor shall be required to alter its blasting methods accordingly at no expense to Employer.

2.10 MEASUREMENT AND PAYMENT

2.10.1 General

(1) Measurement for payment for any class of excavation specified herein will be of the in-situ volume as measured from a survey performed by the Contractor and approved by the Engineer-in-Charge prior to any excavation work and the lines and grades shown on the Construction Drawings or established at the site by the Engineer-in-Charge.

(2) Payment will be made at the appropriate Unit Price per cubic meter entered in the Bill of Quantities, which shall include the entire cost of the following:

a) Provision of all labour, Equipment and materials required for excavation, including any hand work necessary for trimming excavated surfaces; preparation, protection and maintaining excavated surfaces in satisfactory conditions until concrete or fill is placed; all additional excavation for Contractor's convenience; any temporary supports necessary to support the sides of the excavations,

b) Loading, hauling and dumping the excavated material on stockpiles, spoil tips or points of incorporation in Permanent Works up to ~~2~~3 km distance measured along the road i.e. nearest points along the road from designated excavated area and disposal area; clearing of the spoil areas and formation of spoil tips as specified; clearing of the stockpile areas, formation and maintenance of stockpiles and spoil tips, drainage and dealing with water in stockpiles and spoil tips, re-handling of suitable materials including segregating, grading, draining and drying of materials suitable for use in concrete or as backfill.

c) All delays during excavation work resulting from installation of rock supports, stabilisation and protection works required by the geotechnical conditions of the material encountered,

d) Complying with all requirements of statutory laws and regulations relating to blasting work and any restrictions resulting therefrom; obtaining all necessary permits and licenses for the purchase, use, storage and transport of explosives or any other material and Equipment,

e) Surveying, setting-out, checking of excavated profile and alignment, and any subsequent rectification works resulting from undue or incorrect surveys; provision of suitable Equipment for, and delays due to carrying out this work.

(3) ~~Extra payment will be made for handling the excavated material beyond 23 km and up to 4 km at the appropriate unit price as entered in the Bill of Quantities. Measurement for payment will be based on the hauled volume. The volume of the material will be measured during hauling operations by counting the number of return truckloads, and will be calculated by applying the following bulking factors:~~

- ~~For common excavation material: 1.2~~
- ~~For excavated rock: 1.4 and using the formula:~~

~~Number of truck loads x truck capacity / bulking factor~~

~~Payment for the resulting calculated volume will be made at the Unit Price per cubic meter entered in the Bill of Quantities. No payment will be made for any trips by empty trucks. Haulage for the excavated material shall be upto 3 km.~~

~~(9)~~(4) Measurement for payment of additional volumes of excavation resulting from modification of slopes and grades shown on the Construction Drawings, which may be necessary in the course of the work, and is not required by the Contractor for his own convenience, will be of the in-situ volume as measured between the original and the modified lines and grades.

~~(10)~~(5) Payments will be made for protection works (like boulder wire-crates, Random Rubble masonry walls, etc for the dumped material in spoil tips.

2.10.2 Geological Overbreak and Unsuitable Foundations

(1) Measurement for payment for the removal of material arising from geological overbreak accepted by the Engineer-in-Charge as occurring entirely for geological reasons, will only be made if the Contractor request measurement

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directly after excavation, and as long as the overbreak can clearly be determined as being due to adverse geological conditions.

(2) Excavation and refill ordered in writing by the Engineer-in-Charge due to slides or overbreak for geological reasons or unsuitable foundations will be measured for payment and paid for as follows:

a) Removal of material resulting from slides/geological overbreak accepted by the Engineer-in-Charge will be paid per cubic meter in-situ, at the Unit Price entered in the Bill of Quantities.

b) In-situ volumes of the additional excavation required in connection with geological overbreak will be measured in cubic meters and payment will be made at the Unit Price for excavation of approved classification,

c) The concrete placed for refilling additional excavation in rock foundation will be measured in cubic meter of the in-situ compacted volume and payment will be made at the Unit Price per cubic meter for the concrete class as ordered by the Engineer-in-Charge.

2.10.3 Common Excavation

(1) No extra payment will be made for clearing, cutting, burning and disposing of trees and bushes, cost of which is deemed to be included in the unit prices of common excavation.

(2) Measurement for payment for common excavation (including clearing, stripping and loose excavation) will be of the in-situ solid volume of the material removed between the original ground surface levels and the lines and grades shown on the Construction Drawings or the surveyed and agreed surface levels for the classification "Rock Excavation".

(3) Payment will be made at the Unit Price per cubic meter entered in the Bill of Quantities.

2.10.4 Rock Excavation

(1) Measurement for payment for rock excavation by ripping and blasting will be of the in-situ solid volume of the rock material removed between the actual jointly surveyed rock surface and the lines and grades shown on the Construction Drawings or as directed by the Engineer-in-Charge.

(2) Payment will be made at the Unit Price per cubic meter, entered in the Bill of Quantities, which shall, in addition to work included and described under "General", include the entire cost of removal of rock material which cannot be removed by common excavation; protection of structures, properties, installations, trees, etc.; drilling holes for blasting and blasting, development and using controlled blasting methods, blasting tests, and any cost associated with establishing satisfactory blasting techniques.

(3) In addition to material actually removed under this title the following shall also be classified as "Rock Excavation", and shall be measured and paid for under this item:

a) Large boulders and detached pieces of rock that cannot be removed by ripping or by excavation machinery used for common excavation,

b) Rock removed by drilling, wedging or barring, or other approved methods in areas where blasting would be required but not possible or permitted for whatever reason.

2.10.5 Control Perimeter Blasting

(1) Separate measurement for payment and payment will be made for excavation performed at the final surfaces of excavation by controlled blasting methods. Measurement for payment will be of excavation area for which controlled blasting is required, calculated from the required lines and grades shown on Construction Drawings or as directed by the Engineer-in-Charge.

(2) Payment will be made at the Unit Price per square meter entered in the Bill of Quantities.

2.10.6 Line Drilling

(1) Measurement for payment for line-drilling will be of the length of the holes actually drilled into the rock along the side of the excavation as directed by the Engineer-in-Charge.

(2) Payment will be made at the Unit Price per meter of drilled hole entered in the Bill of Quantities, which shall include the entire cost of drilling the holes, light blasting, broaching, wedging, barring, or other methods used in conjunction with line-drilling.

2.10.7 Dental Excavation

(1) Measurement for payment for dental excavation will be of the in-situ volume of material removed.

(2) Payment will be made at the Unit Price per cubic meter entered in the Bill of Quantities, which shall include the use of any special Equipment and hand work.

(3) If measurement by volume proves impracticable, the surface area of seams and cracks to be cleaned may be equated, as the conditions dictate, to a volume mutually agreed upon by the Contractor and the Engineer-in-Charge.

2.10.8 Loose Excavation and Ripping

(1) Measurement for payment for excavation will be of the in-situ volume defined by the excavation lines as shown on the Construction Drawings, unless otherwise modifies or directed by the Engineer-in-Charge.

(2) Payment for Excavation will be made at the same Unit Rate per cubic metre as the item Common excavation entered in the Bill of Quantities.

2.10.9 Minor Excavation Work

(1) Measurement for payment for minor excavation either in loose material or in rock will be of the in-situ volume removed between the original surfaces as surveyed jointly and the lines and grades shown on the Construction Drawings or as directed by the Engineer-in-Charge.

(2) Payment will be made at the Unit Price per cubic meter entered in the Bill of Quantities.

2.10.10 Additional Excavation

(1) Any additional excavation in areas where surface excavation has already been completed, which the Contractor may be directed by Engineer-in-Charge to carry out, will be measured and paid for at the same Unit Prices entered in the Bill of Quantities as for the original excavation. No increase in Unit Prices will be allowed for such additional excavation.

2.10.11 Borrow and Quarry Excavation

(1) No separate measurement for payment or payment will be made for borrow and quarry excavation, clearing grubbing, stripping, trimming, levelling and draining of the borrow and quarry areas. The entire cost thereof shall be included in the Unit Prices for furnishing, placing, mixing, compaction, etc., of such materials as specified in the pertinent Sections of these Specifications.

2.10.12 Exclusions

(1) All costs of dewatering and keeping the surface excavation sites dry will be as specified in the Section "Dewatering during Construction".

(2) No extra measurement for payment or payment will be made for the following:

a) Extra work caused by the Contractor's negligence in setting-out the structures and slopes,

b) Surveys to verify the original ground surface, or for recording the top of the rock surface,

c) Provision and cleaning of drain ditches on the berms,

d) Removal of the materials resulting from the slides or overbreak caused by Contractor's inappropriate working methods and for the additional materials required to fill the voids so created,

e) Additional work of removing material, backfilling voids with approved material, and installing additional rock supports where overbreak due to adverse geological conditions coincides with that due to Contractor's poor working methods or negligence,

f) Excess excavation required for Contractor's convenience and the resulting additional backfilling with approved materials,

g) Additional work resulting from the Contractor changing slopes without prior approval by the Engineer-in-Charge. In such event, payment will be made only to the lines and grades shown on the Construction Drawings,

h) Excavation which is incidental to the installation of Temporary Works,

i) Shoring, bracing, and supporting of excavation surfaces except as specified in the Sections "Rock Supports" and "Slope Protection",

j) Clearing, grubbing and stripping in the borrow and quarry areas, and spoil and stockpile areas,

k) Draining, shaping, and trimming the dumped material in the spoil tips to the lines and grades as directed or approved by the Engineer-in-Charge,

l) Preparation and protection of foundation and slopes with the exception of concrete protective coating, which will be measured and paid for in accordance with the provisions of the Section "Shotcrete",

m) Stockpiling of construction materials from required excavation material, which cannot be incorporated directly into Permanent Works,

n) Work or materials required when foundation surfaces have been allowed to become unsuitable due to the action of ground or surface water,

o) Extra work or material required for repairing damages to the final excavation surfaces caused by the erosion or travel of the construction Equipment,

p) Monitoring of existing structures during blasting operations.

END OF SECTION B.2

SECTION B.4

ROCK SUPPORTS

List of Content

SECTION B.4

ROCK SUPPORTS

4.1 SCOPE OF WORK

(1) Works under this Section include all labour, materials, tests, equipment and services required to protect, stabilise or support rock faces, cuts, slopes and masses exposed in the course of surface and underground excavation works, as well as the anchoring of any concrete structures into surrounding or underlying rock.

(2) This Section covers the following items:

a) Rock bolts, rock anchors, and grouted anchor bars

b) Wire mesh

c) Structural steel supports

d) Temporary supports.

e) Pre-grouting, Fore poling and Pipe roofing etc

(3) Steel Fiber Reinforced Shotcrete (SFRS), Shotcrete with/without wiremesh, grouting and drainage work, which may also be required for rock support purposes, are specified in other Sections.

(4) Principal works required are as follows:

a) Stabilising of surface excavation slopes and cuts particularly at the following open cut locations:

- Dam~~Barrage~~ Area

- Head Regulator, Desilting Basin & Intake area (including cut & cover area)

- HRT Adit Portals

- Silt flushing Tunnel Outlet Portal

The support measures required will be determined by the actual rock conditions encountered, but may consist of individual or pattern rock reinforcement, SFR shotcrete, wire mesh and dental works, and in cases were necessary.

b) Rock support in tunnels and construction adits for which the measures required would be determined by the actual rock conditions encountered, but may consist of individual or pattern rock-bolting, rock anchors, SFR shotcrete, wire mesh, lattice girders and steel ribs with or without lagging.

c) Systematic anchorage of concrete structures by means of grouted anchor bars, as shown on the Drawings, particularly at the following locations:

- Dam~~Barrage~~ Area

- Head Regulator, Desilting Basin & Intake area (including cut & cover area)

- HRT Adit Portals
- Silt flushing Tunnel Outlet Portal

4.2 GENERAL

(1) The rock stabilizing and supporting measures to be undertaken during or after the excavation work for constructing the Works in a safe manner will be as determined or approved by the Engineer-in-Charge, based on the known or presumed behavior of the rock or ground.

(2) In case of emergency or unforeseen exigency, the Contractor is authorised and obliged to undertake independently such supporting measures, as he deems necessary without prior consent of the Engineer-in-Charge. In such cases the Contractor shall inform the Engineer-in-Charge immediately.

(3) The Engineer-in-Charge retains the right to order the Contractor to change the method or system of rock supports being used, if he considers that the Contractor's method of work is unsafe.

(4) In underground works the installation of the rock supports shall follow closely the excavation of heading and they shall be installed before the next round of excavation advance. The Contractor is responsible for the timely and proper installation of the rock supports and for checking and maintaining it until the final lining or structure is placed.

(5) Rock stabilization measures required as the permanent feature of the Works shall be installed as shown on the Drawings or as directed by the Engineer-in-Charge.

(6) Nothing contained in this Section shall be construed to relieve the Contractor from sole responsibility for the safety of the Works nor for liability for injuries to, or death of persons or damage to property, nor of any of his obligations under this Contract.

(7) An adequate quantity of rock support materials and equipment including Post-Tensioned cable anchors shall be stored by the Contractor at the construction sites and be kept ready for immediate use at any time during the whole construction period.

(8) The Contractor shall organize his deliveries of steel ribs, lagging, and rock reinforcement to minimize any material surplus at the time of completion of Works.

(9) The quantities of all rock support items listed in the Bill of Quantities and the support systems shown on the Drawings are only tentative. The actual measures to be taken shall be dictated by the rock conditions encountered.

(10) Grouting of rock bolts of various types and rock anchors is an important and critical requirement. Cement used in grout shall be OPC/PPC/Microfine cement. Contractor shall ensure grout pumps of appropriate type are available at site in sufficient number to achieve the grouting of bolts in a proper manner.

(11) Since installations of bolts require considerable skill, the contractor shall get professional advice from such specialized agencies/experts who shall assist him to achieve the required quality in carrying out the installation.

(12) Works of Pre-grouting, Fore-poling & pipe roofing shall be allowed to be executed only by an agency having both experience and technology for execution of these works.

4.3 SUBMITTALS

(1) Within 28 days from the date of issue of Letter of Acceptance, but before procuring or shipping the materials to the site, the Contractor shall submit to the Engineer-in-Charge the following:

a) Full details of the type and quality of rock reinforcement which is proposed to be used together with manufacturer's instructions and certificates, methods of installations and testing (including details of testing equipment) and, for rock bolts and rock anchors, details of grouting system and anti-corrosion measures. The Contractor may propose in addition alternative types of rock reinforcement to that described in this Section, but acceptance by the Engineer-in-Charge will be subject to full demonstration of its adequacy.

b) Fabrication details of steel ribs, lagging and lattice girders including size, steel quality, accessories and methods of installation together with certified copies of manufacturer's reports.

(2) Not later than 28 days prior to ordering any of the above materials, the Contractor shall submit to the Engineer-in-Charge for approval his proposed materials delivery schedule. Any amendments to the delivery schedule, proposed by the Contractor as the work proceeds, will also have to be approved by the Engineer-in-Charge, and none of the above materials shall be called to the site without Engineer-in-Charge's consent.

(3) Contractor's shop drawings of structural steel supports and precast concrete lagging shall be submitted to the Engineer-in-Charge not later than 42 days prior to their installation.

(4) A detailed test program for all rock reinforcing elements shall be submitted to the Engineer-in-Charge for his approval before the start of the work.

(5) The Contractor shall record the results of all tests performed on the rock bolts prior, during and after the installation, register the readings taken at the load cells installed and submit these documents to the Engineer-in-Charge.

(6) Minimum 48 days before start of use of resin capsules, the contractor shall furnish the details of resin capsules, its installation methodology for approval of Engineer-in-Charge. If required, Engineer-in-Charge may ask the contractor for on site trials of installation of grouted rock bolts before according approval.

(7) Minimum 48 days before start of excavation, the contractor shall furnish the detailed information in respect of pipes for pipe roofing, its installation methodology and name of specialized agency for approval of Engineer-in-Charge.

4.4 ROCK BOLTS, ROCK ANCHORS, GROUTED ANCHOR BARS, WATER EXPANDABLE FRICTION ANCHOR

4.4.1 General

(1) The Contractor shall furnish, install, test and maintain rock bolts, rock anchors, grouted anchor bars, water expandable friction anchor as specified herein. They shall be installed in portions of the Works where anchorage of concrete structures to rock is required and where the stability of excavated or exposed rock faces and slopes has to be assured, either permanently or only temporarily during construction work.

(2) Variations of typical design of excavation limits and rock support patterns and details, as shown on Drawings, has to be expected and allowed for, and could include modifications in the quantities, type, location, pattern, spacing and length of rock reinforcement and accessories. Such variations will be proposed or directed by the Engineer-in-Charge as the excavation proceeds, to suit field conditions.

(3) For the sake of clarity, the terms used in this Section or any other section of these technical specifications are defined as follows, and may be applied in underground or in surface works:

REINFORCING ELEMENT is a general term for rock bolts, rock anchors and grouted anchor bars.

ROCK BOLT (consisting of a rod, a mechanical/cement grouted/Resin end anchorage and a plate and a nut on the threaded end) is a stressed (or tensioned) reinforcing element to be stressed immediately after installation by torquing or jacking, by means of an approved calibrated stressing device. Rock bolts shall be fully grouted (or ungrouted where load cells are provided on them). The rock bolt is synonym with active rock anchor.

ROCK ANCHOR is an un-tensioned reinforcing element consisting of a rod embedded in a cement mortar filled hole. The rock anchor shall have a plate and a nut. Extension pieces may need to be provided on rock anchors for anchorage of concrete structures. The rock anchor is synonymous with "passive rock anchor".

GROUTED ANCHOR BAR is a reinforcing element consisting of a reinforcing bar embedded in a cement mortar-filled hole. It shall extend into structural concrete to provide anchorage of concrete structures.

PIPE ROOFING refers to the installation of seamless hollow pipe on top of the tunnel at advanced face with umbrella alignment followed by grouting.

INDIVIDUAL BOLTING refers to the installation of reinforcing elements in localised areas of instability or weakness, as may be determined during excavation. It is synonymous with "spot bolting".

PATTERN BOLTING refers to the installation of reinforcing elements in a regular pattern over the excavation surface.

(4) The following types of rock bolts shall be used:

a) Expansion-shell rock bolts.

b) Resin grouted/ cements grouted rock bolts.

(5) The following types of rock anchors shall be used:

a) Rock anchors

b) Grouted anchor bars

c) Water Expandable Friction Anchor.

d) Self Drilling Hollow Core Anchor

(6) The type length, diameter, inclination and pattern of the reinforcing elements shall be as determined or approved by the Engineer-in-Charge, except as stipulated in Clause 4.2 (2) here above.

(7) Reinforcing elements shall be furnished complete with all accessories and other materials necessary for their installation, fixing, stressing and grouting.

(8) Bearing plates shall be flat or dished steel plates of following minimum dimensions:

36mm dia.	1 no. plate of 200x200x16mm
32mm dia.	1 no. plate of 200x200x12mm
25mm dia.	1 no. plate of 150x150x10 mm

The plate shall conform to IS 2062 for Structural Steel. The nuts shall be heavy hexagonal type.

(9) The threads on the projecting ends of bolts/anchors shall be protected and lubricated with rust preventive compound.

(10) If directed or approved by the Engineer-in-Charge, the Contractor shall supply and install flat steel plates or rolled steel sections to connect together two or more rock reinforcing elements. The steel plates and sections shall conform to IS: 2062.

(11) When the reinforcing elements are used in conjunction with wire mesh, the mesh shall be connected firmly to the bolts as shown on the Drawings or as directed by the Engineer-in-Charge.

(12) If directed by the Engineer-in-Charge, rock bolts shall be provided with devices for load measuring. In this case they shall not be grouted.

4.4.2 Testing and Monitoring of Reinforcing Elements

(1) The Contractor shall furnish at least 2 sets of testing equipment including hydraulic jacks, fixing device, hydraulic pump with manometer, and all necessary accessories. The testing equipment shall be capable of stressing the largest diameter rock bolt to the yield stress of the bolt.

(2) Prior to the installation of reinforcing elements in the Works, a series of pull-out tests shall be carried out in different rock types designated by the Engineer-in-Charge and which will be representative of the rock expected to be encountered during the excavation, to prove the suitability of the reinforcing elements. During the pullout test both, the load applied and movement undergone shall be measured. At least 5 tests shall be required for each combination of the type of the reinforcing element/installation condition to be able to assess the suitability of the element. The pull-out tests shall be carried out sufficiently in advance of the installation of the reinforcing elements in the Works so that, in the event that the elements do not meet the requirements, the Contractor shall have time to furnish and test elements of a different type. The Contractor shall maintain detailed records of the pull-out tests, the results of which will be used to establish relation between rock quality and type of reinforcing element and tensioning.

(3) During progress of the Works the Contractor shall, in general, perform pull-out tests, in the presence of the Engineer-in-Charge on at least 2 per 100 reinforcing elements installed. The Engineer-in-Charge will determine the elements to be tested depending on rock type and conditions of installation. In case of failure, additional testing shall be performed on selected reinforcing elements installed in the vicinity of the failed one. All tested anchors/ bolts shall be replaced as directed by the Engineer-in-Charge.

(4) Rock bolts shall be tested before grouting. Other type of reinforcing elements shall be tested after the mortar has achieved its design strength. Water expandable friction anchors shall be tested after installation.

(5) As a part of monitoring program during the progress of the work, and when directed by the Engineer-in-Charge, rock bolts shall be fitted with mechanical or electrical read out load cells. Approved load cells which allow to measure the increase or decrease in load in the bolt to an accuracy of 2% shall be supplied by the Contractor, who shall measure the deformation undergone and record the loads registered on each load cell installed twice a month and submit the results to the Engineer-in-Charge within 48 hours of taking such readings. Such load cells shall be installed on the ungrouted rock bolts only.

4.4.3 Drilling Holes and Preparation for Installation

(1) Holes for rock bolts and rock anchors shall be drilled as specified herein and in accordance with the applicable provisions of the Section "Drilling, Grouting and Pressure relief holes".

(2) The diameter of each hole shall be in accordance with manufacturer's recommendations. For grouted anchor bars the diameter of the hole shall be 20 mm greater than the diameter of the bar. For rock anchors the diameter of the hole shall be 1.5 times the diameter of the bar. Spacers shall be used for 32 mm dia. and 36 mm dia. rock bolts for length greater than 4 m for equal grout annulus all around the bolt/anchor bars to ensure the central positioning.

(3) The length of drill hole shall be such as to receive the specified reinforcing element and to provide for its satisfactory anchorage, and sufficient provision of the threaded portion out of hole to fix plate, nut, and coupling for any kind of

extension piece. The holes shall extend 150 to 200 mm beyond the length of the rock bolt or anchor.

(4) After drilling, each hole in sound, washable rock shall be washed out with clean water and cleaned by blowing out all drill cuttings and debris with compressed air. The holes in rock, which tends to swell or is interspersed with clay filled fissures, shall be cleaned with compressed air only. The compressed air shall not contain any oil or other material preventing the bond.

(5) Prior to installing the reinforcing element, the rock surface shall be treated with an initial layer of shotcrete. In case of rock bolt, if the surface is not perpendicular to the hole axis, bevel washer shall be placed between the bearing plate and the nut, or dished bearing plate and hemispherical washer used, to ensure uniform bearing.

(6) If a reinforcing element is not installed immediately after drilling the hole, the hole shall be washed and cleaned as stipulated above immediately prior to installing the element.

4.4.4 Installation of Rock Bolts

4.4.4.1 Expansion Shell Rock Bolts

(1) Expansion-shell rock bolts shall be as per IS 8266 with the yield strength of not less than that of Fe500/ Fe500D grade steel. They shall be supplied complete with all accessories required for installation, stressing and grouting.

(2) The method and equipment used for installation, to effectively seat, and to stress the expansion-shell rock bolts shall be in accordance with the manufacturer's instructions and subject to the approval of the Engineer-in-Charge.

(3) The rock bolts shall be stressed, immediately after installation in the hole, by torquing or jacking, by means of an approved and regularly calibrated stressing device, to an extent specified by the manufacturer or directed by the Engineer-in-Charge on the basis of values established during pull-out tests.

(4) Expansion shell rock bolts shall generally be tensioned at the following maximum values

36 mm dia rock bolt	30 t
32 mm dia rock bolt	24 t
25 mm dia rock bolt	15 t

(5) After initial installation, the Contractor shall ensure that the rock bolts continue to act as effective supports by periodically testing the rock bolts and, if necessary, re-tightening to the directed torque or tension.

(6) Grouting of the expansion-shell rock bolts shall be performed without destressing the bolt. Grouting shall be performed as soon as practicable after, but in any case within 21 days, of rock bolt installation. The bearing plate shall be caulked around its perimeter and grout shall be introduced into the hole through a plastic tube fixed to the shaft and extended to outside through a hole provided in the bearing plate, at a pressure sufficient to fill completely the space around each bolt for the full length without any air-pockets remaining inside the

hole. A grout return tube through another hole in the plate shall be provided to ensure full column grouting.

(7) Cracks and fissures adjacent to the rock bolt, which the grout is found to be flowing from, during the grouting operation, shall be plugged or caulked at the excavation surfaces.

4.4.4.2 Resin Grouted/ Cement Grouted Rock Bolts

(1) Rock bolts shall be of yield strength of not less than that of Fe500/Fe500D grade steel. They shall be supplied complete with all accessories required for installation, stressing and grouting.

The reactable resin mixture as approved by the Engineer-in-Charge shall be contained in an easily ruptured plastic cartridge having one pocket for the resin components and a separate pocket for the curing agent, also known as the hardener or catalyst. A bolt is inserted and a rotary tool is then coupled to the free end of the bolt, turning the bolt, breaking the package and mixing the resin reactants. The mixing time shall be determined at site based on the recommendation of manufacturer and as per site trials as approved by the Engineer-in-Charge. This mixing distributes the curing agent and starts resin cure. When the resin is fully cured and the bolt is anchored fast. The remaining length shall be grouted with Portland cement. Grout mix shall have sand to cement ratio of 1:1 by weight, or as specified by the Engineer-in-Charge. Admixtures shall be approved by the Engineer-in-Charge.

(2) The method and equipment used for installation, to effectively seat, and to stress the rock bolts shall be in accordance with the manufacturer's instructions and subject to the approval of the Engineer-in-Charge.

(3) The rock bolts shall be stressed, immediately after installation in the hole, by torquing or jacking, by means of an approved and regularly calibrated stressing device, to an extent specified by the manufacturer or directed by the Engineer-in-Charge on the basis of values established during pull-out tests.

(4) Rock bolts shall generally be pre tensioned at the following maximum values

36 mm dia. rock bolt	30 t
32 mm dia rock bolt	24 t
25 mm dia rock bolt	15 t

(5) After initial installation, the Contractor shall ensure that the rock bolts continue to act as effective supports by periodically testing the rock bolts and, if necessary, re-tightening to the directed torque or tension.

(6) Grouting of the rock bolts shall be performed without destressing the bolt. Grouting shall be performed as soon as practicable after, but in any case within 21 days, of rock bolt installation. The bearing plate shall be caulked around its perimeter and grout shall be introduced into the hole through a plastic tube fixed to the shaft and extended to outside through a hole provided in the bearing plate, at a pressure sufficient to fill completely the space around each bolt for the full length without any air-pockets remaining inside the hole. A grout return tube

through another hole in the plate shall be provided to ensure full column grouting.

(7) Cracks and fissures adjacent to the rock bolt, which the grout is found to be flowing from, during the grouting operation, shall be plugged or caulked at the excavation surface

4.4.5 Installation of Rock Anchors

4.4.5.1 Rock Anchors

(1) The rock anchors will not be stressed. The rods shall be fully grouted with cement mortar grout.

(2) The rod shall be manufactured from high yield strength deformed reinforcing bars conforming to IS: 1786 Grade Fe500/ Fe500D. The diameter of the bars shall generally be 25/32/36 mm, and the length and position shall be as shown on the Drawings or as directed by the Engineer-in-Charge. For the Contractor's convenience the bars may be installed in shorter pieces as approved by the Engineer-in-Charge. Threaded couplers for the coupling of the single elements shall be able to transfer at least 125% of the yield load of the bar.

(3) The surface of the rock anchors shall be clean of rust, scale, dirt or other foreign matter.

(4) Holes drilled for rock anchors shall be kept plugged until just prior to commencement of grouting and installing operations. Before grouting, each hole shall be thoroughly flushed with water and cleaned with compressed air.

(5) Water shall be removed from the hole before grouting. If the hole cannot be kept dry during grouting, the grout shall be introduced into the end of the hole through a pipe, which shall be gradually withdrawn as the hole is filled.

(6) Portland cement shall be used for the grout mixture. Grout shall have a water to cement ratio of between 0.4 and 0.6 by weight, and a sand to cement ratio of 2:1 by weight (If added), or as specified by the Engineer-in-Charge. Admixtures shall be approved by the Engineer-in-Charge.

(7) The anchor bar shall be forced into the grout-filled hole before the initial set of the grout. The bar shall be vibrated or tapped in order to ensure good contact between the steel surface and the grout.

(8) Anchors bars shall be protected after installations in such a manner as to prevent any movement until the grout has hardened. The Contractor shall replace any bars found to be loose after the grout has set.

(9) The depth of holes indicated on the Drawings or as directed by the Engineer-in-Charge shall be measured from the effective excavation surface.

4.4.5.2 Grouted Anchor Bars

(1) The grouted anchor bars will not be stressed. The rods shall be fully grouted with cement mortar grout. Hooks will be welded to the grouted anchor bars and are covered under the Section "Reinforcing Steel".

(2) The rod shall be manufactured from high yield strength deformed reinforcing bars conforming to IS: 1786 Grade Fe500/ Fe500D. The diameter of the bars shall generally be 25/32/36 mm, and the length and position shall be as shown on the Drawings or as directed by the Engineer-in-Charge.

(3) The surface of the anchor bars shall be clean of rust, scale, dirt or other foreign matter.

(4) Holes drilled for anchor bars shall be kept plugged until just prior to commencement of grouting operations. Before grouting, each hole shall be thoroughly flushed with water and cleaned with compressed air.

(5) Water shall be removed from the hole before grouting. If the hole cannot be kept dry during grouting, the grout shall be introduced into the end of the hole through a pipe, which shall be gradually withdrawn as the hole is filled.

(6) Portland cement shall be used for the grout mixture. Grout shall have water to cement ratio of between 0.4 and 0.6 by weight, and sand to cement ratio of 2:1 by weight, or as specified by the Engineer-in-Charge. Admixtures shall be approved by the Engineer-in-Charge.

(7) The anchor bar shall be forced into the grout-filled hole before the initial set of the grout. The bar shall be vibrated or tapped in order to ensure good contact between the steel surface and the grout.

(8) Bar ends to be embedded in the concrete structure shall be provided with hooks welded to the bar to provide a good anchorage. In order to facilitate the inserting of the bars into the holes, the hooks can be welded to the anchor bar after installing. The welding and the overlap of the bar end with the hook(s) shall be as approved by the Engineer-in-Charge.

(9) Anchors bars shall be protected after installations in such a manner as to prevent any movement until the grout has hardened. The Contractor shall replace any bars found to be loose after the grout has set.

(10) The depth of holes indicated on the Drawings or as directed by the Engineer-in-Charge shall be measured from the effective excavation surface. Should the anchor bars be connected to the reinforcement steel of the concrete structure to be anchored, longer bars shall be provided in case of over excavation, to maintain the required position in the structure.

4.4.5.3 Water Expandable Friction Anchors

(1) Water expandable friction anchors shall be of a reputed make. These shall be of lengths upto 6m and installed as a temporary support at the locations determined by Engineer-in-Charge in the underground excavations. These anchors shall be used generally at places where in the opinion of the Engineer-in-Charge, the strata is such that an immediate temporary support is required and it is not possible to provide other types of rock support within a reasonable time.

(2) The anchor consists of a 41 mm diameter, steel tube of 2 mm thickness which is folded during manufacturing to create a 25-28 mm diameter unit to be inserted in a hole of 32-39 mm diameter. The anchors shall be provided with a domed

shaped face plate, as per the manufacturer's recommendations. The material of steel tube shall confirm to EN 10025-S355JR or equivalent.

(3) The anchor shall have a minimum breaking load of 100 KN and a minimum elongation of 15%. The anchor shall be activated by injection of high water pressure at 30 MPa which inflates the folded tube into intimate contact with the wall of borehole.

(4) Water expandable friction anchors shall be supplied, installed and tested as per recommended procedure of the manufacturer. Additional testing, if required, shall be carried out as determined by Engineer-in-Charge depending on site conditions.

4.4.5.4 Self Drilling Hollow Core Anchor

(1) The anchor shall be a fully threaded steel bar which can be drilled and grouted without the use of a casing. The bar shall have a hollow bore for flushing or simultaneously drilling and grouting.

(2) Self drilling anchors shall be fabricated from EN 10083-1 type of steel or equivalent. The threads shall be of type R32 ISO 10208

(3) The anchor shall be of 25/32/36 mm outer diameter with anchor coupling, nut, anchor plate and drill bit.

(4) The anchor shall be capable of taking minimum ultimate load of 210 KN, and minimum yield load of 160 KN.

(5) The minimum average tensile strength shall be 690 N/mm^2 and minimum average yield strength 530 N/mm^2.

(6) The anchors shall be hot dipped galvanized for corrosion protection

(7) The anchor to be used shall be grouted as directed by the Engineer-in-Charge.

4.4.5.5 Self Drilling type Glass Fiber reinforced Plastic Rock Anchors

(1) Self-drilling type fiber glass reinforced plastic anchor shall be of a reputed make. These shall be of lengths varying between 3m to 6 m and installed as a temporary support at the locations determined by Engineer-in-Charge in the underground excavations in particular for face stabilization, fore poling, and ground support in soft rock, loose or disturbed rock formations.

(2) The self drilling type glass fiber reinforced plastic rock anchors shall consist of a high tensile strength (>1000Mpa) hollow rod of fiber glass reinforced plastic with a suitable drilling bit at the tip for effectively work in rock of UCS up to 50Mpa.

(3) Self drilling type glass fiber reinforced plastic rock anchors shall be installed using equipments with both clockwise and counter clockwise drilling. The rotary bits should be suitable for a variety of rock types and conditions. Self drilling type glass fiber reinforced plastic rock anchors shall conform to National/International Standards.

(4) The Self drilling type glass fiber reinforced plastic rock anchors shall be supplied, installed grouted and tested as per recommended procedure of the manufacturer. Additional testing, if required, shall be carried out as determined by Engineer-in-Charge depending on the site conditions.

4.4.6 Rock Bolt / Rock Anchor Extensions into Concrete

1) Threaded portion of Rock Bolts and Rock Anchor, where required to be extended into structural concrete, shall be protected during excavation and shotcreting operations and shall protrude sufficiently beyond the shotcrete. The extension shall consist of an L-shaped reinforcing bar of similar size (as that of the bolt/anchor) and shall be welded to the bolt. The welding and the overlap of the bolt with extension piece shall be as approved by Engineer-in-Charge.

4.5 MESH REINFORCEMENT

4.5.1 Chain Link Fabric

(1) Chain link fabric shall be installed on surface excavations generally without shotcrete, to protect surfaces from which loose pieces of rock or boulders may fall.

(2) Chain link fabric shall conform to the requirements of IS 2721 for Zinc-coated Steel Chain-Link Fence Fabric. The fabric shall have a mesh size of approximately 50x50 mm and a wire diameter of 3.15 mm.

(3) The fabric shall be clean of mud, grease, oil or other foreign matter in case shotcrete is to be applied.

(4) The fabric shall be placed against excavated surfaces and fastened to rock reinforcement, if present, with extra steel plates of minimum size 100x100x5 mm and nuts. The fabric shall be securely fastened to the rock at intermediate points between the rock reinforcement with steel pins. Sufficient pins shall be provided to ensure that the fabric is held tightly to the rock surface.

(5) The installation of chain link fabric as reinforcement of shotcrete shall generally not be permitted. When the excavated surface is so uneven and rough that placing of welded wire fabric is impractical, use of chain link as reinforcement to shotcrete may be permitted by Engineer-in-Charge.

4.5.2 Welded Wire Mesh

(1) Wire mesh shall consist of welded wires in a fabric. Wire mesh shall be installed in surface and underground excavation as reinforcement for plain shotcrete usually in combination with rock reinforcement. It may also be used with steel ribs, when it shall be laid over the outer flange of the rib and pinned or fixed to the excavated surface between the ribs where necessary.

(2) Wire mesh shall conform to the requirements of IS 4948 (Welded Steel Wire Fabric for general use). The wire mesh shall have a square mesh of 100x100mm spacing made of wires having yield strength not less than 275N/mm^2. The diameter of the wires shall be 3.15 mm.

(3) Where possible, the wire mesh shall be placed at the same time as the rock reinforcement is installed. It shall not be placed between the rock surface and bearing plates, but shall be placed over the heads of rock reinforcement, and fastened to them by separate plates and nuts. It shall be ensured that the fabric is drawn close to the excavated surface so that when SFR shotcrete is applied subsequently, the mesh neither sag nor vibrate excessively and impair the effectiveness of the SFR shotcrete.

(4) Welded wire mesh shall be fixed to rock with suitable mesh anchor (in addition to rock reinforcement near by, if any) of minimum 5KN capacity at minimum spacing of 1m x 1m. Usage of wooden pegs or pins for fastening of the wire mesh to the rock surface will not be permitted.

(5) Wire mesh shall be firmly stretched between the rock reinforcement and other fastening attachments.

(6) Overlap of wire mesh shall be at least 3 times the mesh spacing with the clearance between parallel bars but not less than 300 mm.

4.6 STRUCTURAL STEEL SUPPORTS

4.6.1 General

(1) The Contractor shall install the structural steel supports consisting of lattice girder and/or steel ribs with or without lagging (steel or concrete) in underground excavation to the shape as shown on the Drawings.

(2) Structural steel supports shall be installed in conjunction with rock reinforcement and SFR shotcrete as immediate support after excavation in the heading zone when the material encountered in the process of excavation requires such measures.

(3) Steel ribs shall be furnished complete with bracing, bolts, nuts, washers, plates, tie rods, and other accessories necessary for installation of the supports. Wall plates and horizontal or bent steel bracing in the invert may be required.

(4) Lagging shall be furnished separately from steel ribs.

4.6.2 Materials

4.6.2.1 Steel Ribs

(1) All steel sections and plates used for ribs and accessories shall conform to IS: 2062 “Structural Steel" (Standard Quality).

(2) Steel for bolts, nuts and washers shall conform to IS 8500 “Structural Steel – Micro-alloyed (Medium and High Strength Qualities) – Specification”.

(3) Material used in splices shall conform to the specification of the material being spliced.

(4) All steel and fabrication thereof shall conform to the requirements of IS 800 "Code of Practice for use of structural steel in General Building Construction".

(5) All welding, welding electrodes and workmanship shall conform to IS 814 and IS 816.

(6) Latest revisions of the IS Codes where referred shall be applicable for this Contract.

4.6.2.2 Lagging

(1) Lagging with backfilling are the longitudinal supporting members placed behind the steel ribs where necessary to support the walls and crown of the excavation.

(2) Two different types of steel lagging are envisaged**:**

a) 2 to 3 mm thick to be used behind the steel ribs in profiles already excavated

b) 4 to 5 mm thick when they are to be pressed or hammered ahead of the heading face for protection.

(3) Pre-cast reinforced concrete panels of 7.5 cm (minimum) thickness may be used as lagging instead of the steel profiles. Type of lagging used must be approved by the Engineer-in-Charge before the Contractor starts with the manufacture thereof. Concrete grade used shall be M25/A20 and reinforcement at the rate of 60 kg/m^3 minimum shall be provided.

4.6.2.3 Lattice girders

(1) Lattice girders shall be installed where shown on the drawings

(2) Lattice girders shall consist of 3 no., 25 mm or greater dia reinforcing bars forming an equilateral triangle of 150 mm or greater depth, laced together by 12 mm dia reinforcing bars. The lattice girders shall be installed in similar manner as steel ribs. The accessories of lattice girders, like plates, bolts, nuts washers welding electrodes etc shall be similar as indicated in 4.7.2.1 Lattice girders shall be fully encased in SFR shotcrete, plain shotcrete as per construction drawings.

4.6.3 Execution

(1) Steel ribs shall be cold bent within 1% of the theoretical excavation profile. Reshaping of the bent ribs at the place of installation may only be undertaken with Engineer-in-Charge's consent and only if the material properties would not be impaired. All structural steel used for ribs shall be true to dimension, square, plumb and level. Joints and intersecting members shall be accurately fitted with adequate fastenings. All work is subject to acceptance by Engineer-in-Charge prior to installation.

(2) The Engineer-in-Charge may, based on his judgment, instruct the Contractor to install structural steel support in the underground excavations, and the Contractor has to comply with this instruction with the minimal possible delay.

Whenever the Contractor encounters conditions to install structural steel support in the underground excavation, he has to notify to the Engineer-in-Charge immediately, who shall approve the installation.

The Contractor may, for his own purposes and at his own expense and risk, install structural steel support. However, this installation shall also be subject to the approval of the Engineer-in-Charge.

(3) Excavation shall be completed as close as possible to the "A"-line before installation of steel ribs. Steel ribs shall be placed at spacing as shown on the Drawings or as determined by the Engineer-in-Charge.

(4) Concrete blocks or steel profiles provided as footings for steel ribs, shall be founded on firm rock. Use of timber, as foot blocks shall be strictly prohibited. The footplates shall be of sufficient size and rigidity. If required, the legs of the ribs shall be anchored to the rock by the rock anchors. Where invert bracing is required, it shall be bolted securely to the lower legs of the steel rib in such a way that buckling is not induced in the steel rib by a presence of such bracing.

(5) Immediately after placing the ribs in a correct position, they shall be interconnected and braced by means of steel rods or beams in order to prevent any displacement and to maintain spacing. Use of timber spreaders shall be strictly prohibited.

(6) The space remaining between the outer flange of the steel ribs and the rock surface shall be backfilled immediately after the rib has been placed, with SFR shotcrete over the entire circumference of the steel rib in order to provide uniform load distribution. In over-excavated sections, the bulk of the void space may be filled with concrete blocks or rock pieces, followed by the SFR shotcrete. SFR shotcrete may also be required to be applied between the steel ribs and encasing them to form an arched bracing in the direction of tunnel centreline.

(7) The Contractor shall survey and record the position of all steel ribs installed in order to facilitate drilling operations. Their position and chainage shall be marked on the finished concrete lining surface.

(8) Blocking and wedges used to set the steel ribs may be timber, steel, or concrete blocks. If timber is used, it shall be placed as individual blocks with sufficient space to permit the blocks to be encased in the SFR shotcrete or concrete lining by at least the width of the wood block.

(9) Any steel ribs which have been improperly placed or which have become misalign or damaged due to negligence of Contractor shall be adjusted, repaired or replaced by the Contractor as directed by the Engineer-in-Charge.

(10) Lagging shall be placed behind the steel ribs where necessary to support the roof or the sides of the underground excavations. Where conditions require, it may, supported on the last steel rib erected, be pushed by pressing and/or hammering into the ground ahead and provide a temporary overhead protection while installing the next steel rib.

(11) The space between the rock surface and the lagging shall be backfilled with cast-in-place concrete or SFR shotcrete.

(12) Backfilling between rock and lagging with rock spalls, bracing with timber and timber lagging shall be strictly prohibited.

(13) Should Engineer-in-Charge consider additional support to be required because of buckling of steel ribs which have already been installed, or for any reason whatsoever, the Contractor shall install additional steel ribs or carry out any other repair or remedial work which Engineer-in-Charge requires.

4.7 TEMPORARY SUPPORTS

(1) Temporary supports may be used to support sections of excavation not completed to final lines and grades or to facilitate installation of the permanent support.

(2) All such temporary supports, lagging, or blocking which do not comply with requirements for primary support shall be removed by the Contractor prior to placement of the permanent support.

(3) Timber may be used in temporary supports if specifically approved by the Engineer-in-Charge.

4.8 ADDITIONAL SUPPORT MEASURES REQUIRED IN POOR REACHES OF UNDERGROUND EXCAVATIONS

In general all poor reaches shall be a supported by regular supporting measures (rock reinforcement, SFR shotcrete, lattice girders, steel ribs, etc). However, certain ground conditions may require additional support measures as well. For such situations the additional support measures as described below shall be implemented at site as per directions of Engineer-in-Charge.

4.8.1 Pre-grouting and Fore poling

(1) Poor ground condition in underground excavation may require, ahead of face stabilization/ support using pre-grouting and / or forepoling.

(2) Pre-grouting shall consist of drilling of 45 mm dia. holes (up to 10 m long) at an inclination of 10˚ to 12˚ outgoing along the periphery at a spacing of 1.5 to 3m. These holes shall be grouted using OPC/PPC/microfine/ultrafine cement grout mix with w/c ratio varying from 0.8 to 0.4, bentonite shall be added as necessary and as directed by the Engineer-in-Charge. Grouting parameters shall be adopted to suit ground conditions as determined by Engineer-in-Charge.

(3) Pre-grouting with colloidal silica: In case of very poor geological conditions and heavy ingress of water, pregrouting with colloidal silica shall be carried out at a high pressure (>5 Mpa) as directed by Engineer-in-Charge. Pre-grouting with colloidal silica consist of drilling of 57 mm dia, 15-30 m long (with overlapping of 5 m) at an inclination of 10˚ to 12˚ outgoing all along the periphery and at the face (if required) at the spacing of 2 to 3 m. Appropriate steel pipes/sleeves may also be required if necessary .

Colloidal silica shall be of reputed make and duly approved by Engineer-in-Charge having viscosity of 5mPa-s and particle size of 0.016 µm.

If required, pre-grouting with microfine/ultrafine cement shall be carried out prior to pre-grouting with colloidal silica with the approval of Engineer-in-Charge. In this case pre-grouting with microfine/ultrafine cement grout will fill

the joints with large apertures. Thereafter pregrouting with low viscous colloidal silica grout fills the finer joints and the joints filled with clay and silts.

Suitable dispersing agent with dosage 1.5-2% of cement weight shall be used wherein ultrafine cement grout is resorted in pre-grouting, for which no additional payment shall be made. However, trial mixes should be carried out for grout optimization & its effect.

(4) Fore poling shall consist of installing 32 mm dia. reinforcing bars (up to 10 m long) at a close interval of 200 to 300 mm along the periphery of the tunnel inclined 10˚ to 15˚ outwards from the periphery by hammering or by drilling and grouting

(5) In case drilling is required for installation of fore poles, the drilled hole shall be fully grouted after installing the fore pole.

(6) Specialized sub-contractor/agency shall be deployed by the contractor for handling pre-grouting and fore poling to avoid cavity formation.

4.8.2 Pipe roofing

(1) When ground conditions in tunneling are such that face cannot be supported by regular support like SFR shotcrete, rock bolts, steel ribs, pre-grouting and/or fore poling, the special technique of pipe roofing shall be required to be implemented as directed by Engineer-in-Charge.

(2) The pipe roofing work shall be carried out by a specialized agency.

(3) Depending upon the ground condition drainage in advance of rock mass ahead of the face with long drainage holes may be required.

(4) Pipe roofing consists of high tensile seamless pipe casing (maximum 21 m long) driven into the medium using a Symmetrix drilling system (or equivalent), using sacrificial drill bits. The pipe diameter shall be of 88.9 mm with minimum thickness as 5.49 mm. Alternate perforated pipes and plane pipes each of 3 m length are connected to each other either through a weld connection (fully butt) or through threading system, to create a positive connection. The pipes are spaced at 300 to 500 mm center to center along the periphery of the tunnel. The pipes are inclined 5˚-12˚ outward from the periphery. The perforated pipes are then grouted in stages of 3 to 6 m using packer in each stage, using cement grout (w/c ratio varying between 0.8 to 0.4), at a pressure of 3 to 4 Kg/cm^2. The entire system is required to form an umbrella ahead of face so that safe further excavation can be carried out.

(5) Excavation of tunnel may be required to be performed in parts / or multi-segmental excavation to make space for installation of one steel rib at a time.

4.8.3 Pre-drainage holes

Pre drainage holes of 45 mm dia are provided prior to the excavation in the poor reaches of rock, where there is heavy ingress of water. Pre drainage holes are provided as shown in the construction drawings or as directed by Engineer-In-Charge.

4.9 MEASUREMENT AND PAYMENT

4.9.1 General

(1) The estimated quantities given in the Bill of Quantities for each type of rock supports specified in this Section are not to be considered as an accurate indication of the quantity of work, since actual amount of supports installed will be determined by the geotechnical conditions encountered in the course of work. The Contractor shall not be entitled to any extra payment over and above the Unit Prices entered in the Bill of Quantities by reason of changes to the actual quantity of each support type installed.

(2) The prices entered in the Bill of Quantities shall be applied regardless if the work is performed on the surface or underground, regardless of the excavation method used, full-face or partial excavation (e.g. top heading and benching) or mechanical excavation by raise boring, whether the rock supports are placed within the heading or in the rear zone. For the definitions of the various zones mentioned above see the Section "Underground Excavation".

(3) Extensions/hooks provided on reinforcing elements shall be paid separately at unit rates indicated in Bill of Quantities.

4.9.2 Rock Bolts, Rock Anchors and Grouted Anchor Bars

4.9.2.1 Testing and Monitoring of Reinforcing Elements

(1) Payment will be made for the supply and installation of all rock reinforcing elements used in pull-out tests providing always that the rock reinforcement tested comply with these Specifications. Measurement for payment and payment will be as for rock reinforcement used for the Permanent Works.

(2) Measurement for payment for supplying and installing load cells where directed by the Engineer-in-Charge will be as provided in the relevant section of these specifications.

(3) Measurement for payment for testing of rock reinforcing elements will be made of the no. of tests performed on rock reinforcing elements installed as specified herein above or as required by Engineer-in-Charge. The payment will be made at the Unit Price entered in the Bill of Quantities for performing rock reinforcing elements tests complete in all respects and as specified herein above.

4.9.2.2 Expansion Shell Rock Bolts

(1) Measurement for payment for supply and installation of expansion shell rock bolts will be of the length of rock bolts of various lengths and diameters provided in the Bill of Quantities.

(2) Payment will be made at the appropriate Unit Price per linear meter entered in the Bill of Quantities, which shall include the entire cost of:

a) Purchase and delivery to the Site with all necessary accessories

b) Storage and protection at the Site

c) Drilling of the holes

d) Installation of the rock bolts with all accessories

e) Stressing

f) Furnishing of grout materials and grouting.

(3) This payment will be made only for expansion shell rock bolts installed in the works and approved by the Engineer-in-Charge.

4.9.2.3 Resin Grouted/ Cement grouted Rock Bolts

(1) Measurement for payment for supply and installation of resin grouted/ cement grouted rock bolts will be of the length of rock bolts of various length and diameters provided in the Bill of Quantities.

(2) Payment will be made at the appropriate Unit Price per linear meter entered in the Bill of Quantities, which shall include the entire cost of:

a) Purchase and delivery to the Site with all necessary accessories including resin capsules.

b) Storage and protection at the Site including resin capsules.

c) Drilling of the holes

d) Providing and installation of quickset resin cartridges

e) Installation of the rock bolts with all accessories

f) Stressing

g) Supplying of grout materials and grouting.

(3) This payment will be made only for resin grouted/ cement grouted rock bolts installed in the works and approved by the Engineer-in-Charge.

4.9.2.4 Rock Anchors

(1) Measurement for payment for rock anchors will be of the total length of anchors installed and approved by the Engineer-in-Charge.

(2) Payment will be made at the Unit Price per linear meter entered in the Bill of Quantities, which shall include the entire cost of:

a) Equipment and materials for erection of working platforms

b) Drilling of the holes

c) Washing and water-pressure testing (as required)

d) Furnishing and installing of steel bars, couplers, plates and nuts

e) Furnishing of grout materials and grouting.

(3) Additional payment will be made for drilling with core recovery when such drilling has been ordered by the Engineer-in-Charge for exploratory purposes. The Unit Price for core recovery drilling will be paid per linear meter of drill hole as entered in the Bill of Quantities, and shall include the entire cost of equipment and labour necessary to obtain, store and protect the cores.

(4) Additional payment will be made for consolidation grouting and re-drilling of a hole when such treatment has been ordered by the Engineer-in-Charge. Payment will be made as per the Section “Drilling, Grouting and Pressure relief hole".

4.9.2.5 Water Expandable Friction Anchors

(1) Measurement for payment for water expandable friction anchors will be of the total length installed and approved by the Engineer-in-Charge.

(2) Payment will be made at the Unit Price per linear meter entered in the Bill of Quantities, which shall include the entire cost of:

a) Drilling of the holes

b) Washing and cleaning of the holes

c) Furnishing and installing water expandable friction anchors as per the guidelines of the manufacturer and as directed by the Engineer-in-Charge.

4.9.2.6 Self Drilling Hollow Core Anchors

(1) Measurement for payment for Self Drilling Hollow Core Anchor will be of the total length installed and approved by the Engineer-in-Charge.

(2) Payment will be made separately for each bar diameter at the Unit Price per linear meter entered in the Bill of Quantities, which shall include the entire cost of:

a) Furnishing and installation of Self Drilling Hollow Core Anchor with all accessories of the holes

b) Stressing

c) Furnishing of grout materials and grouting.

4.9.2.7 Self Drilling type Glass Fiber reinforced Plastic Rock Anchors

1) Measurement for payment for Self drilling type glass fiber reinforced plastic rock anchors will be of the total length installed (incld. projected length) and approved by the Engineer-in-Charge.

2) Payment will be made separately for each bar diameter at the Unit Price per linear meter entered in the Bill of Quantities, which shall include the entire cost of furnishing and installation of Self drilling type glass fiber reinforced plastic rock anchors including grouting, stressing complete with all accessories of the anchors and stressing.

4.9.2.8 Grouted Anchor Bars

(1) Measurement for payment for grouted anchor bars will be of the total length of the bars installed and approved by the Engineer-in-Charge.

(2) Payment will be made at the Unit Price per linear meter entered in the Bill of Quantities, which shall include the entire cost of:

a) Drilling of the holes

b) Washing and cleaning of the holes

c) Furnishing, cutting, and installing reinforcing steel bars

d) Furnishing of cement mortar and filling the drill holes.

4.9.2.9 Rock Bolt / Rock Anchor Extensions into Concrete

When a rock bolt/rock anchor is extended into concrete through welding, such extension shall be paid as weight of extension piece in Kg. Welded L-shaped piece of the grouted anchor bar shall also be measured and paid per kg weight installed.

4.9.2.10 Exclusions

No extra payment will be made for the following:

a) Loose and rejected elements, elements which fall out during trimming, slashing or widening, elements which are otherwise damaged or displaced as a result of Contractor's operations. The Contractor shall replace such elements at his own expense. If the rock condition in the underground excavation require an immediate installation of the elements in the heading face, which will be destroyed later as the excavation advances, deviation from this rule may be granted after a mutual agreement between the Engineer-in-Charge and the Contractor.

b) Reinforcing elements which had to be installed as a consequence of Contractor's non-compliance with the approved drilling and blasting methods as specified in the Section "Underground Excavation".

c) No extra payment will be made for installation of temporary rock reinforcing elements (to be removed subsequently for widening, etc.) in temporary excavations (e.g. multi drifts, etc.).

d) The threaded part of the rock bolt/ rock anchor protruding outside the hole shall not be measured for payment. The cost of the same deemed to be included in the unit cost of the rock bolt/rock anchor.

e) Unit Prices for rock reinforcing elements in underground excavations apply regardless of the location or accessibility.

4.9.3 Mesh Reinforcement

4.9.3.1 Chain Link Fabric

(1) Measurement for payment for chain link fabric will be of the net area (without overlaps) actually installed.

(2) Payment will be made at the Unit Price per square meter entered in the Bill of Quantities, which shall include the entire cost of supply and installation of chain link fabric including overlaps, and the provision of all necessary accessories for fixing, such as steel pins and extra plates and nuts for fastening to rock reinforcement.

4.9.3.2 Welded Wire Mesh

(1) Measurement for payment for wire mesh will be of the net area (without overlaps) actually installed.

(2) Payment will be made at the Unit Price per square meter entered in the Bill of Quantities, which shall include the entire cost of supply and installation of wire mesh, including overlaps, and the provision of all necessary accessories for fixing, such as steel pins and extra plates and nuts for fastening to rock reinforcement.

4.9.4 Structural Steel Supports

4.9.4.1 Steel Ribs and Lattice Girder

(1) Measurement for payment for supply and installation of lattice girder and steel ribs will be of the weight of lattice girder and steel ribs installed and approved by the Engineer-in-Charge.

(2) Payment will be made at the Unit Price per metric ton entered in the Bill of Quantities, which shall include the entire cost of:

a) Supply, manufacture and delivery to the Site with all necessary accessories required for installation

b) Storage and protection at the Site

c) Transport to the place of erection and erection

d) Installation of all foot plates, wall plates, ties, bolts, nuts, cross-bracing and all other accessories, including all permanent or temporary welding

e) Backfilling with shotcrete, concrete blocks, or any other material approved by the Engineer-in-Charge, including cement and additives, except in accepted geological overbreak in which case the backfilling will be paid separately as stipulated in the Section "Underground Excavation"

f) Surveying and marking the position and chainages of lattice girder, ribs on the concrete lining.

(3) For measurement and payment purposes, the weight of the lattice girder and steel ribs will be based on the unit weight of the steel profiles per linear meter, as stated on the certified copies of manufacturer's reports which the Contractor have submitted to the Engineer-in-Charge, or, in absence of such reports, by direct weighing at the Site. The weight of steel accessories shall be on the actual.

4.9.4.2 Lagging

(1) Separate Unit Prices are provided in the Bill of Quantities for steel lagging and concrete lagging.

(2) Measurement for payment and payment for steel lagging will be of the weight of lagging.

(3) Payment for supply and installation of steel lagging will be of the weight of lagging actually installed and approved by the Engineer-in-Charge. Payment will be made at the Unit Price per metric ton entered in the Bill of Quantities, which shall include the entire cost of:

a) Supply, manufacture and delivery to the Site with all necessary accessories required for installation

b) Storage and protection at the Site

c) Transport to the place of installation and installation of lagging

d) Over-excavation beyond the theoretical excavation line (A-Line) required for placing of lagging

e) Backfilling with concrete, grout, or SFR shotcrete, including cement and additives, except in accepted geological overbreak in which case it will be paid separately as stipulated in the Section "Underground Excavation".

(4) For the measurement and payment purposes, the weight of the steel lagging will be based on the unit weight of the steel profile per linear metre, as stated on the certified copies of manufacturer's reports which the Contractor has submitted to the Engineer-in-Charge, or, in absence of such reports, by direct weighing at the Site.

(5) Measurement and payment for furnishing and installation of precast concrete lagging will be of the volume of lagging actually installed and approved by the Engineer-in-Charge. Payment will be made at the Unit Price per cubic meter entered in the Bill of Quantities, which shall include the entire cost of:

a) Design and manufacture of concrete lagging including supply of cement aggregate, additives, steel reinforcement and formwork complete

b) Storage, transport to the place of installation and installation of lagging

c) Over excavation beyond the theoretical excavation line ("A"-line) required for placing of lagging

d) Backfilling with concrete, grout, or SFR shotcrete, including cement and additives, except in accepted geological overbreak in which case it will be paid separately as stipulated in the Section "Underground Excavation".

4.9.4.3 Exclusions

(1) Rock reinforcement installed to hold the installed steel ribs/lattice girder in position will be measured and paid under relevant items in the Bill of Quantities.

(2) Shotcrete applied between, or encasing the steel ribs/lattice girder will be measured for payment and paid for as stipulated in the Section "Shotcrete".

(3) No extra payment will be made for the following:

a) Structural steel supports, which have to be replaced, repaired or re-erected as a result of Contractor's operation. The Contractor shall rectify or replace such steel ribs and lagging at his own expense.

b) Structural steel supports which have to be installed as a consequence of the Contractor's non-compliance with the approved drilling and blasting methods as specified in the Section "Underground Excavation".

c) Weight difference in case the Contractor prefers installation of heavier or stronger steel supports or for additional ribs due to closer spacing than those ordered by the Engineer-in-Charge.

d) Transport from the underground working zone back to the storage site, of any unused structural steel supports and further storage to and/or removal from the Site.

e) Unused concrete lagging.

f) Unused steel lagging.

4.9.5 Temporary Supports

No extra payment will be made for furnishing, erection, and removing of temporary supports of any kind and the entire cost thereof shall be included in the Unit Prices for other items of the Works.

4.9.6 Payments for additional support measures

4.9.6.1 Pre-grouting

Measurement for payment and payment shall be as under:

1) Drilling of hole of 45 mm dia for normal pre-grouting and 57 mm dia for pre-grouting with colloidal silica per meter length of hole.

2) Grouting operation in number. Each hole grouted complete shall be considered as one operation.

3) Cost of grouting material (except for colloidal silica) as provided in Section B.7 ‘Drilling, Grouting & Pressure Relief Holes’.

4) Measurement for payment for colloidal silica used for pre-grouting shall be by weight and payment will be made at the unit price per metric ton entered in the Bill of Quantities, which shall include the entire cost of provision, delivery, transportation, storage and mixing, and comply with all requirements specified.

4.9.6.2 Fore poling

Measurement for payment and Payment for fore poling shall be made as under

(a) Drilling & installation/driving of fore pole per meter including cost of reinforcing bars/fore pole.

(b) Grouting operation in number. Grouting operation in each fore pole shall be considered as one operation.

(c) Cost of grouting material as provided in section B.7 'Drilling, Grouting & Pressure Relief Holes'.

4.9.6.3 Pipe roofing

(1) Measurement for payment for pipe roofing will be of the total length of the pipes installed.

(2) Payment will be made at the Unit Price per linear meter entered in the Bill of Quantities, which shall include the entire cost of:

a) Drilling of the holes

b) Washing and cleaning of the holes

c) Supply and installing of pipes and bits

d) Grouting operations except the cost of cement.

(3) Cost of grouting material as provided in section B-7 'Drilling, Grouting & Pressure Relief Holes'.

(4) Payment of excavation shall be made at unit price per cubic meter for the appropriate excavation class as entered in the Bill of Quantities.

4.9.6.4 Pre-drainage holes

1) Measurement for drilling of pre drainage holes will be the total length of drilling in meter.

2) Payment will be made at the Unit Price per linear meter entered in the Bill of Quantities.

END OF SECTION B.4

SECTION B.6

EMBANKMENT CONSTRUCTION AND BACKFILL

List of Contents

SECTION B.6

EMBANKMENT CONSTRUCTION AND BACKFILL

6.1 SCOPE OF WORK

1) This Section covers all labour, materials, equipment and services related to the foundation preparation and construction of the earth and rockfill coffer-dykes, backfill below, around and above structures, and other fill which the Contractor shall execute under this Contract.

2) Most of the embankment fills / backfill materials will be available from the required excavations for the Permanent and Temporary Works. The Section "Surface Excavation" covers these excavations.

3) The work includes processing if required, placing and spreading, compaction, and sprinkling with water as needed for the materials specified hereinafter.

4) The coffer dykes embankment shall include the following material zones as shown on the Construction Drawings:

Impervious Core	:	Zone 1
Graded filter	:	Zone 2
Random Rock fill	:	Zone ~~43A~~
Compacted Rock fill	:	Zone 3B
Dumped Rip-rap	:	Zone 3A~~4~~

5) The Contractor shall be required to undertake related works of the seepage cut-offs, the flood protection and dewatering during construction specified in relevant sections.

6) The embankments / backfill shall be constructed to the lines, grades and dimensions as shown on the Construction Drawings, provided that at any time before or during construction the Engineer-in-Charge may vary the dividing lines between zones of the embankment, the crest elevation of any embankment, inclination of the slopes, as well as the thicknesses of layers specified herein, or order any other modification which he deems to be necessary.

7) The slopes exposed to permanent view shall be levelled according to current construction practice.

8) The approval given by the Engineer-in-Charge to the Contractor's methods and equipment shall not relieve the Contractor of his full responsibility for the proper and safe execution of the coffer dyke embankment or backfill works, or of liability for injuries to, or death of persons, or any obligations under this Contract.

6.2 SUBMITTALS

6.2.1 Submittals before construction

1) Not less than 56 days before the embankment placement begins for coffer dykes, The Contractor shall prepare and submit a detailed planning for the construction of the cofferdyke and pre-cofferdyke, taking into account the monsoon season and activities related to construction of deep seepage cut offs in foundation.

2) Not less than 56 days prior to the commencement of any operations for obtaining material for embankment, the Contractor shall submit to the Engineer-in-Charge for approval details of the proposed methods, procedures, source and equipment that he intends to use to obtain material of the required quality, size and gradation as specified for each zone of the cofferdyke embankment.

3) Not less than 56 days before the embankment placement begins, the Contractor shall submit detailed information on his proposed methods for placing and compacting material in each of the embankment zones to the lines, grades and tolerances specified in this Section. All details, specifications and number of each proposed equipment shall be indicated in the technical report, as well as the type and number of special equipment to be used in places inaccessible for the normal compacting equipment.

4) Similar details (as detailed in above paras) with respect to backfill/ fill works shall also be submitted by the contractor not less than 56 days before the start of backfill/ fill works.

6.2.2 Submittals during construction

1) The Contractor shall submit all results of material tests carried out prior to, and during the placement of the embankment material. These test results shall be submitted within 7 days after completion of the tests. In addition, quarterly reports with format and content approved by the Engineer-in-Charge shall be submitted by the Contractor, summarising fill placement and results of placement control.

2) The Contractor shall submit at monthly intervals the updated, detailed embankment construction programme, progress report and drawings depicting the embankment.

6.3 PLANTS AND EQUIPMENT

6.3.1 Compacting Equipment

1) The type of the compacting equipment used for the rockfill coffer dykes and other embankments/ backfill shall be proposed by the Contractor and approved by the Engineer-in-Charge after the compaction tests have demonstrated the effectiveness of the equipment.

2) Vibratory rollers for compacting rockfill shall be of the smooth steel-drum, either self-propelled or towed type. The total static weight shall be not less than 10 tons. The drum shall be equipped with suitable devices to prevent accumulation of material during operation. Operating frequency shall be between 1,100 and 1,500 vibrations per minute. Dynamic force shall be not less than 20 tons at 1,500 vibrations per minute.

3) Vibrating plate mechanical tampers weighting 600-800 kg will be required for compacting fills not accessible to larger items of compacting plant. The tampers shall be capable of compacting a layer thickness of 50 cm.

4) Compaction of material in areas where it is impracticable to use a roller or larger tamper shall be performed by approved hand power tampers.

6.3.2 Materials Processing Plant

1) The Contractor shall provide and maintain in perfect working conditions an adequate processing plant capable to deliver the quantity, quality and gradation of processed materials required for the cofferdykes as shown on the drawings.

2) Preparation processes required to ensure the quality and gradation of the materials shall include, but not be limited to, the combination of sieving, crushing, washing, separation and re-mixing of materials.

3) The plant capacity shall be determined by the Contractor taking into account the peak demand for materials required by the approved construction schedule.

6.3.3 Transportation Equipment

1) The Contractor shall provide and maintain in perfect working condition adequate no. of transportation equipment capable to transport all types of materials required for the construction of the coffer dyke and other embankments or backfills.

2) This transportation equipment, trucks, conveyor belts, etc., shall have the necessary capacity to transport any kind of material from the place of its origin or from stockpiles to the designated final location as required for the proper execution of the work. The number and capacity of the items of transport equipment shall be sufficient to ensure the construction schedule requirements are met, with an adequate allowance for reserve.

3) The material transporting methods and placement procedures shall be such that segregation or separation of material components during transport or during unloading and spreading is prevented.

4) Spreading and grading equipment shall be provided as required.

5) The Contractor shall provide and maintain in perfect working conditions adequate equipment for spreading and grading of materials brought to the embankments in accordance with these Specifications and capable to fulfil the approved construction schedule.

6) Motor graders, bulldozers, and power shovels shall be available in sufficient numbers for spreading and placing the embankment materials.

6.3.4 Water Supply and Sprinkling Equipment

The Contractor shall provide and maintain in perfect working conditions suitable equipment such as pumps, tanks, hoses, and sprinkler trucks to provide water for dust prevention and for watering of the rockfill, amounting to 200 litre water per m^3, or as directed by the Engineer-in-Charge.

6.4 CONTRACTOR'S LABORATORY AND TESTING

6.4.1 Laboratory and Testing Equipment

1) The Contractor shall build, equip, operate, and maintain an adequate field laboratory for sampling and testing of materials as stipulated in the Section "Site Installations". The laboratory shall be run by Contractor's personnel experienced in sampling and testing of materials, and quality control. All sampling and testing to be undertaken shall be under the direct supervision of the Engineer-in-Charge.

2) Concerning the construction of the earth / rockfill coffer dyke, and other embankments and backfills, the Contractor's laboratory and its staff shall carry out the following:

   a) Organisation and evaluation of the tests
   b) Control of the construction materials
   c) Control of the placing of material in the embankments,

3) The testing of materials shall be performed both in the excavation and quarry areas and on the embankments. The Contractor shall plan his testing activities in such a way that a minimum interference with the ongoing construction work is caused. However, it may be sometimes necessary to reduce or stop the construction if the proper performance of the tests so dictates.

4) The Contractor shall be able to perform with its equipment the following tests in accordance with the Standards indicated:

Grain size distribution	IS 2720 (4) or ASTM D 422
Hydrometer analysis	IS 2720 (4) or ASTM D 422
Atterberg's limits	IS 2720 (5) or ASTM D 4318
Shear Strength Test	IS 2720 (XII)
Swelling Index Test	IS 2720 (XL)
Shrinkage Test	IS 2720 (6)
Moisture content	IS 2720 (2) or ASTM D 2216
Specific gravity & absorption	IS 2720 (3) or ASTM C 127
Specific gravity of soils	IS 2720 (3) or ASTM D 854
Compaction test (Proctor)	IS 2720 or ASTM D 698
Relative density	IS 2720 or ASTM D 4254
Field density test	IS 10379 or USBR Earth Manual E-24

Los Angeles Abrasion test	ASTM C 535
Soundness test	IS 2386 (5) or ASTM C 88
Point load strength	IS 8764
Compressive strength	ISRM
Basic friction angel of rockfill	ISRM

5) Further, equipment shall be available to perform field density and field permeability tests.

6) Material passing the 63.0 mm size sieve shall have its grain size distribution determined by sieve analysis according to IS 2720. Particles larger than 63.0 mm shall be removed and graded by weight on site.

6.4.2 Material Testing

Before placement of any embankment material, at least 2 series of the applicable tests listed in S. No (4) of the Clause 6.4.1 above shall be performed on all materials of the different zones. During placement of the embankment, tests shall be carried out as instructed by the Engineer-in-Charge.

6.4.3 Tests on Embankment

1) Tests shall be conducted on embankment to enable the Engineer-in-Charge to confirm or modify the layer thicknesses and/or the number of compaction passes at specified velocity and vibration ranges, and the required volume of water to be used for placement.

2) In case of changes in the quarry or borrow area, changes in characteristics of material, or changes in the construction equipment, the Contractor shall, upon request of the Engineer-in-Charge, perform new test sections.

6.5 CONSTRUCTION MATERIALS

6.5.1 General

1) Materials originating from the excavation of tunnels and river bed excavations shall generally be used for zone 4~~3A~~ & 3B for embankment construction. Excavation and haulage procedures, drilling and blasting patterns etc. shall be such to ensure that a maximum amount of the material excavated for these structures and Works will be suitable for construction of the dyke.

2) Material for zone 1 shall be brought from the specified borrows area.

3) Part of the material for all the zones may also be obtained from borrow areas and quarries as already identified or as may be designated in the course of the work and approved by the Engineer-in-Charge. Contractor's operations in the quarries and borrow areas shall be as specified in the Section "Surface Excavation".

4) Coffer Dyke construction materials from the required excavation areas, from approved quarries or from borrow areas shall be brought to the embankment directly, stockpiled or prepared by processing to meet the requirements specified in this Section, as proposed by the Contractor and approved by the Engineer-in-Charge.

5) Construction materials shall be obtained, transported, prepared, processed, and stockpiled in such a manner that embankment construction can proceed without delay. The Contractor shall select his plant and organise his operations taking fully into account all delaying factors such as monsoon season rains and their effects, floods, groundwater levels, construction phases etc., so that the approved construction schedule is kept.

6) The Contractor's attention is drawn to the provisions contained in the Section "Surface Excavation" referring to the excavated materials and the disposal thereof.

7) The characteristics of the placed materials shall conform to the requirements stipulated herein. All such requirements stipulated in the following clauses refer to the materials after placing and compaction in the final locations.

6.5.2 Material properties

1) There are no specific requirements for material and gradation of Zone 43A. The Contractor may select Zone 43A material as he requires diverting the river.

2) Materials for zone 3B shall comprise of unweathered or slightly weathered rock obtained from the excavations. Rock of unsatisfactory characteristics or containing organic material, soil or other unsuitable material will not be accepted.

3) Following additional requirements shall be fulfilled for zone 3B material:

Maximum size	80 cm
Amount passing 40 mm	10-45 %
Amount passing 4.75 mm	< 20 %
Amount passing 0.075 mm	< 5 %

4) The semi-pervious to impervious material for Zone 1 consists of sandy clay , silty clay to clayey, which can be obtained from overburden, natural deposits and in situ weathered rock in the required excavation or approved borrow areas.

5) The filter material for zone 2 shall consist primarily of crushed unweathered rock obtained from the required excavation conforming to Indian Standards. The material for these zones shall satisfy the filter criteria given in the USBR earth manual.

6) The material for dumped riprap shall be locally available selected boulders and placed by most appropriate methods so as not to damage the embankment. No compaction shall be required.

6.5.3 Foundation Preparation

1) Unless otherwise directed by the Engineer-in-Charge, foundation preparation is not required for Zone 4~~3A~~.

2) Rock blocks and boulders, where directed, shall be removed or broken into pieces for reuse or disposed as directed by Engineer-in-Charge.

3) No embankment material shall be placed in any section until the foundation of this section has been dewatered (except for the portions where underwater placement is required), adequately prepared, and approved by the Engineer-in-Charge.

4) Immediately before the foundation receives embankment, it shall be compacted with 6 passes of a 10 t vibrating roller or equivalent.

6.6 EXECUTION

The coffer dykes shall be constructed in stages commensurate with the construction programme for the seepage cut off works specified in relevant sections.

1) The distribution and gradation of the materials throughout the coffer dykes earthfill shall be as shown on the drawings or as directed by Engineer-in-Charge. The fills shall be free from lenses, pockets, streaks or layers of materials differing substantially in texture or gradation from the surrounding material. The combined excavation and placing operations shall be such that the materials when compacted in the earthfill will be blended sufficiently to produce the best practicable degree of compaction and stability.

2) Successive loads of materials shall be dumped on the coffer dykes earthfill so as to produce the best practicable distribution of the material. For this purpose, the locations in the earthfill where the individual loads shall be deposited may be designated with a view to ensure that the most impervious materials shall be place in the central core of the earthfill and the more pervious material shall be placed on the outer shoulders so that the permeability of the fill will be increased towards the upstream and downstream slopes of the earthfill.

3) No stone pebbles or rock fragments, having maximum dimensions of more than 10cms shall be placed in the coffer dykes earthfill. Such stones and pebbles shall be removed either at the borrow pit or after being transported to the embankment but before the materials in the earthfill are rolled and compacted.

4) If in the opinion of the Engineer-in-Charge the surface of prepared foundation or the rolled surface of any layer of coffer dykes earthfill is too dry or smooth to bond properly with the layer of material to be placed thereon, it shall be moistened or worked with harrow, scarified or other suitable equipment in an approved manner to a sufficient depth to provide a satisfactory bonding surface before the next succeeding layer of earthfill materials is placed. If the rolled surface of any earthfill is found to be too wet for proper compaction of the layer of earthfill material to be placed thereon, it shall be raked up and allowed to dry, or be worked with harrow, scarier or any other suitable equipment to reduce the moisture content to the required amount, and then it shall be compacted before the next succeeding layer of earthfill material is placed.

6.6.1 Underwater Placement (Zone 4~~3A~~)

1) No special compaction is required for the construction of this Zone, however the surface shall be graded to prevent the formation of pools of water.

2) The material shall be dumped and graded simultaneously in order to arrest the saturation of the material.

6.6.2 Construction of Rockfill (Zone 3B)

1) Zone 3B rockfill shall be placed normally from one abutment to the other, in layers of thickness not exceeding 1.0 m and rolled with at least six (6) passes. Sluicing with up to 100-200 litres/m^3 will be required.

2) The vibratory roller shall not be operated at speeds in excess of 5 km/hour. As a general rule, the direction of the roller travel shall be reversed after each completed pass.

3) Zone 3B shall be compacted to at least 80% relative density for which requisite testing shall be carried out as per USBR "Earth Manual"

6.6.3 Graded Filter (Zones 2)

1) The gradation of the filter layers shall be chosen so to meet the following criteria with respect to the gradations of the adjacent layers:

a) $$\frac{D_{15}\ \text{of the filter}}{D_{85}\ \text{of the base material}} < 5$$

The D_{15} size of filter should not be larger than five times the D_{85} size of the protected soil.

b) $$\frac{D_{15}\ \text{of the filter}}{D_{15}\ \text{of the base material}} > 4 \text{ and } < 20$$

The 15% size of the filter, D_{15} (i.e. the particle size which is coarser than the finest 15% of the soil) should be at least four times as large as D_{15} size of soil being protected by the filter.

c) $$\frac{D_{50}\ \text{of the filter}}{D_{50}\ \text{of the base material}} < 25$$

d) The gradation curve of the filter material should be nearly parallel to the gradation curve of base material.

2) The Zone 2 shall have a horizontal permeability of about 10^{-5} m/s.

6.6.4 Construction of Impervious fill (Zone 1)

1) The material in Zone 1 shall be placed in layers of thickness not exceeding 40 cm, when un-compacted. This thickness shall be compacted to 30 cm thickness with at least 6 passes of vibratory roller (Min. 10 T weight) or as required by Engineer-in-Charge. The layer thickness shall be subject to modification by the Engineer-in-Charge if the tests on the cofferdyke/ embankment so require.

2) The material shall be placed in the earth fill in continuous horizontal layers, not exceeding the specified thickness after being rolled unless specifically authorized by the Engineer-in-Charge. The material shall be compacted to achieve Maximum Dry Density (MDD) of 95% of the standard proctor density arrived at after laboratory tests. During construction, a small traverse slope from centre towards edges should be given to avoid pools of water forming due to rains.

3) The levels of Zone 1, Zone 2 and Zone 3B shall be maintained approximately equal during construction.

4) The distribution and gradation of the materials throughout the cofferdyke/ embankment shall be as shown on the drawings or as directed by Engineer-in-Charge. The fills shall be free from lenses, pockets, streaks or layers of materials differing substantially in texture or gradation from the surrounding material. The combined excavation and placing operations shall be such that the materials when compacted in the cofferdyke/ embankment will be blended sufficiently to produce the best practicable degree of compaction and stability.

5) Successive loads of materials shall be dumped on the cofferdyke/ embankment or earth fill so as to produce the best practicable distribution of the material. For this purpose, the locations in the cofferdyke/ embankment where the individual loads shall be deposited may be designated with a view to ensure that the most impervious materials shall be place in the central core of the cofferdyke/ embankment and the more pervious material shall be placed on the outer shoulders so that the permeability of the fill will be increased towards the upstream and downstream slopes of the cofferdyke/ embankment.

6) No stone pebbles or rock fragments, having maximum dimensions of more than 10 cm shall be placed in the earth fill. Such stones and pebbles shall be removed either at the borrow pit or after being transported to the cofferdyke/ embankment but before the materials in the cofferdyke/ embankment are rolled and compacted.

7) If in the opinion of the Engineer-in-Charge the surface of prepared foundation or the rolled surface of any layer of earth fill is too dry or smooth to bond properly with the layer of material to be placed thereon, it shall be moistened or worked with harrow, scarified or other suitable equipment in an approved manner to a sufficient depth to provide a satisfactory bonding surface before the next succeeding layer is placed. If the rolled surface at any level is found to be too wet for proper compaction of the layer of earth fill material to be placed thereon, it shall be raked up and allowed to dry, or be worked with harrow, scarier or any other suitable equipment to reduce the moisture content to the required amount, and then it shall be compacted before the next succeeding layer of earth fill material is placed.

6.6.5 Concrete Facing

Concrete facing may be provided on the face of the cofferdyke as per construction drawings or as directed by Engineer-in-Charge. The concrete shall be of grade M25/A40 and shall be as per Section B.9 of this Technical Specifications.

6.6.6 Rip Rap

6.6.6.1 Riprap material

(a) Riprap material shall be sound, durable blocky fragments of higher quality and shall be free of silt, clay, organic material, and debris.
The overall material shall be predominantly angular and blocky in shape such that the maximum dimension is not greater than three times the minimum dimension and shall be of uniform gradation so as to produce a dense in-place protection for the upper side slopes, with voids between the large stones filled, and the finished facing presenting a uniform, well covered appearance. Care shall be exercised by the Contractor so that rocks of same colour are not concentrated in one spot, but are well mixed throughout the finished surface area. Material shall have a gradation such that the largest dimension of the maximum rock pieces is 90 cm. Oversize material shall be processed to required size before use. The block dimensions shall be as indicated below:

(i) IS Sieve Designation Riprap (Rockfill 0/900)
D_{max} (less than 10% D_{max}) 900 mm
D_{min} (less than 10% D_{min}) 600 mm

(b) Stones used shall have sufficient strength to withstand their transport and placement. The blocks shall be free from cracks and have good matrices quality.

(c) Riprap shall remain stable in contact with air and water. It shall withstand drying and wetting cycles and the presence of swelling or evolving elements shall not be permitted.

(d) Riprap shall be insensitive to freezing and thawing cycles. It shall have very low porosity and be free from micro-cracks.

(e) The hardness of the blocks shall be sufficient to withstand abrasion by water with sediment loads.

6.6.6.2 Placing of Riprap

Stone for riprap shall be placed as indicated in approved drawings in such a manner as to produce a well-graded mass of rock with the minimum practicable percentage of voids, and shall be constructed within the specified tolerance to the lines and grades.

6.7 BACKFILL

6.7.1 General

1) The Contractor shall place and compact backfill of the specified type to the lines, grades and dimensions in the locations shown on the Construction Drawings, behind structures, in over-break, over-excavation, or where directed by the Engineer-in-Charge.

2) Material to be used as backfill shall be subject to the consent of the Engineer-in-Charge, and shall be, as far as possible, obtained from required excavation for Permanent or Temporary Works.

3) The distribution and gradation of backfill material shall be such that the finished backfill is free from lenses, pockets, streaks or layers of material differing substantially in texture or gradation from the surrounding material. Backfill material shall include no organic matter and the Engineer-in-Charge reserves the right to reject entire loads of material, which contain high percentage of organic matter, which can not be satisfactorily removed.

4) The traffic over the backfill shall be adequately controlled to avoid rutting or cutting the placed backfill. Each load of material shall be placed in such a way as to achieve the best practicable distribution of material. The operation of trucks and heavy equipment shall be restricted near buildings, walls, piers or other facilities to avoid damage to any Permanent Works.

5) Any material which, in the opinion of the Engineer-in-Charge is objectionable or inadequate shall be removed to the Contractor's own cost. If the compacted surface of any layer of material is determined to be too smooth and impermeable to bond properly with the succeeding layer, it shall be loosened by harrowing or by other approved method before the succeeding layer is placed thereon.

6) Backfilling adjacent to the concrete structures 1m and over in height shall not commence before 7 days from concrete placement. Prior to backfilling, forms shall be removed and the area cleaned of trash and debris. All Works to be covered by backfill shall be inspected and approved by the Engineer-in-Charge prior to start of backfilling. Backfill shall be placed in proper sequences so that no differential earth pressures occur on footings, pipes, or other structures.

7) Backfilling operations shall not be performed with frozen materials and lumps and during low temperatures if the material will affect adversely the Works.

8) The Contractor shall maintain and protect the finished backfill in satisfactory conditions at all times until completion and acceptance of the Works. After backfilling operations have been finished and prior to finish grading, the Contractor shall slope the surfaces to prevent ponding of water.

6.7.2 Random backfill

1) Random backfill shall consist of earth and rockfill of unspecified gradation placed as it comes from excavations. It shall be placed and compacted in horizontal layers 20 to 50 cm of loose thickness, depending on equipment used. The final thickness will be determined by the Engineer-in-Charge.

2) The moisture contents prior and during compaction shall be near the optimum moisture content distributed evenly throughout each layer of material.

3) Random backfill shall be compacted to at least 80% relative density in accordance with relevant IS specifications.

4) Random backfill to be placed adjacent to structures shall be carefully placed to prevent any displacement or damage. Material to be placed within 1 m of the structure shall contain no material greater than 100 mm.

6.7.3 Compacted Backfill

1) Compacted Backfill material shall consist of a well graded mixture of sandy gravels and cobbles with a maximum particle size of 300 mm (except as stated below), and a maximum of 3% by weight passing U.S.Standard Sieve No. 200 (0.075 mm).

2) Material to be placed within 1m of the structure shall contain no material greater than 100 mm.

3) Compacted backfill shall be placed moist in layers not exceeding 500 mm, after compaction. It shall be compacted to 80% relative density for which requisite testing shall be carried out as per USBR “Earth Manual”.

4) Backfill shall be compacted by vibratory rollers. Where backfill is required to be placed adjacent to structures or in other restricted areas, it shall be compacted by mechanical tampers or other approved method of compaction.

6.7.4 Free-Draining Backfill

1) Free-draining backfill material shall consist of a well graded mixture of sandy gravels and cobbles with a maximum particle size of 300 mm (except as stated below), and a maximum of 3% by weight passing U.S. Standard Sieve No.200 (0.075 mm).

2) Material to be placed within 1m of the structure shall contain no material greater than 100 mm.

3) Free-draining backfill shall be placed moist in layers not exceeding 500 mm, before compaction. It shall be compacted to 70% relative density as defined in IS: 2720.

4) Free-draining backfill shall be compacted by vibratory rollers. Where backfill is required to be placed adjacent to structures or in other restricted areas, it shall be compacted by mechanical tampers or other approved method of compaction.

6.7.5 Sand-Gravel Backfill /Fill

Reasonably well-graded sand and gravel shall be used for backfilling/filling as shown in the drawings or as instructed by Engineer-in-Charge. The maximum particle size shall not exceed 75 mm and a maximum of 5% by weight passing U.S. Standard Sieve No. 200 (0.075 mm). The material shall be spread in layers of 200 mm and compacted by hand tamping.

6.8 MEASUREMENT AND PAYMENT

6.8.1 General

1) Measurement and payment for the clearing, stripping, excavation, placing of shotcrete, grout and concrete will be made in accordance with the corresponding Sections of these Specifications.

2) All costs of dewatering and keeping the foundation surface dry will be covered in the Section "Dewatering during Construction".

3) Foundation preparation: no extra measurement for payment will be made for the preparation of the foundations and protection or maintaining excavated surfaces in satisfactory conditions until the embankment fill is placed, including any temporary supports necessary to support the sides of the excavations.

4) Measurement and payment for the removal of unsuitable material from the foundation below or outside the lines and grades shown on the Construction Drawings or ordered by the Engineer-in-Charge will be made as specified in the Section "Surface Excavation" for dental excavation.

5) In case the volume of backfill concrete which had to be placed in the foundation exceeds 0.5 m^3 per 1 m^2 of the foundation, as approved by the Engineer-in-Charge, payment will be made as specified in the Section "Concrete" for backfill concrete in surface excavation.

6.8.2 Embankment Construction

1) Measurement for payment of the cofferdyke/ embankment materials will be made to the lines and grades shown on the Construction Drawings, or as adjusted by the Engineer-in-Charge, notwithstanding any variations from these lines as allowed by the tolerances specified in this section.

2) Measurement for payment for the different zones of the cofferdyke/ embankment specified herein will be of the in-situ volume of the material placed and compacted in specified layers, and to the required densities, by the number of passes prescribed by the Engineer-in-Charge.

3) Payment will be made at the appropriate Unit Price per cubic meter entered in the Bill of Quantities, which shall include the entire cost of, but not be limited to, the following:

   a) Provision of all labour, equipment, and materials required for the preparation, segregating, grading, blending and mixing, wetting or drying of the materials in order to obtain the required gradation, moisture content and other properties.

   b) Stockpiling and re-handling if any.

   c) Loading the materials at the processing plants or stockpiles.

   d) Transport of materials.

   e) Provision of all labour, equipment and materials required for the placing, spreading, compacting, watering as needed for the cofferdyke/ embankment materials; dressing of the slopes, trimming, compacting and protecting the upstream cofferdyke face.

   f) Quality control and performance of testing as required, with exception as stipulated in the Section "Site Installations".

   g) Surveying, setting-out, checking of cofferdyke/ embankment profile and alignment, and any subsequent rectification works resulting from undue or incorrect surveys; provision of suitable equipment for, and delays caused due to carrying out this work.

4) If the Engineer-in-Charge determines that, with the equipment used, more passes/ sluicing are required to obtain an appropriate compaction of the fill, he may order the Contractor to execute additional passes with the compacting equipment. Such additional passes will not be paid separately.

5) Haulage for ~~Extra payment will be made for transport of~~ impervious material shall be upto ~~beyond 151550~~ km ~~(distance of farthest borrow area)~~ from the axis of the cofferdyke/ embankment.

6) Haulage for ~~Extra payment will be made for transport of~~ cofferdyke/ embankment fill materials other than impervious materials shall be upto ~~from beyond 4410~~ km from the axis of the cofferdyke/embankment.

7) Measurement for payment will be based on the hauled volume. The volume of the material will be measured in the cofferdyke/ embankment after compaction. Payment will be made at the Unit Price per cubic meter per km entered in the Bill of Quantities. The transport distance will be measured shortest road length between the established point on the cofferdyke/ embankment and the place of excavation regardless of the place of the processing plant, stockpiles, or other detours.

6.8.3 Backfill / Fill

1) Measurement and payment for the different types of backfill/fill will be of the in-situ volume of material placed and compacted if required.

2) Payment will be made at the appropriate Unit Price per cubic meter entered in the Bill of Quantities, which shall include the supply of material, placing, and compacting as specified.

6.8.4 Exclusions

1) No extra measurement for payment or payment will be made for the following:

   a) Extra work caused by the Contractor's negligence in setting-out the structures and slopes.

   b) Rectification, removal and replacement of the materials which during the placement or afterwards have been frozen, contaminated with foreign matter, mixed with materials from other zones, or lost due to erosion.

   c) Extra work or material required to repair damages to the temporary or final surfaces caused by the erosion or travel of the construction equipment.

   d) Increase of quantities caused by settlement resulting from the consolidation of the cofferdyke/ embankment during the construction.

   e) Damage and repair to the concrete structures caused by Contractor's operations.

   f) Preparation and protection of foundation for placement of cofferdyke/ embankment fill.

2) No adjustment to the Unit Price entered in the Bill of Quantities will be made due to variation of the division lines between the various zones of cofferdyke/ embankment.

3) All costs for concrete are excluded from this Section and shall be measured and paid for in accordance with the provisions of the Section B.9.

END OF SECTION B.6

SECTION B.7

DRILLING, GROUTING AND PRESSURE RELIEF HOLES

List of Contents

SECTION B.7
DRILLING AND GROUTING

7.1 SCOPE OF WORK

(1) The work under this Section includes all labour, materials, equipment, operations and services required for the execution of drill holes, water-pressure test, performance of grouting in the holes from surface and from the underground construction sites, at locations shown on the Drawings or as directed by the Engineer-in-Charge.

(2) Drilling from the surface shall include the following:

a) Drilling of exploratory holes,

b) Drilling for consolidation grouting for Dam~~Barrage~~ area, ~~Head Regulator, desilting Basin,~~ Intake area (including cut & cover area), outlet portals of various tunnels and adits.

c) Drilling of check holes to determine the effectiveness of grouting,

d) Drilling of drainage holes,

e) Drilling for installation of instrumentation (if required).

(3) Drilling from the underground shall include the following:

a) Drilling of exploratory holes,

b) Drilling for consolidation grouting of zones of sheared and disturbed material and/or of zones of high water inflow,

c) Drilling of pressure relief holes,

d) Drilling for installation of instrumentation,

e) Drilling of water-pressure test holes,

f) Drilling for contact grouting,

g) Drilling for consolidation grouting of rock surrounding the excavated tunnels and caverns when geological conditions so require,

h) Drilling for crack grouting

i) Drilling for curtain grouting around tunnel plug

(4) Grouting operations shall include the following:

(a) Contact grouting, at pressure of up to 5 bar to fill voids between concrete and rock, between backfill concrete and steel lining, and in the concrete plugs in the tunnels,

(b) Consolidation grouting of rock foundation of ~~Desilting Basin, Head Regulator,~~ Intake area (including cut & cover area) and of the rock surrounding the tunnels, which shall commence after placing of the concrete lining and completion of contact grouting,

(c) Curtain grouting to a sufficient depth in order to create a high density zone with a low permeability. It shall be executed in adit plugs only.

(d) Fill grouting, at pressures of up to 5 bar, of drainage trench conduits, sump pits, and of exploratory drill holes and drain holes.

(e) Crack grouting, at pressures of up to 5 bar, to seal open cracks and joints in the tunnel concrete lining.

(5) Water pressure tests shall be carried out by the Contractor in grout, exploratory and check holes / control holes as directed by the Engineer-in-Charge.

(6) The location, orientation and depth of the drill holes for the contact, consolidation and curtain grouting are tentatively indicated on the tender drawings for the purpose of tender preparation. The final no., length, location and inclination of the drill holes as well as the composition and consistency of the grout mixes, grouting pressure, pumping rates and sequence in which the holes are to be drilled and grouted shall be governed by actual conditions encountered on site and shall be at all times subject to the approval by the Engineer-in-Charge.

(7) The entire temporary drainage system in the underground shall be filled with grout.

(8) The extent of crack grouting will be determined by Engineer-in-Charge.

(9) Drilling for installation of rockbolts, rock anchors, grouted anchors bars, and prestressed tendons shall be performed in accordance with the provisions set forth in the Section "Rock Supports".

(10) The Jet grouting pertaining to coffer dyke shall be performed as per Section B-8A “Jet Grouting”. All activities relating to the Jet grouting works shall be executed by the specialised contractor.

7.2 SUBMITTALS

7.2.1 Drilling

(1) Prior to the start of drilling (and/or grouting work) in any one working area, the Contractor shall provide notice of and make available to the Engineer-in-Charge a drilling and/or grouting plan, with 56 days time for review. Once work has commenced and as the local sub-surface conditions are disclosed, the drilling and/or grouting plan may have to be modified accordingly on the basis of consultation with and direction by the Engineer-in-Charge. The Contractor shall always be prepared and equipped for variations in the drilling and grouting work.

(2) The Contractor shall make drilling logs and other pertinent information available to the Engineer-in-Charge on completion of each work phase and as needed during the work.

(3) The Contractor shall provide notice of, and make available to the Engineer-in-Charge reports giving the results of each water-pressure test performed within one working day of the end of the shift in which the tests were carried out. The reports shall contain complete records of the execution of the test as described in this Section.

(4) The Contractor shall provide to the Engineer-in-Charge (prior to scheduled use in the field) documentation of the effects on the grouting mixture of any

additive proposed for use in the drilling water, and no additives shall be used without prior approval by the Engineer-in-Charge.

(5) Within 24 hours of completion of any drilling with core recovery, the Contractor shall submit, in duplicate, a technical log of the drill hole in a form approved by the Engineer-in-Charge. The log shall be in accordance with IS: 4464 and shall include the following data:

a) Date of beginning and end of drilling,

b) Drill hole number,

c) Location, ground surface elevation, collar elevation, coordinates, inclination, direction, and length of drill hole,

d) Type and diameter of drilling bit and core barrel used, make of drilling rig and length and diameter of casing, if used,

e) Elevation of ground water levels encountered, including dates and times of measurement,

f) Results of leakage tests and other drill hole tests, if any,

g) A record of the driller's observations on progress of drilling, rate of penetration, speed and uniformity of rotation of bit, action of the drill rig such as jerky, smooth, rough, steady, etc.,

h) Length of each core run and the length, or percentage, or both of the core recovered and location and cause of core losses,

i) Any changes in the character of the drilling water or mud, and in case the drilling water was lost (partly or totally), the elevation or depth when this happened,

j) A simple driller's interpretation and description of the nature of the formation encountered as the drilling progress,

k) Location and nature of cavities, seams, cracks, soft or broken rock, whether filled or open, and any other observation which could give information in connection with the purpose of exploratory drilling,

l) Names of drillers and inspectors.

(6) Geological logging shall be performed by the Engineer-in-Charge. When required by the Engineer-in-Charge the Contractor shall provide assistance during core logging, and in particular with handling of core boxes and cleaning of cores.

(7) Colour photographs of the core boxes from each drill hole shall be submitted to the Engineer-in-Charge in 3 copies within 10 days from the completion of the drill hole.

(8) The Contractor shall submit reports in duplicate giving the results of each water-pressure test performed, within 24 hours of the end of the shift in which the tests were carried out. The reports shall contain the following:

a) Location and number of drill hole,

b) Date and time of test performance,

c) Type of test,

d) Pressure readings and water levels before and after testing,

e) Packer rod characteristics and depth of packer(s),

f) Total injected water volume and rate per minute and per linear meter of hole for various pressures applied. A plot showing water take versus increasing and decreasing pressure shall be prepared and both data and plot shall be submitted,

g) Description of all surface water leaks indicating the distance and approximate quantity.

(9) If the Contractor intend to use a water-soluble additive to drilling water, he shall submit a notification and a sample of the additive to the Engineer-in-Charge for approval at least 15 days prior to being used.

7.2.2 Grouting

(1) At least 56 days prior to the start of the grouting works, the Contractor shall submit for approval fully detailed proposals and a detailed layout of his proposed arrangements for grouting, including specifications of all equipment, tools and all grouting materials to be used, and qualification and experience of the proposed personnel, and extent of technical support from external agency.

(2) An overall grouting program shall be drawn up jointly between the Contractor and the Engineer-in-Charge. Grouting mixes pressures, pumping rates and sequencing will be selected, subject to modifications, to meet local conditions encountered during the performance of the work. Grouting works shall be planned in such a manner that they can be carried out according to the approved plan concurrently with other activities. Modifications to the grouting program shall be implemented as directed by the Engineer-in-Charge.

(3) Prior to each phase of grouting, the Contractor shall submit for approval a detailed program for the particular grouting works along with information relating to the methods he proposes to use and details of grout mixes. No grouting work shall be executed without prior written approval by the Engineer-in-Charge.

(4) During the performance of the grouting works, the Contractor shall keep complete daily records of all grouting operations. These grouting records shall be compiled on an approved form and shall be submitted weekly to the Engineer-in-Charge. Results of water pressure tests and grout takes shall be presented in tabular form as well as graphically. The records shall contain all the information as per guidelines of IS: 6066, and shall include the following:

a) Number and location of the drill holes,

b) Results of water-pressure tests,

c) Grouting method,

d) Date and time of commencement of grouting and of each change in grouting operations,

e) Rate of pumping,

f) Grouting pressures and gauge reference number,

g) Water-cement ratio and its variations,

h) Separate quantities of cement, sand, bentonite, fly ash, admixtures and chemicals used,

i) Connections, if any, with other holes and cracks, as well as any surface leakage of water or grout; crack location, how it was caulked and the success of caulking shall be described and approximate station and offset of each surface leak shall be recorded .

j) Number of holes and depth of holes left for re-drilling,

k) Time of completion,

l) Name of the foreman in charge.

(5) The Engineer-in-Charge reserves the right to require any additional information deemed necessary to be included in the documents to be submitted.

7.3 DEFINITIONS

These definitions are applicable for drilling and grouting in rock only.

Grouting is defined as injecting a mixture of cement and water with the addition of admixtures, sand, bentonite, and fly ash, if required, or similar approved mixture under pressure into overburden or rock mass or between rock/concrete contact through a system of boreholes by means of a pump designed for such a purpose. Cement grouts are subdivided into stable and unstable mixtures:

Unstable mixtures are simple suspensions of cement in water. These suspensions are only homogeneous as long as they are in movement and the sedimentation starts as soon as the movement is stopped.

Stable mixtures are colloidal suspension dissolved in water which grain size is so small that no appreciable sedimentation occurs during the grouting operation. These suspensions are obtained by high speed mixing of cement with addition of bentonite.

Zone is part of the impervious curtain grouting or consolidation grouting where all the drill holes have the same depth or the same inclination or where a level for the depths of holes is specified. In a zone, Engineer-in-Charge may adjust the drill holes as required by the topographical and geological conditions to ensure a continuous grouting curtain.

Stage is a section of a drill hole in which grouting or water pressure testing is performed.

Packer grouting consists of drilling a hole to its full depth in a single operation, cleaning and washing, water-pressure testing if required and grouting the hole in successive stages in any desired sequence of section which are isolated by use of packers from the ungrouted sections. This method shall generally be used.

Stage grouting consists of drilling and grouting a hole by stages. First a hole is drilled to a limited depth, cleaned, subjected to water pressure tests if required and then grouted. Just after the initial set of grout, the hole is cleaned by washing or by other appropriate means. Then the hole is drilled to another limited depth, cleaned, subjected to water pressure tests if required and grouted and so continued in

successive stages until satisfactorily grouted to its full depth. This method is to be used only when directed by Engineer-in-Charge.

Full depth grouting means that each hole is drilled to the full desired depth, washed, pressure tested and grouted in one operation. This method is usually limited to short holes 5 m or less or holes up to 10 m that have only small cracks and joints and there is no risk of surface leakage.

Split spacing consists of progressively closing curtain or consolidation grouting by drilling and grouting holes midway between holes which have previously been drilled and grouted. The spacing between primary and secondary holes may vary from one zone to another depending upon geological conditions encountered.

Consolidation grouting is the drilling of shallow holes and grouting of the rock surrounding concrete lining of tunnels and shafts.

Curtain grouting is the grouting executed to form a continuous impervious wall. In principle, this curtain shall consists of a single row of holes divided into zones of variable depths, inclination and spacing

Contact grouting is drilling and grouting at low pressures required to fill the voids between concrete and rock surface or between concrete and steel lining.

Open end washing is the process of cleaning drill cuttings and sludge from a drill hole by injecting water or water and air at the bottom of the hole and returning the fluid and suspended matter to the top of the hole.

Grouting pressure shall mean the pressure of grout injection as measured at the nearest pressure gauge near collar of hole while the grout is being pumped into the hole.

Effective pressure shall mean the actual pressure of grout at the packer end, taking into consideration the difference of elevation between the packer end and the nearest pressure gauge or the water table.

Successful connection means the completion of all operations necessary to achieve a proper seating of a packer assembly that can sustain the required pressure without leakage or loss of pressure during pressure water testing or grouting to refusal.

Grout take or grout absorption is the quantity of materials injected in a hole expressed in units of kg of dry cement/bentonite and of sand.

Water cement ratio is the ratio of the mass of water to the mass of cement.

7.4 EQUIPMENT

7.4.1 Drilling Equipment

(1) All drilling equipment used shall be of a type, capacity and mechanical condition capable of performing the drilling required under this Contract, and shall be subject to the approval of Engineer-in-Charge.

(2) The Contractor shall have sufficient drilling rigs at the Site for the timely completion of the Works. The drilling rigs shall be in good operating condition and adequate for the satisfactory progress of the work. Combustion engines for operation of drilling equipment will not be permitted for underground work.

(3) Drilling equipment shall be capable of drilling at any angle, upward or downward, and shall have the following capacity:

- Exploratory holes up to 100 m,
- Consolidation grouting up to 20 m,
- Curtain grouting up to 60 m
- Contact grouting up to 5 m.

(4) Standard drilling equipment of the rotary and percussion type shall be used to perform the drilling as specified herein or as required by the Engineer-in-Charge. Percussion drilling equipment shall be equipped with a water swivel for continuous flushing of the holes during drilling.

(5) The Engineer-in-Charge may require some of the grout holes and pressure relief holes to be drilled using rotary type drills with core recovery. The rotary type machines shall be capable of drilling NX size holes utilising double tube / triple tube core barrels equivalent and capable of recovering soft or friable materials with maximum possible core recovery. The equipment and crew shall be made available at site when Engineer-in-Charge requires exploratory holes to be drilled. All such cores shall be properly stored in wooden boxes and logged for inspection as per the Indian Standard.

(6) The drilling units shall be mobile and of size suitable to the dimensions of the galleries.

(7) The contractor shall keep at the Site, an ample supply of different types and sizes of drilling bits to allow optimal drilling in the different materials to be encountered in the course of work, and sufficient rods and casings of various diameters to allow proper telescoping and to ensure the stability of drill holes.

(8) The Contractor shall provide measuring equipment for checking the actual inclination and alignment of drill holes.

7.4.2 Grouting Equipment

(1) Only modern, properly operating grouting equipment approved by the Engineer-in-Charge and operated by trained and experienced crew shall be used for the performance of the work. This shall be specifically observed when dealing with chemical products.

(2) The grouting equipment required to carry out the work shall include mixers, grout pumps, packers, pipes, grout lines, fittings, pressure gauges, telephones, lighting circuits, trolley grout platforms and miscellaneous supplies. Sufficient grouting equipment shall be provided to meet the construction schedule and each plant shall be capable of satisfactorily supplying, mixing, stirring, pumping and injecting grout mixes of various viscosities as specified herein. The equipment shall be maintained in good operating condition at all times and any grout hole that is lost or damaged due to mechanical failure of equipment or inadequate delivery of grout shall be replaced by another grout hole by Contractor at no additional cost to Employer.

(3) The grouting equipment for mixing and placing the grout shall be such as to provide a continuous circulation of grout throughout the system and to permit accurate volume and pressure control. It shall be capable of effectively mixing

and stirring the grout and forcing it into the hole in a continuous uninterrupted flow at any desired pressure up to the maximum required grouting pressure for a flow rate of 150 litre/min.

(4) Grout pumps shall be of the progressive cavity type and shall be capable of pumping at least 150 litres/min of grout at a maximum discharge pressure of 1,700 kPa (1.7 N/mm^2).

(5) Grout mixers shall have a minimum capacity of 0.5 m^3 and shall be mechanically operated horizontal paddle type or preferably colloidal high speed impeller type. Facilities shall be provided at the mixer for the accurate measurement of grout materials so that mix proportions can be carefully controlled.

(6) Sump or holding tanks having a minimum capacity of 0.5 m^3 shall be mechanically operated and designed to keep the mixed grout agitated and in suspension. All grout should be discharged from the mixer into the agitator and from the agitator into the pump panel through a 2.36 mm screen to remove lumps and large particles.

(7) Water meters shall be calibrated in litres and tenths of litres without by pass so that water can be measured directly in the mixer. A strainer with cleaning valve shall be provided in the water supply line, upstream of the meter to prevent sand and abrasive particles from entering the meters.

(8) Pressure gauges of the approved make shall be of such calibration to cover a range of pressures from 0 to 0.5 N/mm^2 (500 kPa) and from 0 to 1.5 N/mm^2 (1500 kPa), An adequate number of spare gauges shall be provided at each grout plant. Contractor shall provide a standard master gauge against which all other gauges shall be checked periodically for accuracy and satisfactory operation. All the pressure gauges shall be numbered for identification.

(9) Packers shall be capable of effectively sealing the grout holes at the specified elevation and shall be capable of withstanding without leakage pressures up to the maximum grouting pressure. The type of packer to be used shall be of the pneumatically expanded rubber sleeve type. Double packer assemblies separated by up to 3 m of perforated pipe shall also be provided.

(10) A double line circulating system shall be used and the inside diameter of all lines, walls and connections shall be not less than 25 mm. Hoses and supply lines shall be capable of withstanding pressure 50% greater than those specified for grouting.

(11) Grouting headers shall be provided for feeding grout into the holes. The header shall include a supply connection, a connection with a valve to the hole, and a return line with valve. Two number of approved make pressure gauges for the appropriate pressure range shall be installed. One shall be installed to indicate the pressure of the supply at the pump and the other to measure the back pressure at the hole.

(12) Contractor shall furnish, install, maintain and operate satisfactory communication system between grout plants and the holes being grouted regardless of grout area locations.

(13) Contractor shall supply sufficient operating personnel, supervisors, labour, spare tools, to carry out each phase of the work properly and expeditiously.

(14) The grouting units shall be mobile and of size suitable to the dimensions of the galleries/drifts.

7.4.3 Water Pressure Testing Equipment

(1) The washing and water-pressure testing equipment shall include pumps, piping, pressure gauges, valves, seal assemblies and all other accessories, necessary to perform the Work.

(2) The Contractor shall provide a sufficient number of complete sets of pressure testing equipment (with spares) to allow simultaneous testing at the various drilling and/or grouting locations.

(3) The pumps furnished shall be of the gear, centrifugal, or other acceptable types, with a minimum output of not less than 0.28 m^3/min at 1.5 N/mm^2 (1500 kPa) gauge pressure and shall be capable of maintaining constant pressure.

(4) The Contractor shall supply water storage tanks sufficient for the pumps in addition to flow meters and pressure gauges for calibration and checking.

(5) Water-meters and pressure gauges shall be calibrated and certified by an independent laboratory prior to installation at the Site and shall be subject to periodic verification. One pressure gauge and one water-meter shall, after independent checking, remain at the disposal of the Engineer-in-Charge for further checking purposes. The Contractor may be requested to establish, by way of tests, correction graphs for pressure losses occurring in the pipes. Pressure gauges shall be installed directly at the collar of the drill hole.

7.4.4 Embedded Pipes and Fittings for Grouting

(1) Standard mild steel pipes and fittings for grouting shall be set in the rock and concrete as the Engineer-in-Charge may direct, or where shown on the Drawings. The pipes and fittings embedded in concrete shall be cleaned thoroughly of all dirt, grease, grout and mortar immediately before embedding and shall be firmly held in position and protected from damage or displacement while the concrete is being placed. A standard coupling and nipple wrapped to facilitate eventual removal shall be attached to the grout pipe where embedded in concrete. No portion of the pipe shall be allowed to remain within 50 mm of the concrete surface and the resulting recess, after removal of the pipe or fitting, shall be filled with dry-pack mortar.

(2) Care shall be taken to avoid premature blockage of pipes. Any pipe that becomes blocked before completion of operations shall be cleaned out in a satisfactory manner or replaced by the Contractor.

7.5 SITE LABORATORY

(1) The Contractor shall have a laboratory specially equipped for studies and tests relative to drilling and grouting works available on the Site. The laboratory shall be manned by experienced laboratory assistant(s) familiar with conventional grout tests.

(2) In addition to the usual general laboratory equipment such as scales, oven, permeability meter and the like, it shall be equipped with:

- A multi-speed laboratory mixer,
- A Marsh test cone,
- A mould for pressure testing the above cubes, variable from 0 to 2 tons,
- A set of sieves for grain size analysis of fines,
- Conventional laboratory glassware, including 1 litre beakers and test tubes,
- Thermometers and aerometers, and Atterberg limit measuring cups,
- A Baroid scale type mud density meter.

(3) The Engineer-In-Charge shall be given free access to the laboratory and shall be entitled to carry out any studies and measurements he deems necessary.

(4) The Contractor shall prepare and test the trial mixes as directed by the Engineer-in-Charge at least 28 days before commencement of any grouting. Materials for use in grout mixes shall be tested for compliance with the applicable requirements stipulated in "Materials" of this Section. Tests shall be performed on the grout mixes proposed for use in the Works, to establish the consistencies in mixes, practical mixing ratios, initial and final setting times, and such other properties as may affect the quality of the grout.

(5) During the actual grouting operations the Contractor shall carry out tests on grout mixes at the same time as grouting, and shall plot values of viscosity, sedimentation limits, compressive strength, and maximum viscosity possible for the grouting on a diagram. The frequency of testing will be once for each grouting job site or until acceptance criteria have been met. However, if a significant change in the cement source occurs, sampling and testing must be repeated and the new mix approved by the Engineer-in-Charge.

7.6 GROUTING MATERIALS

(1) Water used for all drilling, washing and water testing and as an ingredient of grout mixtures shall be fresh, clean and free from deleterious amounts of silt, organic matter, alkali, acids, salts, oil and other impurities.

(2) Cement used in the grout mixes shall be OPC/PPC/Micro-fine, conforming to IS:269 / IS:8112 / IS:12269 / IS:1489 Part-1 / IS:16993. The fineness shall be such that 99.0 percent passes the 74 micron IS sieve and that the Blaine fineness is not less than 3,000 cm^2/gm. The cement shall be free from lumps.

(3) Whenever sand is added to the grout mix, it shall consist of clean, hard and durable particles free from lumps or clay and objectionable foreign matter. A supply of 5 cubic metres of sand shall be kept in proximity of the work at all times. Sand shall conform to the following grading requirement:

Sieve size (mm)	Percentage passing by weight
2.360	100
1.800	95-100
0.600	60-85

0.300	30-50
0.150	10-30
0.075	0-5

(4) Bentonite may be required in grout mixes. The bentonite used shall be conforming to IS: 12584.

(5) Approved admixtures shall be used by Contractor in the grout mix to optimise the strength, viscosity, density, decantation, setting time and shrinkage. The admixtures shall be commercially available retarding or accelerating agents or grout plasticizer for water reduction and expansion during the plastic stage. Only admixtures proved by testing prior to the start of grouting may be used, when approved by the Engineer-in-Charge. Manufacturer's certificates or guarantees will not be accepted as relieving the Contractor of his responsibility for the suitability of any admixture.

(6) The Micro fine cement is micro cement with excellent penetration characteristic ideal for extremely demanding injections. The cement is finally ground to a specific particle size distribution, and a combination of special grinding process and special clinker produce a product.

(7) The micro fine cement is having high fineness value. The fineness value should be around 2000 m^2/kg (BET method) with maximum particle size of 20 micron (95 % passing) to avoid premature blockage of the fine openings caused by jamming of the coarsest particles.

(8) During grout operations, suitable Dispersing agent shall be used where-in microfine cement grout is used as it has de-flocculating property & provides better chemical stability with improved final strength of grout and lower permeability. Dosage of dispersing agent should be 1.5-2% on weight of microfine cement i.e. 1.5-2 ltrs/100 kg of microfine cement. However, trial mixes should be carried out for grout optimisation & its effect. No additional payment for use of dispersing agent shall be made.

7.7 GROUT MIXES

7.7.1 Selection of Grout type

Following table shall be used as a general guidance only for selection of grout type for a particular application and may require other additives to be determined during grout optimisation process:

Type of grouting	Objective	Ground Characteristics	Grouting Compounds
Contact grouting in tunnels	Void filling		Pure cement slurries (w/c ratio < 0.8)

Consolidation grouting in tunnels and to assist excavation	Strength	Narrow or wide joints and fissures filled with sand or clay	Pure cement slurry
		Wide empty joints or fissures high permeability	Thick stabilized cement suspensions
		Injected grout leaks into adjoining open holes. Inflowing water in fissures	Thick Thixotropic suspensions (bentonite added for thixotropy)
		Crushed rock injected grout leaks to the surface	Thick thixotropic suspension with fine sand added, additives for quick setting (if required)
Curtain grouting	Impermeability	Fine interconnected fissures, medium to low permeability	Thick cement or Cement-bentonite suspensions
		Rock containing many narrow interconnected fissures large permeability	Stabilized cement or cement bentonite suspensions
		Highly fractured rock high permeability	Thick cement suspensions with some fine or medium sand, addition of bentonite for thixotropy

7.7.2 Pure Cement Slurries

1) Water/cement slurry mixes are defined in terms of the W/C (water/cement) ratio by weight.
2) High-turbulence mixing of these slurries shall last at least two minutes after pouring of the full cement weight into the mixer.

7.7.3 Use of Bentonite in cement suspension grout

Preferred rate of sedimentation of a grout suspension is below 10%. Normal grout mixes don't meet this requirement when the water cement ratio is more than 0.8.

To meet the requirement of sedimentation rate below 10%, the grout suspension must be stabilised. As a rule, stabilization is effected by bentonite addition in the range of 1% to 4% of the weight of cement. The relative loss of strength of hardened grout is negligible up to 6% Bentonite addition.

7.7.4 Stable Bentonite-Cement Grouts

1) Stable Bentonite/cement grouts shall be laboratory tested prior to use. The following graphs, in particular, shall be drawn:

   a) Equiviscosity curves,

   b) Bleed limit curves,

   c) Curves of equal mechanical strength,

   d) Curve of maximum possible viscosity for grouting.

2) These figures shall be obtained with a mixer which reproduces the high turbulence of the site mixers and with the same materials (cement, bentonite, water) as will be used on the site. Bentonite/cement mixes for grouting shall not bleed more than 5%, expressed in terms of the volume of water visible above the grout after setting and the total volume prior to setting, as measured in a 1 litre, 6 cm diameter test tube.

3) Viscosity shall be measured with a Marsh cone or equivalent method.

4) Unconfined compressive strength after 7 and 28 days shall be measured on 5 cm cubes stored in water. 28 days compressive strength shall be not less than 1 MPa.

5) The time to initial set shall not be longer than 24 hours.

7.7.4.1 Preparation

1) The Bentonite/cement grout shall be made by first mixing a bentonite/water parent slurry in a high - turbulence mixer and storing it, once adjusted to the defined W/B ratio, for approximately 24 hours in a large tank where it shall be kept in gentle movement, after which a quantity of parent slurry shall be taken and mixed with additional water and cement in a high-turbulence mixer.

2) The final mixing of the parent slurry with cement shall last at least two minutes after addition of all ingredients.

3) The same mixing drum shall under no circumstances be used for mixing both Bentonite/cement grouts and bentonite/water slurries. Bentonite shall not be suspended in water which contains even the slightest amount of cement.

4) The Contractor shall provide detailed information regarding the material and batching, mixing and grouting plant he proposes using in his submission for the Engineer-In-Charge's approval.

7.7.4.2 Grout Types

1) Three stable grouts with different batching proportions shall be developed on site to respect the above conditions: they shall be the thinnest possible mix (grout A), a mix of average viscosity (grout B), and the thickest possible pumpable mix (grout C). For Clarsol type FB 2 bentonite, the composition of these mixes for one cubic meter of grout should be approximately as given in the table below:

	Grout A	**Grout B**	**Grout C**

Water	850 lt	848 lt	846 lt
Bentonite	30 kg	40 kg	50 kg
Cement	425 kg	424 kg	422 kg
Total volume	1,000 lt	1,000 lt	1,000 lt
Density	1.30	1.31	1.32
Viscosity (Marsh)	35 sec	40 sec	50 sec
Bleed	4 %	2.5 %	1 %
28 day strength	1.2 MPa	1.2 MPa	1.2 MPa

These compositions are given as a guide only and shall be adjusted to suit the materials used. A greater variety of mixes may be required.

7.7.5 Micro Fine Cement Grout

1) Micro fine cement grout is a suspension composed of water and very fine grains of cement and/or other binder material and/or addition (like bentonite for instance). To be qualified as micro fine cement grout, the suspension shall not contain more than 5% of the grains in weight having a diameter greater than 20 microns. The micro fine cement grout is stronger and less permeable than existing cementitious grouts, has a high compressive strength and extremely small particle size (only a few microns, in contrast to typical particle sizes of 60 to 70 microns in conventional cements).
2) Micro Fine cement grout shall conform to IS 16993and should have following properties:

Sl. No.	Characteristic	Requirement	Method of Test, Ref to
i)	Fineness, m^2/kg, Min BET method (Nitrogen adsorption)	2000	IS 11578
ii)	Particle Size, µm, Max: a) D_{50} b) D_{95}	 10 20	Using laser diffraction PSD analyzer
iii)	Setting Time a) Initial setting time, h, Min b) Final setting time, h, Max	 1 20	Annexure B of IS 16993
iv)	Bleeding test at 3 h from the time of mixing, percent, Max	5	Annexure C of IS 16993
v)	Compressive strength, MPa (see Notes 2 & 3): a) 3 days, Min b) 7 days, Min c) 28 days, Min	 16 22 33	IS 4031 (Part 8)

Notes:

1. D_{95} indicates that 95% of the particles on a mass basis are below a given size while D_{50} indicates that 50% of the particles on a mass basis are below given size.

2. For compressive strength test, microfine cement and standard sand in the ratio of 1:3 and water cement ratio of 0.5 shall be used.
   In case the mix is found to be harsh and does not have the plastic consistency required for proper compaction, required quantity of superplasticizers conforming to IS 9103 may be added for proper workability and mixing. The type and dosage of superplasticizer, if added, may be reported.
3. Notwithstanding the strength requirements, the compressive strength shall show a progressive increase in strength specified at 3 day.
4. The contractor shall submit the test ceritificates of the product to the Engineer-in-Charge at least 56 days prior to start of the grouting works.

7.7.6 Colloidal Silica

Colloidal silica used for grouting shall be of reputed make and duly approved by Engineer-in-Charge having viscosity of 5MPa-s and particle size of 0.016 µm. Low viscous colloidal silica grout fill the finer joints and the joints filled with clay and silts.

7.7.7 PU Grout

Grouting with two component (Polyisocynates and Polyalcohalas) rapid setting Pu grout shall be carried out as per construction drgs after approval by the Engineer-in-charge. Hydrophobic Polyurethane (foamed) is formed by reaction of two compounds polyisocynates and Polyalcohals which shall create a barrier/ resistance to seepage / void filling /crack filling etc.
Two components in the ratio of 1:1 or as manufactures instructions by volume shall be injected through two component injection pump equipped with in-line mixer to achieve thorough mixing of the two components during injection.

Standard testing for properties shall conforming to ASTM-D 1622 for density, ASTM-D2127 water absorption, ASTM-D 1638 for Viscosity , ASTM-D 1623 for elongation and tensile strength ASTM-C 273 for shear strength etc.

7.8 EXECUTION

7.8.1 General

(1) The extent of proposed drilling and grouting programme is tentative. Engineer-in-Charge reserves the right to increase or decrease any part of the drilling and grouting programme should conditions indicate that this is required.

(2) The Contractor shall provide sufficient pump capacity and storage to ensure a continuous supply of water to all grouting operation at all times at each grouting location. Minimum water pressure in the supply lines shall be 0.35 N/mm^2. Sufficient compressed air shall be supplied by the Contractor to perform the work with all equipment using compressed air operating at full capacity, the minimum delivery pressure in the air supply lines shall be 0.70 N/mm^2 at all times.

(3) In order to ensure efficient and satisfactory performance, Contractor shall employ competent and experienced drilling and grouting supervisors who shall execute directions of Engineer-in-Charge and supervise the work to be done.

(4) During drilling, grouting, washing and pressure testing operations, the Contractor shall keep concrete and rock surfaces free and clean of oil, grease, drill cuttings, grout, cement, excess of water or any kind of waste. At all times during the progress of the work covered by this section Contractor shall protect all open drill holes from becoming plugged or filled with oil, grease, drill cuttings, grout or waste. Contractor shall clean up; and remove all waste upon completion of the work in each area before he vacates that area.

(5) Modifications to drilling and grouting techniques may be required as the knowledge and experience of rock and foundation conditions are gained. The Contractor will be required to alter his operations properly to meet such modifications as per instructions of the Engineer-in-Charge. Necessity may also arise for drilling holes at certain places in a telescopic manner for which equipment and accessories are required to be available.

(6) Both percussion and rotary core drilling will be required (grouting and pressure relief) from surface as well as tunnels at various angles including vertically upwards.

(7) All drill holes shall be thoroughly washed and cleaned by allowing drilling water to run until the return from the hole is reasonably clean as explained in IS: 6066.

(8) All drill holes shall be protected from being clogged. Clogged holes shall be re-drilled and cleaned at Contractor's cost.

(9) Unless indicated otherwise, the drill holes shall not deviate from their designed alignment by more than 3% of their designed length.

(10) Drilling through overburden shall be done by ODEX or other suitable method approved by the Engineer-in-Charge. Consequently grouting shall be done by method "grouting through tubes with sleeves" as described in IS: 4999 or any other equivalent method approved by Engineer-in-Charge. Execution and controls shall be as per IS: 4999 for overburden grouting.

7.8.2 Drilling

7.8.2.1 Percussion Drilling

(1) The holes shall be drilled at locations, in the sequence, orientation, inclination and to the depths shown on the Drawings or as required by Engineer-in-Charge.

(2) Most of the holes for consolidation, curtain or contact grouting, pre-drainage and pressure relief will be drilled with drill of the percussion type which shall be equipped for constant water flushing at the far end of the drilling rod.

(3) Holes drilled for contact/consolidation/curtain grouting in various structures shall be 45 mm. Holes drilled for pre-drainage and pressure relief shall also be 45 mm, unless otherwise stated.

(4) The use of rod dope, grease or other lubricants on drill rods shall not be permitted. No drilling water additives of any kind shall be used without the written permission of Engineer-in-Charge.

(5) All holes shall be established to within 250 mm of the specified location. All orientation shall be within 1 degree of the orientation specified. If for any reason the drill hole deviates in inclination or orientation in such a way that it does not satisfy the purpose for which it was intended, the Contractor shall correct the deviation or shall drill another hole to the satisfaction of Engineer-in-Charge.

(6) Whenever the drill water is lost or artesian flow is encountered drilling operations may be stopped by Engineer-in-Charge who may require the hole to be grouted before drilling operations are resumed. The Contractor is required to record the location, the flow and pressure of any artesian conditions encountered in any drill hole.

(7) On completion of drilling and washing of any grout or pressure relief holes drilled through the floor of the galleries, the Contractor shall immediately cap the holes with proper removable plugs (wooden or plastic) and shall protect them from entry of dirt or other foreign material. Any grout or pressure relief hole that gets obstructed prior to grouting or installation of elbow shall be cleaned out or another hole shall be drilled by the Contractor.

(8) Pressure relief holes shall be installed with perforated PVC pipe or PVC slotted liner. The diameter of PVC slotted liner; pattern and size of its slots shall be as shown in the drawings or as directed by the Engineer-in-Charge.

(9) Grout or pressure relief holes shall not be drilled within 12 m of another hole which is being grouted or which has been grouted within the previous 24 hours.

(10) No hole shall be drilled through concrete before 5 days after the placement of the concrete.

7.8.2.2 Drilling of Exploratory Holes, Check Holes, and Holes for Instrumentation etc.

(1) The Contractor shall perform exploratory drilling holes through overburden, concrete, rock and hardened grout at any inclination as directed by Engineer-in-Charge. The amount of and the requirement for, exploratory drilling will be determined by Engineer-in-Charge.

(2) The use of mud or any other drilling fluids besides water is not permitted when coring.

(3) Whenever the Engineer-in-Charge asks for the core recovery, the Contractor shall collect the cores and the cores shall be placed in wooden boxes in the correct sequence and designated accurately by permanently labelled wooden blocks recording the measured distances in the hole. No box shall contain cores from more than one hole. Designation marks, hole numbers and depth values shall be inscribed in the boxes, the cover securely fastened to the core boxes, and the boxes delivered at an area near the site as designated by the Engineer-in-Charge.

(4) Maximum core recovery will be required and if the blocking of the core is indicated by the drill behaviour, the core shall be removed immediately from the hole, regardless of the length of run, which has been made.

(5) Exploratory holes shall be water pressure tested and grouted under pressure if required by Engineer-in-Charge.

(6) The Contractor shall give the Engineer-in-Charge all the necessary assistance and facilities to perform in situ tests or examination using bore hole camera, or a geophysical tests in the selected exploratory holes if required by Engineer-in-Charge.

7.8.2.3 Drilling for Crack Grouting in Concrete Lined Tunnels

(1) The contractor shall drill holes for the crack-grouting and sealing of open cold joints, construction joints, and cracks in the concrete lining as directed by the Engineer-in-Charge and as stipulated in Section 'Concrete'.

(2) The drilling shall consist of a series of 38 mm dia drill holes executed within or along the cracks, which have been determined by the Engineer-in-Charge to receive such treatments. Rotary drilling shall be used unless otherwise approved by the Engineer-in-Charge.

7.8.2.4 Non-Return Valve (NRV)

The contractor shall supply and install the Non-Return Valve (NRV) of requisite size to the locations shown on construction drawing or as directed by Engineer-in-Charge. The specification of NRV regarding size, type, material of different component part of valves, pressure class, coating, testing etc shall be according to IS: 778, subject to approval of Engineer-in-Charge.

7.8.3 Washing and Water Pressure Testing

(1) Immediately before grouting or pressure testing, the hole shall be thoroughly washed with water as explained in IS: 6066 or any other standard practice as approved by the Engineer-in-Charge.

(2) For routine grouting operations, simple water tests shall be conducted immediately prior to a stage of any grout hole is grouted.

(3) A simple water pressure test involves isolating a segment of a hole generally 3 to 5 m in length by means of a single or double packers and pumping in water at constant pressure for a period of 15 minutes. The tests shall be carried out as per IS: 6066 or any other standard procedure or code of practice approved by the Engineer-in-Charge.

7.8.4 Grouting

7.8.4.1 General Grouting Procedure

(1) Grout holes shall not be grouted except with permission from the Engineer-in-Charge, until the concrete/shotcrete within a radius of 12 m from the grout hole has been completed and cured for five days.

(2) Full depth grouting shall be limited to 5 m depth of hole in rock, however with latest information about rock geology, experience and pre-grouting results the Engineer-in-Charge may allow full depth grouting up to 10 m depth.

(3) For deeper grout holes, more than 5 m length the grouting shall be performed in stages of not more than 5 m length of grout holes as directed by the Engineer-in-Charge.

(4) Once the grouting of a stage of a hole has been commenced it should be continued without interruption until completion. In general a stage may be considered complete when absorption of grout at the desired limited pressure is less than 2 lit./min. averaged over a period of 10 minutes.

(5) As far as practical, a continuous flow of grout should be maintained at the desired pressure and the grouting equipment shall be operated to ensure continuous and efficient performance throughout the grouting operation. The Contractor shall respond quickly and effectively to manipulate the desired changes in the grout mix consistency, rate and pressure of injection, etc., as directed by the Engineer-in-Charge during the grouting operation.

(6) When grouting is interrupted due to plant break down, about 500-1,000 litres of clean water should be run into the hole and allowed to stand.

(7) Should any hole connect to another during injection, the grout should be allowed to escape from the coupled hole until it is of the same consistency as that being injected; the coupled hole should then be capped and the combined holes brought up to pressure. After the first hole has been grouted, all the other holes are successively connected to the grouting header to subject them to the full pressure.

(8) Grouting shall be stopped whenever pressure gauges register a sudden drop of pressure or the rate of grout absorption increases abruptly or there is any indication of upheaval, disturbance or leakage. Additional holes may have to be drilled and grouted in the vicinity or sealing cracks which might have been left due to premature blocking of holes by interruption of grouting operation.

(9) It is advisable to begin with a low initial pressure of 0.1 - 0.25 kg/cm^2/m of overburden and built up pressure gradually. The pressure shall be raised only when the intake rate falls below 5 lit/min. or as specified otherwise.

(10) The true pressure at any depth should take into account the pressure head caused by weight of the grout in the hole as explained in IS: 6066.

(11) The control of pressure shall be exercised according to the guidelines of IS: 6066.

(12) The recommended range of grout mixture falls from 5:1 to 0.8:1 (ratio by weight of water and cement) depending upon experience 2 to 3% (by weight of cement) bentonite can be added with or without other admixtures as instructed by the Engineer-in-Charge.

(13) Composition of all grout mixes shall be approved by the Engineer-in-Charge.

(14) All grout holes shall be backfilled with grout mix 0.7 water : 1 cement with 3% bentonite or by a mix as approved by Engineer-in-Charge after the grouting. A minimum 25 mm dia delivery pipe is lowered to the bottom of the hole. Grout is pumped in the delivery pipe until it flows from the hole, then

the delivery pipe is slowly withdrawn while pumping continues. If settlement of grout occurs after initial set, the holes shall be again backfilled by grout. For inclined holes, the hole shall be caulked/plugged suitably, so as to prevent the grout from falling.

(15) When pressure does not build up even after the grouting, a thick grout i.e. with water cement ratio lesser than 0.6:1 by weight or by grout with filler such as sand and bentonite, it is desirable to stop grouting after predetermined limit of consumption is reached. Additional holes shall have to be drilled and grouted in the vicinity of such holes.

(16) The Contractor shall caulk, dry pack or seal any surface leaks in rock or concrete before continuing grouting operation.

(17) In areas of higher grout consumption sand may be required to be incorporated in the mix, the proportions of the sand permitted shall normally not exceed 2 parts of sand for 1 part of cement with approved plasticizer.

(18) The grout mixes, which cannot be injected within 2 hours of mixing, shall be wasted.

7.8.4.2 Contact Grouting in Underground Structures

(1) Low pressure contact grouting shall be carried out between concrete lining and rock over the entire length of concrete lined hydraulic tunnels through 45mm dia holes.

(2) Contact grouting shall normally be performed from holes drilled in the concrete lining of the tunnels, shafts and caverns, and shall be carried out in advance of consolidation grouting operations.

(3) Contact grouting in the completed concrete plug in adits shall be performed through the pipe system embedded into the body of the plug.

(4) In sections of underground structures where permanent lagging with or without backfill concrete has been installed during excavation, spaces between the rock surface and the backfill concrete / lagging shall be filled with grout by contact grouting as decided by the Engineer-in-Charge.

(5) Washing and water pressure testing will not be required prior to contact grouting.

(6) In any section of the underground structure, the concrete lining within 90 m of that section shall have been in place for at least 21 days before grouting commences.

(7) Contact grouting shall be carried out at low pressure and shall continue until all voids are filled, unless otherwise directed by the Engineer-in-Charge. Vent pipes for the release of air and water during grouting shall be provided in locations directed or approved by the Engineer-in-Charge.

(8) After the grouting of any hole is completed, the pressure shall be maintained by means of a stopcock or other suitable device until the grout has set.

(9) Check grouting shall be carried out where directed by the Engineer-in-Charge, to verify that voids have been completely filled with grout. Grouting will be

regarded as being satisfactory if the pressure can be maintained for at least 5 minutes without further grout take.

7.8.4.3 Consolidation Grouting

(1) Consolidation grouting shall be performed through 45mm dia holes underneath or around structures from the surface at the following locations:

a) Dam~~Barrage~~ area, ~~Head Regulator, Desilting Basin,~~ Intake area (including cut & cover area), outlet portals of various tunnels and adits.

b) Tunnels & Access adits

c) In any other zone within the construction sites where conditions so dictate and as the Engineer-in-Charge may direct.

(2) Consolidation grouting shall normally be performed in a single stage through a nipple or packer installed at the collar of the hole within the concrete lining, but if geological conditions so dictate multiple-stage grouting either in ascending or descending arrangement shall be performed in the deeper holes.

(3) Consolidation grouting at an open air structure shall first commence 7 days after concrete placement. Grouting for rock consolidation in any section of the completed underground structure shall not start earlier than 14 days after completion of contact grouting within 100 m of that section.

(4) Consolidation grouting of the foundation shall extend over the full length founded on the rock. It shall be performed in small areas by drilling and grouting from 1 to 4 holes at a time to a depth of approximately 5m at a spacing of 3m or as directed by the Engineer-in-Charge. Grouting shall be done in a continuous operation avoiding disturbance of zones grouted within the previous 24 hours. The grout pressure shall not exceed 2.0kg/cm^2. Shotcreting or slush grout will precede consolidation grouting whenever necessary to seal the surface cracks and to prevent grout leakage.

(5) Consolidation grouting of the rock surrounding tunnels shall be carried out as shown on the Drawings or as directed by the Engineer-in-Charge. Consolidation grouting may also be required during the excavation works in order to consolidate the heading face or seal off the inflow of groundwater.

(6) Immediately before grouting, the grout holes shall, rock characteristics permitting, be thoroughly washed out under pressure until the returning water is clear, and pressure tested.

(7) Grout holes adjacent to a grout hook-up shall be left open during grouting operations to facilitate the escape of air and water from pockets in surrounding rock. Where, during grouting of any hole, grout is found to be flowing from adjacent holes or cracks of any kind, such openings shall be capped temporarily by plugging or caulking.

(8) When performing the multiple–stage grouting in descending arrangement, the grout that is within the hole shall be removed from each stage except the deepest one, by washing, or by the use of chopping of a “fishtail” bit before the grout sets.

(9) In the event of a sudden drop in pressure or a sudden increase in grout take, grouting operations shall be temporarily halted until the crack or opening

causing the loss is located and caulked. During this time the drill hole shall be continuously washed to avoid a premature grout set which would inhibit grouting to resume. If such a pressure drop or increase in grout take can be related to hydro fracturing, grout pressure shall be reduced.

(10) If surface grout leaks cannot be located and successfully caulked, or the cause for the pressure loss cannot be determined, within 1 hour, the washing of the drill hole will be stopped and the grout in the rock formation shall be allowed to set for 24 hours. After setting, the drill hole shall be hooked onto again and grouted. If the hole, or stage does not accept grout, the hole shall be re-drilled or a replacement hole shall be as directed by the Engineer-in-Charge.

(11) If, during grouting, there is a communication between the holes, the Contractor shall either set packers in the communicating holes, which shall be bled of, accumulated air frequently and continue grouting one hole after another, or he may pressure grout the communicating holes simultaneously.

(12) Grouting injection will be deemed to be completed when the take has become less than 30 Litre or less per stage of hole being grouted during 10 minutes at the specified grouting pressure and mixture.

(13) After completion of grouting, the packers shall remain in the hole and the pressure shall be maintained until the grout has attained its initial set.

(14) Testing of efficacy of grouting: The contractor is required to do the testing for the efficacy of the grouting in water conductor system, in all reaches wherever consolidation grouting is performed and shall cover the entire periphery of the tunnel by way of water pressure tests. The water pressure test shall be carried out both for pre and post grouting stage to assess the effectiveness of grouting operations. Based on the information of water pressure testing, the Engineer-In-Charge shall determine whether the grouting in each section of works under consideration is completed in a satisfactory manner, or whether additional grouting in separate drill hole is required. The termination of grouting work in any sequence in any section of the Works will be as determined by the Engineer-in-Charge.

7.8.4.4 Curtain Grouting

(1) Curtain grouting shall be performed through 45mm dia holes around concrete plug in construction adits as indicated on the Drawings, or as directed by the Engineer-in-Charge. Hole depths, inclinations, sequence of grouting, method of grouting, whether single or multi-stage, in ascending or descending arrangement will be adapted by the Engineer-in-Charge based on information from exploratory drilling or current operations. The holes shall be drilled and grouted by the split-spacing method.

(2) Normal sequence of grouting shall be ascending from bottom to top of hole in stages determined from water-pressure tests. Where the permeability exceeds 15-20 Lugeons, grouting shall generally be performed in descending arrangement.

(3) When performing the multi-stage grouting in descending arrangement, the grout that is within the hole shall be removed from each stage except the

deepest one, by washing, or by the use of a chopping of a "fishtail" bit before it takes a hard set.

(4) Stage length shall be a maximum of 5 m.

(5) Unless otherwise directed, air, wash water, and grout pressure shall not exceed 2 bars plus 0.25 bar per linear meter of the depth measured from the collar of the hole to the bottom of the packer. In no cases shall grouting result in heave or hydrofacturing (sudden increase of take). Grout pressure shall not be released nor packers moved until the grout in each successive stage has achieved an initial set.

(6) The curtain grouting shall be performed from one or several grout stations. If several such stations are used, each shall be equipped complete, with mixers, agitator sumps, pumps, gages and measuring devices, and shall have a sufficient supply of grouting materials.

(7) In case when the required pressure is not reached even when injecting maximum volume, the Engineer-in-Charge will decide whether the grouting will be interrupted, or the grout mixture is to be changed, or accelerator added.

(8) Where grout is found to be flowing from adjacent holes or cracks of any kind, such openings shall be capped temporarily by plugging or caulking. If this does not bring satisfactory results, further grouting shall be interrupted and the injected material allowed to harden.

(9) Grouting injection will be deemed to be completed when the take has become less than 2 lt/min per stage of hole being grouted during 10 minutes at the specified grouting pressure and mixture.

(10) After the conclusion of the grouting program, the Contractor shall drill inclined check holes. The check holes shall be drilled at the spacing of 30 m, and two-thirds the depth of the grout curtain. These holes shall be filled with grout. Based on the results obtained in the check holes, the Engineer-in-Charge may order additional grout holes or a new line of grout holes to be executed.

(11) The general target of permeability of the grouted rock is 3 lugeon.

7.8.4.5 Protection of Drainage System During Grouting

The Contractor's grouting plan shall be such as to afford maximum protection against blockage of temporary and permanent drains. If necessary, the Contractor shall maintain a flow of water through the drains likely to be affected during grouting operations. Should leakage of grout into drains occur, the Contractor shall remove grout from the affected drains.

7.8.4.6 Fill Grouting

(1) After completion of consolidation grouting (and installation of the permanent drainage system where required), the entire system of temporary invert drains and sump pits in the tunnel shall be filled by grouting with a cement-sand

grout at pressures directed by the Engineer-in-Charge. During grouting operations the permanent drainage system shall be protected.

(2) The Contractor shall use a systematic procedure for fill grouting of the invert drains and sump pits to ensure displacement of water and complete filling of the drains.

(3) Fill grouting for void filling in the concrete lined hydraulic tunnels shall be as described in sub section 9.16.4 "Backfill Concrete" of Technical Specifications.

7.8.4.7 Closure of Holes and Clean-up

(1) Upon completion of grouting work each hole shall be filled with thick grout and connections not embedded in the concrete shall be removed. The drilled holes in the concrete lining shall be reamed or re-drilled to a 150 mm depth and cleaned with water, and the wet hole shall be filled with Cementitious Mortar conforming to EN 1504-3 (R4) as described in Chapter 9 "Concrete" section 9.15.3.1 "Cementitious Mortar", flush with the concrete surface. In the steel lined section the holes shall be closed as described in content 7.8.4.3 "Contact Grouting in Steel lined Pressure Shafts, Manifold and Penstocks" in this section.

(2) After completion of the grouting works the internal surface of the concrete or steel lining shall be cleaned and restored to its original condition.

7.8.4.8 Crack Grouting in Concrete Lined Tunnels

(1) Crack grouting shall be performed to seal the cold joints, construction joints, shrinkage cracks, honeycombs, poorly closed grout holes etc. in the structural concrete linings of underground structures as directed by the Engineer-in-Charge and as stipulated in Section "Concrete".

(2) Crack grouting shall consist of injecting a stable, cement-water mix through holes specially drilled into cracks or joints. Prevention measures shall be taken by plugging the joint with wooden wedges, cardboard, cement-gypsum mortar, or other suitable means to prevent the grout from flowing out of the crack.

7.9 MEASUREMENT AND PAYMENT

7.9.1 General

(1) The estimates of the quantities for drilling, water pressure testing, sampling, and grouting given in the Bill of Quantities are to be considered merely as a guide serving the Contractor to prepare his Tender and not as an accurate indication of the quantity of the work.

(2) The quantities for each of the pay items will be varied to suit the conditions disclosed in the course of the work, and the Contractor shall not be entitled to any extra payment over and above the Unit Prices entered in the Bill of

Quantities by reason of changes of the amount and length of holes to be grouted and amount of material absorbed, by reason of the location of the grouting required by the Engineer-in-Charge, or by reason of the timing of the grouting in relation to excavation, concreting or other works.

(3) The Unit Prices for drilling stipulated hereinafter shall apply regardless if drilling is performed by percussion or rotary drilling.

(4) Measurement for payment and payment for grouting will be made separately for 'placing grout' and for 'grouting materials'.

(5) Unit Prices for placing grout shall include, but not be limited to, the entire cost of labour, equipment, processing, mixing, hooking-up to the hole (where appropriate), injecting grout, testing, hole closures and clearing up, and shall be independent of the volume or weight of materials injected. Where multiple-stage grouting is employed, this item shall also include cleaning grout from the holes at the completion of a grouting stage. Each stage of grouting shall constitute one operation

(6) Unit Prices for grouting materials shall include, but not be limited to, the entire cost of supply, handling, transportation, storage, and testing.

7.9.2 Drilling

7.9.2.1 Drilling for Consolidation Grouting

(1) Measurement for payment for drilling of 45 mm dia grouting holes through any material for consolidation grouting, carried out either during the excavation or after placing of the concrete lining or after placing the tunnel plugs will be of the length of holes drilled in positions shown on the Drawings or established at the Site by the Engineer-in-Charge. Payment will be made at the Unit Price per linear meter entered in the Bill of Quantities, which shall include the entire cost of labour, equipment and materials for drilling and washing out of the holes, maintaining the holes free from obstructions until grouted, reaming or re-drilling the holes after completion of grouting and filling with Cementitious Mortar (EN 1504-3 (R4)). Payment of Cementitious Mortar (EN 1504-3 (R4)) will be made separately at unit price as entered in Bill of Quantities.

(2) Where drilling is required after placing of the structural concrete lining, measurement of the length of hole drilled shall include the theoretical thickness of the lining irrespective of whether the hole was actually drilled through the lining or formed by other means.

(3) When drilling of the hole is carried out successively for multiple-stage grouting, the measurement for payment will only be of the total length of the hole drilled actually in the rock or concrete. Any re-drilling required because of the Contractor's failure to clean the grout out of the hole before it has set shall be performed at the expense of the Contractor.

(4) Measurement for payment for any required re-drilling where the grout has been allowed to set at the direction of the Engineer-in-Charge will be of the actual length of re-drilled hole. Payment for this length in linear meters will be made in the form of an additional payment over and above that made for the original drilling at the rate of 50% of the appropriate Unit Price.

7.9.2.2 Drilling of Pressure Relief Holes

(1) Separate measurement and payment will be made for the following

a) Drilling and washing out of the hole,

b) Supply and installation of slotted PVC pipes / liner,

c) Supply and installation of drain holes outlet devices.

(2) Measurement for payment for drilling of pressure relief holes of 45 mm dia will be of the length of holes actually drilled in positions as directed by the Engineer-in-Charge. Payment will be made at the Unit Price per linear meter entered in the Bill of Quantities, which shall include the entire cost of labour, equipment and materials for drilling and washing out of the holes and for temporary casing, if required. The Unit Price shall apply irrespective of the location, inclination or direction of the hole.

(3) Measurements for payment of PVC pipe / liner of 36 mm dia installed in the drainage holes as directed by the Engineer-in-Charge will be of the length of pipe so installed. Payment will be made at the Unit Price per linear meter entered in the Bill of Quantities, which shall include the entire cost of supply and installation of perforated or non-perforated pipes, as well as all necessary couplings.

(4) Measurement for payment for the supply and installation of drain holes outlet devices will be of the number of outlets installed. Payment will be made at the Unit Price per piece entered in the Bill of Quantities, which shall include the supply and installation of all required accessories and sealing with mortar.

(5) Where re-drilling of the previously drilled drainage holes is required after an additional grouting, measurement for payment will be of the actual length of re-drilled hole. Payment for this length in linear meters will be made in the form of an additional payment over and above that made for the original drilling at the rate of 50% of the appropriate Unit Price.

7.9.2.3 Drilling of Exploratory Holes, Check Holes, and Holes for Instrumentation

(1) Separate measurement for payment and payment will be made for the following:

a) Drilling of holes 45 mm minimum diameter with or without core recovery.

b) Drilling of holes 76 mm minimum diameter with or without core recovery.

c) Drilling of holes 98 mm minimum diameter with or without core recovery.

d) Extra for core recovery

(2) Measurement for payment for drilling of exploratory holes will be of the length of holes of different diameters drilled in positions as directed by the Engineer-in-Charge. Payment will be made at the appropriate Unit Price per linear meter of drill holes of different diameter entered in the Bill of

Quantities, which shall include the entire cost of labour, equipment and materials required for rotary drilling of holes.

(3) Measurement for payment for core recovery when ordered by the Engineer-in-Charge will be of the length of the core hole. Payment will be made at the Unit Price per linear meter entered in the Bill of Quantities, which shall include the entire cost of labour, equipment and materials required for the core recovery, provision of core boxes, preservation and storage of cores, preparation of technical logs of the drill holes, provision of colour photographs of the boxes cores, and any assistance provided by the Contractor to the Engineer-in-Charge during the geological logging and handling of core boxes.

(4) The Unit Prices for drilling from the underground shall apply irrespective of the location, inclination or direction of the drilling.

(5) The Unit Prices for drilling from the surface shall apply for drilling at any inclination.

7.9.2.4 Drilling for Contact Grouting in Underground

(1) Measurement for payment for drilling the holes for contact grouting between the concrete and rock in the concrete-lined of underground structures will be of the length of holes drilled in positions shown on the Drawings or established at the Site by the Engineer-in-Charge, irrespective of the location or inclination of the hole. Payment will be made at the Unit Price per linear meter entered in the Bill of Quantities, which shall include the entire cost of labour, equipment and materials required for setting-up drilling equipment, drilling and washing out the holes, reaming or re-drilling the holes after completion of grouting, and filling with Cementitious Mortar (EN 1504-3 (R4)). Payment of Cementitious Mortar (EN 1504-3 (R4)) will be made separately at unit price as entered in Bill of Quantities.

(2) Measurement for payment for drilling the holes for contact grouting between the steel/concrete lagging and rock or in any other zone will be of the length of holes drilled in accordance with Engineer-in-Charge's instructions, regardless of the location, inclination, direction or diameter of the hole. Payment will be made at the Unit Price per linear meter entered in the Bill of Quantities, which shall include the entire cost of labour, equipment and materials required for setting up drilling equipment; drilling and washing out of holes, reaming or re-drilling the holes after completion of grouting, and filling with dry-pack mortar.

7.9.2.5 Drilling for Crack Grouting

No separate measurement for payment or payment will be made for drilling holes for crack grouting and sealing of cracks in the structural concrete lining and the cost thereof shall be included in the corresponding unit prices for the concrete lining in question.

7.9.2.6 Drilling for Curtain Grouting

(1) Measurement for payment for drilling of 45 mm dia grouting holes in rock / concrete will be of the length of holes actually drilled in positions as directed by the Engineer-in-Charge. Payment will be made at the Unit Price per linear meter entered in the Bill of Quantities, which shall include the entire cost of labour equipment and materials for drilling and washing out of the holes and for temporary casing, if required. The Unit Price shall apply irrespective of the location, inclination or direction of the hole.

(2) When drilling of the hole is carried out successively for multiple-stage grouting, the measurement for payment will only be of the total length of the hole drilled actually in the rock or concrete. Any re-drilling required because of the Contractor's failure to clean the grout out of the hole before it has set shall be performed at the expense of the contractor.

(3) Measurement for payment for any required re-drilling where the grout has been allowed to set at the direction of the Engineer-in-Charge will be of the actual length of re-drilled hole. Payment for this length in linear meters will be made in the form of an additional payment over and above that made for the original drilling at the rate of 50% of the appropriate Unit Price.

7.9.2.7 Water-Pressure Testing

(1) Measurement for payment for water-pressure tests will be of the number of tests satisfactorily performed, irrespective of size, length, or inclination of hole, or whether carried out in holes drilled from the surface or underground.

(2) Payment will be made at the Unit Price per test entered in the Bill of Quantities, which shall include the entire cost of labour, equipment, and materials used for carrying out the water-pressure test, the provision of test records and reports to the Engineer-in-Charge, and all costs associated with interruptions to the drilling caused by the intermittent nature of the testing work.

7.9.2.8 Embedded Pipes and Fittings for Grouting

(1) Separate measurement for payment and payment will be made for standard mild steel pipes and fittings in rock and concrete.

(2) Measurement for payment for such embedded steel pipes and fittings left permanently in place will be by weight, regardless of pipe diameter. Payment will only be made for pipes whose installation has been expressly ordered or approved by the Engineer-in-Charge or when shown on the Drawings. Payment will be made at the Unit Price per kilogram entered in the Bill of Quantities, which shall include the entire cost of supply, installation, and protection against blockage of pipes and fittings.

7.9.2.9 Non-Return Valve (NRV)

Measurement for payment for Non Return Valve (NRV) shall be paid in numbers entered in BOQ. The cost shall be inclusive of supply installation and testing.

7.9.2.10 Exclusions - Drilling

(1) All costs for drilling the holes for rock reinforcement (viz. rock bolts, rock anchors and grouted anchor bar etc.), pregrouting, forepolling, pipe roofing

and pre drainage holes are excluded from this Section and will be measured and paid for in accordance with provisions of the Section B.4 "Rock Supports".

(2) No extra measurement for payment or payment will be made for the following:

(a) Drilling through steel ribs, steel lagging, reinforcing steel or steel lining,

(b) Installation and removal of grout stub pipes,

(c) Reaming or re-drilling any holes through the concrete lining for the purpose of placing, and for supplying and placing, the dry-pack mortar,

(d) Holes which have been blocked and cannot be used because of cave-ins, lost drill rods or packers, or striking other obstructions (e.g. reinforcement bars), and drilling the new holes to replace them.

7.9.3 Placing Grout

7.9.3.1 Contact Grouting in concrete lined hydraulic tunnels, surge shaft, steel lined pressure shafts

(1) Measurement and payment for placing grout will be paid as number of operations, and payment will be made at Unit Price per grouting operation (Nos. of grouting operation is equal to nos. of holes upto 5m length) entered in the Bill of Quantities

(2) When contact grouting has been specifically ordered by Engineer-in-Charge, measurement and payment for placing grout will be paid as number of operations, and payment will be made at Unit Price per Grouting operation entered in the Bill of Quantities.

7.9.3.2 Fill Grouting

(1) Measurement for payment for filling the temporary drainage system in tunnel, or elsewhere, with grout will be of the length in which fill grouting has been completed to the satisfaction of the Engineer-in-Charge. Payment will be made at the Unit Price per linear meter entered in the Bill of Quantities, which shall include the provision of any standpipes, blockouts or extra drilling work required.

(2) Measurement for payment for fill grouting of exploratory or control holes where directed by the Engineer-in-Charge will be of the length of holes so grouted. Payment will be made at the Unit Price per linear meter entered in the Bill of Quantities.

(3) Unit rate of fill grouting shall include the cost of grouting material and entire cost of grouting operations.

7.9.3.3 Consolidation Grouting

(1) Measurement for payment and payment will be made for placing grout in holes

a) In single – stage grouting.

b) In multiple – stage grouting

(2) Measurement for payment for placing grout in a single stage will be of the number of holes injected with grout. Payment will be made at the Unit Price per hole entered in the Bill of Quantities.

(3) When multiple-stage grouting in holes, as directed by the Engineer-in-Charge, has been performed, measurement for payment and payment will be made for holes grouted in descending and in ascending arrangement. Measurement for payment will be of the number of stages in each hole injected with grout. Payment will be made at the appropriate Unit Price per stage entered in the Bill of Quantities.

7.9.3.4 Curtain Grouting

(1) Measurement and payment for placing grout will be paid as number of operations. Each grouting operation shall consist of a stage, normally 5 meters in length. The payment will be made at Unit Price per Grouting Operation entered in the Bill of Quantities.

7.9.3.5 Crack Grouting

(1) No extra measurement for payment or payment will be made for crack grouting and the cost thereof shall be included in the Unit Prices for structural concrete lining.

7.9.4 Grouting Materials

7.9.4.1 Cement

(1) Measurement for payment and payment for cement used for grouting (except for contact grouting in concrete lined hydraulic tunnels and fill grouting) will be of the quantity, by weight.

(2) When contact grouting has been specifically ordered by Engineer-in-Charge for lining of tunnels already executed by previous contractor, payment of cement used for grouting will be made at the unit price entered in the Bill of Quantities.

(3) Payment will be made at the Unit Price per metric ton entered in the Bill of Quantities, which shall include the entire cost of provision, delivery, transportation, storage and mixing, and complying with all requirements specified.

7.9.4.2 Sand and Bentonite

(1) Measurement for payment for sand and bentonite will be of the weight of materials with average natural water content, obtained from the mixing plant records or by other means approved by the Engineer-in-Charge.

(2) Payment will be made at the appropriate Unit Price per metric ton entered in the Bill of Quantities for each material which shall include the entire cost of provision, delivery, transportation, storage and mixing and complying with all requirements specified.

7.9.4.3 Admixtures

(1) Measurement for payment for admixtures will be of the weight of the agreed dosages established at trial mix stages or the approved modifications thereof.

(2) Payment will be made at the Unit Price per kilogram entered in the Bill of Quantities, which shall include the entire cost of supply, handling, storage, and dispersing.

7.9.4.4 Micro Fine Cement

(1) Measurement for payment and payment for micro fine cement used for grouting will be of the quantity, by weight.

(2) Payment will be made at the Unit Price per metric ton entered in the Bill of Quantities, which shall include the entire cost of provision, delivery, transportation, storage and mixing, and complying with all requirements specified.

7.9.4.5 PU Grout

(1) Measurement for payment and payment for PU grout used for grouting will be of the quantity of material used, by weight.

(2) Payment of PU grout, will be made at the unit price per Kg entered in the bill of quantities, which shall include the entire cost of provision, delivery, transportation, storage, mixing, pumping and complying with all requirements specified.

7.9.5 Exclusions - Grouting

(1) All costs for grouting of the rock bolts, grouted anchor bar, post-tensioned rock anchors are excluded from this Section and will be measured and paid for in accordance with the provisions of the Section "Rock Supports".

(2) No extra measurement for payment or payment will be made for following:

(a) Preparation and testing of trial mixes,

(b) Grouting materials used in contact grouting in the concrete lined tunnel except in the tunnel where the concrete lining has already been executed by the previous Contractor.

(c) Grouting materials used in mixture which has been prepared more than one hour prior to injecting or which have been lost due to improper handling or rejected due to improper mixing,

(d) Supply and injection of water

(e) Plugging and caulking leaks during grouting,

(f) Protection of drainage system, if any, during grouting,

(g) Communication facilities required during grouting,

(h) Closure of the holes as specified and clean-up,

(i) Preparation and submission of records and reports on grouting operations.

END OF SECTION B.7

SECTION B.9
CONCRETE

~~(Formwork, Reinforcement and Joints)~~

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List of Contents

SECTION B.9

CONCRETE

~~(Excluding Formwork, Reinforcement, and Joints)~~

9.1 SCOPE OF WORK

(1) The work under this Section includes all labour, materials, equipment, testing and services related to the concrete work to be carried out by the Contractor under this Contract.

(2) The concrete work shall be performed to the dimensions as shown on the Construction Drawings or as otherwise directed by the Engineer-in-Charge. Lift drawings shall be prepared by the Contractor.

(3) The Contractor shall cooperate with all other contractors and organisations related to the construction of Permanent Works where the material or equipment is to be fixed to, or embedded in the concrete structures.

(4) Formwork, reinforcement and shotcrete are covered separately in other Sections of these Specifications.

(5) The approval given by the Engineer-in-Charge to the Contractor's plants and equipment or their operation, or of any construction methods shall not relieve the Contractor of his full responsibility for the proper and safe execution of concrete work or any obligations under this Contract.

9.2 STANDARDS

(1) The standards and recommendations of Indian Standards Code of Practices shall be followed in respect of all materials, equipment and performances.

(2) The following Indian Standards are specifically mentioned:

IS: 8112 - 43 Grade Ordinary Portland Cement

IS: 12269- 53 Grade Ordinary Portland Cement

IS: 456- Code of practice for plain and Reinforced Concrete

IS: 383- Coarse and fine aggregates from natural sources for Concrete

IS: 2386 (Part-IV) - Method of testing of aggregates for Concrete Mechanical Property

IS: 5878 (Part-V) - Code of practice for Construction of tunnels conveying water: Concrete Lining

IS: 516 - Method of test for strength of Concrete

IS: 269 - Ordinary Portland Cement 33 grade

IS: 1489 – Portland - Pozzolana Cement Fly Ash based

IS: 1199 - Method of sampling and analysis of Concrete

IS: 457 - Code of practice for general construction of plain and reinforced concrete for dams and other massive structures

IS: 9103- Concrete Admixtures: Specifications

IS: 7861 (Part-I and Part-II) Code of practice for Extreme weather concreting. Recommended Practice (Hot weather and Cold weather concreting)

IS: 2505- Concrete vibrators – Immersion type general requirements

IS: 4031- Method of Physical test of Hydraulic Cement (Part-1 to 15)

IS: 4032- Method of Chemical Analysis of Hydraulic Cement

IS: 15388:2003- Silica Fume – Specifications

(3) In absence of relevant Indian Standards and specifications, the recommendations of "ACI Manual of Concrete Practice" and U.S.B.R. Concrete Manual shall be followed.

9.3 SUBMITTALS

9.3.1 Submittals Before Construction

(1) Submittals listed herein are related to items, which require the consent of the Engineer-in-Charge and are to be submitted by the Contractor before the appropriate work may proceed.

(2) Within 28 days from the date of issue of Letter of Acceptance but before procuring or mobilising to the Site the equipment, the Contractor shall submit to the Engineer-in-Charge updated and detailed plans and descriptions, consistent with those submitted with his Tender and any subsequent amendments and additions agreed to by the Engineer-in-Charge and the Contractor, of the following:

a) Aggregates Processing Plant:

Description, flow diagrams and drawings in sufficient details to indicate layout, type, numbers and capacity of crushing, screening, washing, conveying and other aggregate processing and handling equipment.

b) Batching and Mixing Plants:

Description, flow diagrams, numbers and drawings of the plants, and details of the equipment the Contractor intends to use to determine and control the amount of each separate concrete ingredient and mixing thereof into uniform mixture.

c) Concrete Cooling Plant:

Details of refrigeration and ice plants and methods which the Contractor proposes to use to comply with concrete temperature requirements.

d) Transport and Placing of Concrete:

Full details of the equipment and methods for transporting the concrete from the concrete plant to the final point of placing, including numbers, type and capacity of transport vehicles, concrete pumps, vibrators, collapsible & movable shutters and details of standby plants to be installed.

e) Mode and methodology of concrete compaction, and concrete curing,

f) Sampling and Testing of Materials:

List and details of equipment for sampling and testing, detailed program for quality control of concrete work, and qualification and experience of the proposed personnel.

g) Foundation and surface preparation equipment.

(3) At least 56 days in advance of any concrete work being carried out at the Site, the Contractor shall submit to the Engineer-in-Charge following notifications based on the results of the preliminary material testing.

a) Notification of the mill or mills from which cement will be obtained and whether cement will be ordered in bulk or bags. If cement is to be obtained from several mills, the estimated amount of cement from each mill and the proposed schedule of shipment shall be stated,

b) Notification of the source, analysis, method of delivery, and storage of water for concrete manufacture,

c) Notification of any admixtures and pozzolanas which the Contractor proposes to use, manufacturers thereof, and information about the chemical names of the principal ingredients and the effects of under or over dosage. Should the Contractor intend to use an accelerator in any concrete work for his own convenience, he shall give full details of the type, dosage, influence on construction, and the cost savings involved.

d) Details of the materials for formwork and surface finishes, treatment of construction joints, and construction techniques which the Contractor proposes to use in order to achieve the required concrete surfaces and allowable tolerances.

e) Details of special additives like silica fume for production of high performance concrete.

f) System, methods and equipment for prestressing steel and grouting of cables in prestressed concrete elements.

(4) At least 28 days prior to procuring or despatch to the Site of the particular item of work to which the submittal relates, the Contractor shall submit to the Engineer-in-Charge the following:

a) Details of curing compounds, if any,

b) Details of epoxy mortar for concrete repair.

(5) Drawings showing the location of construction joints proposed by the Contractor which differ from those shown on the Construction Drawings, including Formwork and reinforcement details, shall be submitted to the Engineer-in-Charge at least 28 days prior to commencement of work on that particular structure.

9.3.2 Submittals During Construction

(1) Contractor shall provide the Engineer-in-Charge with a weekly placing schedule giving the detailed location of the pours, the approximate extent of pours, and the date on which the concrete will be placed. This weekly programme of

concrete placement shall be submitted to the Engineer-in-Charge for his acceptance at least 2 days prior to the commencement of the week.

(2) Before commencement of the concrete placement the Contractor shall prepare a checklist regarding all preparations for the specified work such as rock surfaces and other foundations, cleaning, formwork, reinforcement, embedding, and submit this list to the Engineer-in-Charge, who after his satisfaction about the work preparations will permit the contractor in writing to commence concrete placement.

(3) The Contractor shall keep and make available to the Engineer-in-Charge records of the date, amount, and storage location of each delivery of cement and of the part of the Works in which it was used and shall provide facilities for checking the stock of cement.

(4) During the performance of the concrete work, the Contractor shall keep a diary where he shall record the construction procedures related to concreting. This diary shall be made available to the Engineer-in-Charge upon request. The records shall contain at least the following:

a) Commencement and termination of concreting of various parts of the structures,

b) Quantities and quality of aggregates and cement provided, and the storage from which they were drawn,

c) Temperature of air, water, cement, aggregates, and concrete,

d) Meteorological conditions and humidity of air,

e) Sampling and testing performed and summary of results,

f) Personnel employed during various stages of the concreting operation and name of the responsible inspector or foreman,

g) Equipment used,

h) Directives received from the Engineer-in-Charge,

i) Any special material or procedures employed.

(5) The Engineer-in-Charge reserves the right to require any additional information deemed necessary to be included in the submitted documents.

9.4 CONSTITUENTS OF CONCRETE

9.4.1 Cement

(1) The Contractor shall supply Ordinary Portland cement Grade 43 or Grade 53 conforming to the requirements of IS: 8112 or IS: 12269.

(2) The Contractor shall supply PPC conforming to IS 1489 Part-1. The Percentage of fly ash shall not be less than 30% in PPC. Average compressive strength of not less than 3 mortar cubes tested as per IS 4031 at 672 ± 4 hrs shall not be less than 43 MPa.

(3) Cement shall be procured from the cement sources/ plants approved by the Engineer-in-Charge. At least two sources/ plants shall be selected out of those intimated by the contractor so that one is a standby for any eventualities.

(4) Each consignment of cement delivered to the site shall be accompanied by a test certificate issued by the manufacturer in quadruplicate. The Engineer-in-Charge will have the right to attend the sampling and testing at the manufacturer's plant at any time, if delivery is not directly from the manufacturer, the intermediate storage and delivery arrangements shall be subjected to the approval of the Engineer-in-Charge.

(5) Cement which does not comply with relevant IS Code or is damaged in consignment, handling or storage shall be promptly removed from the Site.

(6) All carriers shall be clean and dry prior to loading with cement and shall be equipped with weatherproof closures on all openings. All facilities for transport and storage of cement shall be subject to approval of the Engineer-in-Charge and shall be such that easy access for inspection is assured.

(7) Sufficient storage facilities shall be provided at the batch plant to enable each new consignment of cement to be stored separately from cement received earlier and approved for incorporation in the work.

(8) Bulk cement shall be transported from the port or mill to the site in adequately designed weather-tight trucks, or other means where cement will be protected from exposure to moisture. Immediately upon receipt at the site, cement shall be stored in a dry, weather-tight and properly ventilated structure with adequate provisions for the prevention of absorption of moisture, and constructed in such a way that there will be no dead storage. The vents of the bins and silos shall be equipped with dust collectors to reduce loss of cement during handling and inconvenience to the personnel.

(9) Cement bags shall be stored in weatherproof buildings with a raised, well ventilated wooden floor, and placed so that each consignment can be segregated if required and used in order of its age. Bags shall not be stacked more than 1.5 m high. Cement shall not be stored outdoors, except for immediate use, and in such event shall be protected during storage and handling by waterproof covers and a raised floor. Unused cement shall be placed back into the storage buildings. Bulk storage bins or silos shall be emptied completely and cleaned of all cement accumulations every 3 months.

(10) Arrangements shall be made such that stocks of approved cement are adequate to meet the programme of work at all times. The programme shall allow time for testing and approval of each consignment before such cement is incorporated in the work.

(11) Cement shall be preferably used in same order in which it has been received at the Site. Cement shall be used on "first supplied" & "first used" basis. Storage of cement shall be limited to 90 days in bags and 150 days in bulk. Cement that has been in storage for longer than these periods or which may have absorbed moisture shall not be used unless it has been re-tested by the Contractor and approved by the Engineer-in-Charge. Cement that has become lumpy shall not be used. The cements coming from different mills or of different makes shall be stored separately.

(12) The temperature of cement upon arrival to the Site shall not exceed 70˚C and when entering the mixers shall not exceed 50°C unless otherwise approved.

(13) Fly ash (pozzolana) shall not be allowed to be mixed with cement at place other than factory/manufacturing unit. Fly ash (pozzolana) mixed at factory shall conform to IS: 3812 and IS: 1344.

(14) The Contractor is solely responsible for the timely supply of cement meeting the requirements of these Specifications and the Works. The delay due to lack of suitable cement will not give the Contractor any right for the extension of time for the completion of Works, or any claims resulting therefrom.

9.4.2 Aggregate

9.4.2.1 General

(1) Concrete aggregates shall conform to the requirements of IS: 456 and IS: 383. They shall be tested in accordance with the provisions of IS: 2386.

(2) Aggregates shall consist of clean, hard, dense, durable and uncoated materials, and shall have stable moisture content and grading when delivered to the batching plant. Aggregates shall not contain substances which may impair the quality of the concrete, attack reinforcing steel or reduce bond. The following substances are regarded as being harmful: loam, clay, pieces with large cavities, foam-like or vitreous pieces, and organic materials such as topsoil, roots, wood, coal, lignite, etc. The deleterious substances are defined in IS: 2386. In doubtful cases the effects of harmful substances shall be established by tests.

(3) Use of aggregates containing minerals which can cause alkali reactivity will not be permitted. Presence of such minerals in the stones to be used as aggregates will be determined by testing.

(4) The Flakiness and elongation indices of the aggregate as defined in IS: 2386 shall not exceed 25% individually. Rock which breaks down into such shape, regardless of the type of processing equipment used, will not be approved for use in the production of aggregates.

(5) The Contractor shall make provisions for crushing and processing of material in accordance with recommendations contained in IS:383 to meet the gradation and other requirements of these Specifications, in order to obtain the total amount of aggregate required for concrete manufacture. Crushing, screening and washing operations, benefaction of aggregates, and blending of crushed and natural aggregates shall at all time be subject to the consent of the Engineer-in-Charge.

(6) The handling, transporting, and stockpiling of aggregates shall be such that there will be a minimum amount of fines resulting from breakage and abrasion of material resulting from free fall and improper handling. Excess in any of fine or coarse aggregate sizes shall be disposed of in approved manner.

(7) The Contractor shall remove all rejected aggregate from the Site.

9.4.2.2 Source

(1) Coarse and fine aggregates shall be produced from suitable material obtained from required excavation for Permanent and Temporary Works and from the approved quarry and borrow areas shown on the Drawings and described in the

Information for Bidders, or from other sources as may be designated or approved in the course of the work.

(2) The Contractor shall carefully clear the area from which aggregates are to be produced of unsuitable materials and other objectionable matter. The area shall be operated so as not to affect the usefulness of the area. All materials removed from the area and not used in the work shall be disposed of as directed.

(3) Alternative sources developed by the Contractor shall be subjected to approval by the Engineer-in-Charge. The Contractor shall carry out tests to furnish satisfactory evidence that aggregates from such alternative sources comply with the requirements of this Section.

(4) The aggregate source shall be subject to the approval of the Engineer-in-Charge. However, such approval of source shall not be construed as acceptance of all materials to be taken from that source. The Engineer-in-Charge reserves the right to reject certain localised areas, strata, or channels within the approved areas and zones, when the material is unsatisfactory for use.

9.4.2.3 Fine Aggregates

(1) The term "fine aggregate" is used to designate aggregate in which the maximum size of particles is 4.75 mm.

(2) The gradation of fine aggregate shall be as given below:

Square Mesh Sieve Opening	Percentage Passing (by Weight)
4.750 mm	95-100
2.360 mm	80-100
1.180 mm	50-85
0.600 mm	25-60
0.300 mm	10-30
0.150 mm	2-10
0.075 mm	0-3

(3) The percentage of deleterious substance in the fine aggregate shall conform to IS: 383, except that the fine aggregate shall contain not more than 0.1% by weight of deleterious (reactive) ferrous sulphide. The total percentage of deleterious substance must not exceed 5% by weight.

(4) Fine aggregate having specific gravity of less than 2.6 shall be rejected. Fine aggregates, when subjected to soundness test with a solution of sodium sulphate, after five cycles of tests, shall not suffer a loss of weight in excess of 10 per cent.

(5) Fineness modulus of fine aggregate shall be 2.6 ± 0.4.

(6) Fine aggregate, upon delivery to the batching plant, shall have uniform and stable moisture content. The amount of moisture shall be less then 6% by weight, and shall not vary by more than 0.5% per hour.

(7) River sand shall not be used for concrete mix.

9.4.2.4 Coarse Aggregates

(1) The term "coarse aggregate" is used to designate aggregate, which is retained on sieve opening 4.75 mm. The coarse aggregate shall be well graded and its gradation will be decided based on the laboratory tests to obtain dense mass of concrete. The gradation will be approved by the Engineer-in-Charge before production of the concrete.

(2) Coarse aggregates shall be stored separately in stockpiles or bins in such a manner to avoid intermixing of different size of aggregates. The storing shall be done in following sizes:

4.75-10 mm

10-20 mm

20-40 mm

40-80 mm

80-150 mm

(3) The percentage of deleterious substance in the coarse aggregate shall conform to IS: 383, except that the coarse aggregate shall contain not more than 0.3% by weight of deleterious (reactive) ferrous sulphide.

(4) When subjected to following tests as specified in IS:383:2016, the coarse aggregate shall comply with following requirements:

	High Performance Concrete	**All Other Concrete**
(a) Aggregate Crushing Value	Less than 22%	Less than 30%
(b) Aggregate Impact Value	Less than 22%	Less than 30%
(c) Los Angles abrasion value	Less than 22%	Less than 30%

(5) When subjected to sodium sulphate soundness test, coarse aggregate shall not suffer a loss of weight in excess of 12% after five cycles.

(6) Coarse aggregate shall be hard, dense, durable, uncoated rock fragments. Rock having absorption greater than 3% or specific gravity less than 2.5 shall not be used.

(7) Aggregate delivered to the batching plant shall have uniform and stable moisture content.

(8) The nominal maximum aggregate size in relation to the structure dimension shall not be larger than:

a) 0.20 of the narrowest dimension between the sides of forms,

b) 0.75 of the minimum clear spacing between the reinforcing bars,

c) 0.25 of the slab depth.

9.4.2.5 Aggregate Storage

(1) Aggregates shall be stored in a manner so that each size of aggregate is stored separately & without intermixing, in free-draining piles in a manner that reduces breakage, deterioration, contamination and segregation to a minimum. Storage arrangements shall be subject to acceptance by the Engineer-in-Charge.

(2) The Contractor shall maintain sufficient aggregate storage at the Site at all times to permit continuous placement of concrete in accordance with the contractual time schedule and weekly placement schedule submitted by the contractor.

(3) The moisture content of aggregates shall be controlled as far as practicable, by wetting the stockpiles and by adequate drainage. All aggregate shall remain in a free-draining stockpile for at least 12 hours prior to use.

(4) The preparation of stockpile areas, the storage of processed aggregates and the disposal of any rejected material shall at all times be subject to the approval by the Engineer-in-Charge.

(5) Materials shall be removed from stockpiles by methods, which minimise segregation and crushing & do not result in intermixing. No fine aggregate from the bottom 500 mm of the stockpile shall be used for mixing concrete.

9.4.3 Water

(1) A reliable and adequate water supply shall be installed and maintained by the Contractor for washing of aggregates, manufacturing and curing of concrete. The water shall be clean and free from harmful quantities of oil, acids, alkalis, sugar, salt, silt and other organic matters and shall conform to IS: 456.

(2) Water shall contain not more than 1,000 mg/l of sulphates (SO_4), not more than 100 mg/l of chlorides (Cl), and shall have a turbidity limit of not more than 1,000 ppm.

(3) Adequate water storage shall be provided at the batching plant to ensure smooth concrete production.

(4) Contractor shall familiarise himself with source and quality of water available. Attention is drawn to the possible requirement of settling pond and other facilities that he may be required to provide.

9.4.4 Admixtures

(1) Admixtures shall be proposed by the Contractor and shall be used only upon written approval of the Engineer-in-Charge. Only admixtures that have been commercially used with satisfactory service in a similar type of concrete work shall be considered for approval. All admixtures shall be manufactured by reputable company(ies), supported by a fully staffed technical service organisation and research group.

(2) The Contractor may use the following admixtures when required with the approval of the Engineer-in-Charge:

a) Water-reducing, set-controlling admixture to improve workability without reducing the strength or durability of the mix,

b) Air-entraining agent (complying to IS: 9103),

c) Accelerating agent (alkali free) in the concrete, mortar or grout to increase the rate of hydration, shorten the setting time or increase the rate of hardening or strength development (complying to IS 9103).

d) Plastifying agents to increase the workability of concrete particularly in concrete for tunnel and for pumped concrete in general.

(3) Admixtures shall comply with the provisions of IS: 9103 and in case of lack of corresponding IS, with the ASTM Specifications C494 and C260.

(4) Admixtures shall be stored and handled so as to avoid contamination or damage to their properties by temperature or moisture changes or other influences.

(5) The quantity of admixture used and the method of mixing shall be strictly in accordance with the manufacturer's printed instructions, or as required to produce specified results and approved by the Engineer-in-Charge.

(6) The Contractor shall be held liable for any damages and difficulties resulting from the selection and use of admixtures such as delay in concrete placing or damage to concrete during forms removal, and shall not be entitled to any time extension or claims resulting herefrom.

9.5 CONCRETE MIX DESIGN

9.5.1 General

(1) Designations of concrete classes is based on the characteristic cube compressive strength (in Newton per square mm) and maximum aggregate size.

(2) The cube compressive strength is defined as the compressive strength of 150 mm cube as measured at 28 days. The strength shall comply with the requirements of IS: 456.

(3) The following table shows, in general, the anticipated classes of concrete required in various sections of work. The specific class of concrete to be used in each area will be shown on the Construction Drawings or designated by Engineer-in-Charge:

Class of concrete	Max. size of aggregates	Nominal Cement content	Max. slump	28 -day strength	Location
	(mm)	(kg/m^3)	(mm)	(N/mm^2)	
HPC (M70)	20	500	120	70	Glacis & wearing surface of spillway, ~~-bucket~~~~stilling basin in barrage bays~~, Invert of SFT and other wearing surfaces or as directed by Engineer-in-Charge
M45	40	425	120	45	Trunnion bracket, Padding concrete for pre-stressing in piers etc.

M35 (Self Compacting)	20	425	600 (min. Slump flow)	35	Selected locations for Second Stage Concreting around Embedded Parts, Block-out Concrete etc.
M35	40	375	100	35	Part pier of Dambarrage, etc.
M25	20	325	100/ 120	25	Cut-off wall, Beams, Columns, Slabs for Control room, DG room & Power pack room etc. and other locations as directed by Engineer-in-Charge
M25	40	300	80/ 120	25	Precast RCC guide wall, Capping of cut-off wall Bridge abutment wall, Parapet Wall, RaftBarrage Floor (raft), Part pier of Dambarrage,, Spillway glacis, Divide wall, Training wall, Head Regulator, Desilting Basin, Intake Structure including cut & cover, GOC-SFT, Road Bridge, Cladding Works, Toe wall, Precast/Cast-in-situ Concrete Blocks, Invert & overt RCC lining of HRT, overt of SFT etc.
M20	40	275	120	20	Tetrapods, Invert & overt of HRT and RCC lining of access tunnel, construction adits tunnel plug and other tunnels etc.
M15	40	210	50	15	Mass concrete in Retaining wall, Concrete in footings and backfill concrete, Adit to SFT & HRT outlet
M10	20	175	50	10	Levelling and Lean concrete
M10	80	150	50	10	Backfill in surface works

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(4) At least 4 months prior to commencement of any concreting of Permanent Works, the Contractor shall start the testing of materials, propose the composition of concrete mixes and prepare trial mix of each of the proposed concrete class. The Contractor shall prepare the trial mixes using the cement, water, aggregates and admixtures intended for the work and which conform to the requirements specified in this Section.

(5) Contractor shall determine, in accordance with IS standards and/or ACI Manual of Concrete Practice, the mix proportions for the designated classes of concrete. The contractor shall submit the test reports to the Engineer-in-Charge for approval. This preliminary test program shall include the determination of following parameters:

a) Cement properties,

b) Characteristics of aggregates,

c) Mix water properties,

d) Admixture properties,

e) Proportion of aggregate ranges in the mix,

f) Proportion of uncrushed to crushed aggregates,

g) Cement content,

h) Water-cement ratio (W/C),

i) Workability of concrete mixes,

j) Compressive and tensile strength,

k) Entrained air,

l) Density,

m) Water-tightness.

(6) These test shall be carried out until the concrete mixes show appropriate strength, workability, density and water-tightness without the use of excessive cement and water. The actual cement content in the mix design shall be optimised and justified by using cement of various manufactures during trial mix.

(7) To carry out these preconstruction tests, full-scale machine-mixed test batches shall be made and test samples taken therefrom. Tests shall be carried out well in advance so that complete and acceptable results are available before concreting of structures.

(8) Test samples shall be made in accordance with IS: 1199 and tested in accordance with IS: 516. The test results shall be analysed in accordance with IS: 456.

(9) The mixes for different classes of concrete shall be selected jointly by the Engineer-in-Charge and the Contractor and shall be approved by Engineer-in-Charge.

(10) During the progress of the work, the mixes may be changed whenever, in the opinion of the Engineer-in-Charge, such change is necessary or desirable to secure the required strength, workability, water-tightness, density, economy, or to limit shrinkage. The Contractor shall not change the approved mix proportions without the written permission of the Engineer-in-Charge.

(11) Water to be added to the mix shall be adjusted to compensate for any variation in the free moisture content of the aggregate as they enter the batch plant. Water

beyond the specified water-cement ratio shall not be added without the written permission of the Engineer-in-Charge.

9.5.2 High Performance Concrete

(1) This high performance concrete shall be obtained by adding silica fume in the concrete. Depending on the mix, design quantity of silica fume will be approximately 45 kg per cubic meter. Mix proportions to be used will be determined by trial mix design. Test samples shall be made in accordance with IS: 1199, tested as per IS: 516 and analysed as per IS: 456. Source of aggregate for high performance concrete shall meet the requirement of wearing surface and shall be as identified by Engineer-in-Charge.

(2) Silica fume shall comply with IS: 15388 or equivalent international standards. In addition, it shall meet the following requirements:

Chemical Requirement

- SiO_2 (Min. % by Mass) 85%
- Moisture Content (Max. % by Mass) 3.0%
- Loss on Ignition (Max. % by Mass) 4.0%
- Total alkali as Na_2O (Max. Percent) 1.5%

Physical Requirements

- Specific Surface (Min.) 15 m^2/g
- Oversize percent retained on 45 micron IS sieve (Maximum) 10.0%
- Oversize percent retained on 45 micron IS sieve, variation from average percent (Maximum) 5.0%
- Compressive strength at 7 days as percent of control sample (Min.) 85.0%

In addition to the standard requirements for individual materials, the blended cement and silica fume for high strength concrete shall comply with the following requirements (IS:4031 (3), (5), (6) and (10) and IS: 4032

- Min. compressive strength at 28 days 70 MPa
- Min. initial setting time 90 minutes
- Max. mortar shrinkage at 28 days 0.07%
- Max. sulphate content (SO_4) 5%
- Max. autoclave expansion 0.5%
- Max. CaO content 45%

The Contractor shall present the results of quality control tests carried on a representative sample by the supplier. Once approved, the silica fume shall only be

supplied from the same production plant. Deliveries shall be in impervious sacks weighing about 40 kg and shall be accompanied by manufacturers' quality assurance certificates.

9.6 QUALITY CONTROL

9.6.1 General

(1) The Contractor shall be completely responsible for performing detailed quality control program during the execution of the work. This quality assurance program shall be subject to inspection and checking by the Engineer-in-Charge.

(2) The Contractor shall keep records of test results, which shall be presented to the Engineer-in-Charge upon request.

(3) Should the Contractor wish to reduce his approved testing program he shall notify the Engineer-in-Charge of these changes 2 weeks in advance.

(4) Besides from Contractor's testing program the Engineer-in-Charge will make control test to the extent, as he deems necessary. The Contractor shall give all required assistance in sampling and provide for the proper storage and transport of the specimens to be tested by the Engineer-in-Charge.

(5) The Contractor shall make such arrangements or purchase new equipment should the test results prove that changes in the aggregates or concrete plant are necessary to obtain required concrete quality.

9.6.2 Site Laboratory

(1) The Contractor shall build, equip, and operate the site laboratory in which the tests included in the Quality Control Programme will be carried out. In some cases where special tests are required, they will be made in other specialised laboratories after approval by the Engineer-in-Charge.

(2) The laboratory shall be equipped with all the necessary equipment to carry out the tests indicated below.

a) Tests on aggregates as per IS: 2386 (Parts I, II, III, IV)

- Sieve analysis
- Compressive strength
- Specific gravity
- Water absorption
- Flakiness
- Sand equivalent
- Soundness and organic matter
- Los Angeles abrasion
- Impact test

b) Tests on cement

- Equivalent alkaline content (IS 4032)

- Specific Blaine surface (IS 4031 (6))
- Standard Mortar Compressive strength (IS 4031 (6))
- Shrinkage (IS 4031 (10))
- Heat of hydration (IS 4031 (9))
- Setting time IS 4031 (5))

c) Tests on fresh concrete

- Consistency through slump test (IS 1199)
- Workability
- Heat of hydration using thermometers, cells and recording instruments

d) Tests on hardened concrete

- Compressive strength on all classes of concrete (IS 516)
- Shrinkage IS 4031 (10))

(3) The site laboratory shall be properly air-conditioned and equipped with temperature and relative humidity recording instruments.

9.6.3 Concrete Sampling and Testing

9.6.3.1 Aggregates

(1) Aggregate samples shall be taken from silos at the batching plant or from the conveyor belt.

(2) The sampling shall be done at the frequency of one every 1,000 m^3 of produced concrete (cumulative of all concrete classes) and once a week at minimum.

(3) The following tests will be carried out:

- Sieve analysis
- Sand equivalent
- Cleanliness of gravel
- Flakiness of gravel
- Los Angeles abrasion
- Crushing value
- Impact value

9.6.3.2 Cement

(1) Quality control of cement shall first take place at the cement factory. This will be exercised by the factory itself under the supervision and the follow-up of the contractor who shall submit the copies of test results of cement to the Engineer-in-Charge for the final approval. The quality control program will be established jointly with the Contractor and shall be submitted for the approval of the Engineer-in-Charge. To ensure that this quality control program is properly

conducted, the Contractor shall post at the factory one of his officials, where necessary

(2) The requirements on the Site laboratory are stipulated in the Section "Site Installations and Services".

(3) Once a train/truck with trailer/ Heavy duty truck has been loaded at the factory and is ready for departure, six samples will be taken in six different cars and mixed in order to prepare one unique sample, which will be split into two parts:

- The first part will be analysed by the cement factory laboratory,
- The second part Sealed in a container, will be despatched to the Site laboratory.

(4) The following tests will be carried out at both laboratories and compared:

- Setting time,
- Expansion
- Specific Blaine surface
- Equivalent alkali content
- Standard mortar compressive strength
- Heat of hydration

(5) Furthermore, each week, a sample of cement shall be taken at the batching plant and the following tests shall be carried out:

- Setting time,
- Specific Blaine surface,
- Standard mortar compressive strength at 3, 7 and 28 days.

9.6.3.3 Admixtures

(1) All the admixtures to be used for concrete production shall be Alkali free and conform to relevant ASTM standards.

(2) Admixtures to be used for concrete production shall be tested for their suitability with the cement and other materials under actual working conditions. Each shipment of admixtures shall be tested for density and dry extract.

(3) Admixtures older than 12 months, (From manufacturing date), shall be tested for deterioration.

(4) Total lot of admixtures from which the tested sample failed the criteria shall be rejected.

9.6.3.4 Water

A sample of water will be taken from the concrete batch plant every 3 months and submitted to chemical analysis as described in IS: 3025.

9.6.3.5 Fresh Concrete

(1) The following tests shall be carried out by the Contractor on fresh concrete samples:

- Consistency (slump tests) on all concrete classes
- Air content,
- Temperature.

(2) These tests shall be carried out at the beginning of production of the concrete for each work or part of the work and for large quantities once every 100 m^3.

(3) All consistency tests shall be determined on that portion of the total sample, which passes a 40 mm size.

(4) Air content shall be determined in accordance with the established standard.

(5) One air test (0.006 m^3 capacity bowl) is required at the beginning of each shift, whenever a grade change occurs, whenever air test results are deviating from specifications and at 500 m^3 intervals for each class of concrete in production.

(6) Routine air tests as noted above will be determined on that portion of the total sample which passes a 40 mm sieve size.

9.6.3.6 Hardened Concrete

(1) Set of six samples for compressive strength tests at 7 and 28 days will be taken and tested for each part of the work, being defined as the volume poured in one concreting operation.

(2) For large concreting operations, this set of sample will be taken every 200 m^3.

(3) Compressive strength specimens shall be prepared by the Contractor and shall be performed in accordance with Indian Standards and Code of Practice.

(4) All coarse aggregate larger than one quarter the minimum dimension of the mould will be removed by wet screening. Portions of samples of concrete used for slump, air content, unit weight, etc. will not be used to mould specimens for compressive strength testing.

9.6.3.7 Analysis of Results

(1) The test results will include the different components analyses, the values obtained on fresh and hardened concrete and the characteristics of the corresponding batch given by the printer of the batching plant.

(2) The Contractor shall present regularly to the Engineer-in-Charge a synthesis of all the results in the form of tables, charts, statistical analyses (weekly and monthly reports).

9.6.3.8 Concrete Plant

Monthly checks, or when requested by the Engineer-in-Charge, of the concrete plant's weight-batching accuracy, including the accuracy of any admixture dispenser, shall be made by the Contractor in the presence of the Engineer-in-Charge. When checked by standard weights and volumes its accuracy shall be within 0.5% or as specified by the manufacturer.

9.7 ACCEPTANCE CRITERIA

9.7.1 Concrete Components

(1) The measured values shall be within the specified range of values indicated above.

(2) Any unsuitable material should be eliminated and the concrete manufacturing be suspended until the Contractor justifies that the replacing component is acceptable.

9.7.2 Fresh Concrete

Any controlled batch which will not satisfy the specified conditions in terms of consistency, air content and temperature, will be eliminated and concreting suspended until it is shown that corrections brought to the following batches are satisfactory.

9.7.3 Hardened Concrete

(1) The acceptance criteria for hardened concrete shall be as per IS: 456.

(2) If analysis of test cube results indicate poorer concrete in the structure as per the acceptance criteria of IS: 456, the Engineer-in-Charge will order the Contractor to provide core tests. Location and number of cores will be decided by the Engineer-in-Charge. The Contractor shall take out the specified sizes of cores from the structure.

(3) In case the concrete cores fail to meet the specifications and the Engineer-in-Charge is not satisfied with various tests results and quality, he will then instruct the Contractor for removal or subsequent suitable strengthening measures for such works.

9.8 BATCHING AND MIXING

9.8.1 General

(1) The Contractor shall provide, operate, and maintain at the Site automatic batching equipment to determine and control the amount of each individual material entering the concrete. Batching equipment shall be designed for such capacities which will permit performance of the concrete work in accordance with Contractual Construction Program.

(2) Water, cement, admixtures, fine aggregate and coarse aggregate shall be measured separately and not cumulatively. The accuracy of the measuring devices shall be maintained so that the indicated measure does not vary by more than 1 per cent from true measure throughout their range of use. The devices shall be capable of being operated to control the delivery of materials so that the combined inaccuracies in feeding and measuring do not exceed the following limits:

Material	Percent (by weight)
Cement	1
Water	1
Aggregates	3
Admixtures	1

9.8.2 Batching Equipment

(1) At the batching plant, standard certified test weights shall be provided and such other auxiliary equipment as may be necessary to check the operating performance of each scale or other measuring device. When required by the Engineer-in-Charge, operator shall make these tests in his presence. Unless otherwise required by the Engineer-in-Charge, check tests of equipment used for measuring water, cement, aggregates and admixtures shall be made at least every week. After completion of each check test, operator shall report the results to the Engineer-in-Charge and make such adjustment, repairs or replacement as the Engineer-in-Charge deems necessary to secure satisfactory performance before further use of the measuring devices.

(2) The batching equipment shall be capable of handling a minimum of three different sets of mix proportions concurrently, without having to reset scales manually, and recording the number of batches of each mix separately.

(3) Each measuring unit shall include a visible springless dial (metric) which will register the scale load at any stage of the measuring operation or shall include an over-and-under indicator which will show the scale in balance at no load when loaded to the beam setting. The masses of the components of each batch shall be automatically recorded and the records submitted to the Engineer-in-Charge at daily intervals.

(4) Each measuring indicator and volume measuring device shall be in full view of the operator, and the measuring equipment shall be arranged so that the operator may conveniently observe the operation of the bin gates, the materials discharging into the mixer and the concrete during mixing and discharging. The batch panel shall be equipped with chatter controls to control the dribble for each material batched and a volume selector capable of settings from 1 m^3 up to the mixer capacity in increments of 1 m^3.

(5) The batching equipment shall be so constructed and arranged that the sequence and timing of the batcher discharge gates can be controlled to produce an intermixing of the aggregate, water and cementing materials, as the materials pass through the charging hopper into the mixer. The batching controls shall be so interlocked that a new batching cycle cannot be started until all the weighing hoppers are completely empty.

(6) The operating mechanism in the water measuring device shall be such that no leakage will occur when the valves are closed and the discharge valve cannot be opened until the filling valve is closed.

(7) The device for adding admixtures shall be interlocked with the batching and discharging operation of the water so that the batching and discharging of the admixtures will be automatic. The device shall be capable of permitting the quantity of admixture being batched to be adjusted should this prove necessary, and shall be equipped with a suitable warning device to indicate when the level in the reservoir tank is low.

(8) A calibrated container shall be incorporated in each admixture holding system such that normally the admixture will bypass the container during batching. However, at any time it will be possible to direct the batched material into the container to check the accuracy of measurement.

(9) The batching equipment shall include an accurate recorder for providing a continuous visible record of the measurement of each separate material, including all added water and admixture.

(10) The measuring and recording equipment shall be supported on foundations independent of those for the mixing plant to prevent them from being affected by vibration.

(11) Effective communication system including telephone shall be provided between the concrete plant and the point of placement at all times, and such facilities shall also be available at either location for use by the Engineer-in-Charge as required.

(12) Volume batching will not be permitted.

(13) In case of use of fully automated batching plant, all the recording and indicating system intentioned above shall be available and on-line control of all components of the batching plant shall be provided.

9.8.3 Mixing

(1) Concrete shall be mixed in a power-driven stationary batch mixers of approved type and size. They shall be kept clean and in proper working order. The mixing blades in the drum shall be replaced when worn by 10% of their design dimensions.

(2) Movable truck mixers shall not be permitted for mixing concrete mixes.

(3) The batching plant shall be provided with a bypass such that the mix materials can be discharged directly into a transit mixer drum. This bypass is to be used only in emergency and with permission of the Engineer-in-Charge.

(4) The mixing equipment shall be capable of combining the aggregate, cementing materials, water and other ingredients, within the time hereinafter specified, into a thoroughly mixed and uniform mass, and of discharging the mixture without segregation.

(5) The mixers shall be so charged that some water will enter in advance of cement and aggregate and all materials shall continue to flow in as rapidly as possible. The construction of the mixers should prevent loss of materials during charging.

(6) The mixers shall not be charged beyond their rated capacities and the entire contents of the mixer shall be discharged before recharging.

(7) Unless otherwise authorised by the Engineer-in-Charge for mixers of 1m^3 capacity or less, the mixing of each batch shall continue for not less than +1.5 minutes as specified in IS: 456 (but not more than 5 minutes when mixing air-entrained concrete) after all materials, except the full amount of water, are in the mixer. For mixers of larger capacity, the minimum mixing time will be increased by 15 seconds for each additional 0.5 m^3. In this regard, the relevant clause of IS:456 may also be referred.

(8) The mixing time shall be increased when, in the opinion of the Engineer-in-Charge, the charging and mixing operations fail to result in the required uniformity of composition and consistency within the batch and from batch to batch.

(9) Mixers shall be rotated at the rate recommended by the manufacturer of the mixers.

(10) The arrangement for controlling, measuring and mixing operations shall be such that the operator may observe the concrete discharging from the mixer.

(11) Each mixer shall be equipped with a mechanically or electrically operated timing and signalling device for indicating and assuring the completion of the required mixing period and for counting the batches.

(12) Should a mixer at any time prove unsatisfactory, it shall be replaced or its use discontinued until it is made satisfactory.

(13) Each mixer shall be cleaned after each period of continuous operation and shall be maintained in such a condition that the mixing action will not be impaired.

(14) Where the distance between the batching plant and a concrete pour is such that it would in the opinion of the Engineer-in-Charge cause deterioration of mixed concrete in transit, any batching may be permitted using transit mix trucks in accordance with IS: 457. Water shall be added not later than 30 min after batching.

(15) On no account shall any addition be made to any component of a concrete batched once that batch has been mixed and discharged from the mixer, whether for the purpose of retempering or for any other reason.

(16) Batching and mixing of concrete shall not commence unless due notice, at least 24 hours in advance, has been given to the Engineer-in-Charge and written approval has been obtained for the placing arrangements, and for the preparation and accuracy of the part of the Works in which concrete is placed.

9.9 HOT AND COLD WEATHER CONCRETING

9.9.1 Temperature of Concrete

(1) The maximum permitted temperature rise in concrete and temperature distribution after placement will be determined by the Engineer-in-Charge based on the laboratory test performed prior to the start of concrete work using the actual cement, concrete mix proportions, and diffusibility for the concrete under consideration, or by actual field monitoring.

(2) As a general rule, the maximum temperature developed after placement should not be higher than 55-60˚C and the temperature difference within the pour or

lining should not exceed 20°C. For linings of tunnels, these values shall be limited to 50˚C for maximum heat of hydration, and 10˚C maximum temperature gradient in any section of the lining.

(3) The temperature of concrete when being placed in hot weather shall be as follows, unless otherwise permitted by the Engineer-in-Charge:

a) Mass concrete including 40 mm aggregate concrete plugs in construction adits not more than 12˚C,

b) Structural concrete and tunnel lining, not more than 20˚C,

c) All other concrete including reinforced concrete, not more than 30˚C.

(4) The Contractor shall supply and install thermocouples in the fresh concrete in the tunnel and perform temperature measurement

(5) The temperature of concrete when being placed in cold weather shall be as follows:

a) Mass concrete, not less than 7˚C,

b) Structural concrete, not less than 10˚C,

c) Structures thinner than 300 mm, not less than 13˚C.

(6) Cold weather conditions will be considered to be in effect when the mean daily temperature drops below 5˚C for more than 3 successive days.

(7) When temperatures above 10˚C occur during more than half of any 24-hour period, the concrete should no longer be regarded as "winter concrete", and normal concreting practice should apply.

9.9.2 Hot Weather Precautions

(1) The Contractor shall furnish, install, operate, and maintain equipment and make the necessary provisions in order to maintain the temperature of concrete, when being placed, below the maximum temperatures specified above.

(2) Following means shall be employed to attain the specified concrete temperatures:

a) Pre-cooling of coarse aggregate by sprinkling, immersion in cold water or with cold air blast,

b) Refrigerating the mixing water or adding the chip or flake ice as a portion of the mixing water,

c) Insulating the water tanks and water supply lines, cement silos, mix drums, exposed pipelines for pumped concrete and sheltering the aggregates,

d) Mixing and placing the concrete at night.

(3) Ice, when used for mixing water, shall be completely melted before mixing is completed.

(4) The temperature of concrete at the mixing plant shall be 2˚C lower than the placing temperature specified above.

(5) The Contractor's concreting operations shall be in accordance with the recommendations contained in IS: 7861 (Part 1).

(6) The use of liquid nitrogen in lieu of ice may be permitted by the Engineer-in-Charge after review of proposed details for its use submitted by the Contractor.

9.9.3 Cold Weather Precautions

(1) The contractor shall furnish, install, operate, and maintain equipment and make the necessary provisions in order to maintain the temperature of concrete, when being placed, above the minimum temperatures specified

(2) Following means shall be employed to attain the specified concrete temperatures:

a) Mixing water shall be heated under such a control and in sufficient quantity as to avoid appreciable fluctuation in temperature from batch to batch.

b) Insulating the water tanks and water supply lines, cement silos, mix drums, exposed pipelines for pumped concrete and sheltering the aggregates.

c) Mixing and placing the concrete at day.

(3) The Contractor's concreting operations shall be in accordance with the recommendations contained in IS: 7861 (Part II)

9.10 CONVEYING

(1) The method and facilities for concrete transport shall be selected by the Contractor within the limitations of these Specifications, and he shall be responsible for adequacy and suitability of the transporting system. The time elapse between mixing and the initial set of the concrete shall be taken into consideration. All methods used shall be reviewed by the Engineer-in-Charge.

(2) The concrete transporting methods and facilities shall be such that it will prevent segregation of coarse aggregate, excessive loss of slump, and loss of ingredients. Equipment such as transit mixers, buckets, cars, conveyers and pumping equipment which may be used for conveying concrete, shall be of such size, design and condition as to ensure an even and adequate supply of concrete at the placement area. All equipment shall be kept clean and in good working condition.

(3) The use of chutes to convey concrete will not be permitted, except that chutes less than 3 m in total length may be used immediately adjacent to or in the forms with acceptance of the Engineer-in-Charge. Where chutes are used, they shall be so constructed and arranged as to permit continuous flow of the concrete without separation of the ingredients.

(4) There shall be no vertical drop greater than 1.5 m, except where equipment satisfactory to the Engineer-in-Charge is used to confine and control the falling concrete.

(5) Concrete may be dropped through flexible elephant-trunk chutes, provided methods are used at the lower end to retard the speed of the falling concrete and prevent it from segregating. Where it is necessary to drop concrete from

more than 1.5 m it shall fall into a hopper with a capacity of 1m^3 more than the total capacity of the full trunk.

(6) Buckets for transporting concrete shall be manufactured as low slump concrete buckets.

(7) All conveying plant shall be supported independently of the forms, except as specifically permitted by the Engineer-in-Charge.

(8) The conveying plant shall be kept free from hardened concrete and foreign materials, and shall be cleaned at frequent intervals.

9.11 PLACING

9.11.1 General

(1) Contractor shall place concrete in a given location only after the Engineer-in-Charge has agreed with the placement of such concrete. All concrete shall be placed in presence of the Engineer-in-Charge. Concrete placed without prior knowledge and approval of the Engineer-in-Charge may be required to be removed and replaced at Contractor's cost.

(2) The Contractor shall furnish, install, maintain and operate a telephone system or radio, linking the points of placing concrete with the concrete batching and mixing plant. These facilities shall also be available to the Engineer-in-Charge at all times.

(3) When placing the concrete by pumping, direct communication shall be maintained between the concrete placing crew and the pump operators.

(4) In order to reduce bleeding, slump shall not be higher than necessary to achieve proper placement and consolidation. Concrete shall be placed before initial set has occurred, initial set time being determined in the laboratory.

(5) No concrete shall be placed when the atmospheric conditions are, in the opinion of the Engineer-in-Charge, such that proper placing and hardening of the concrete are not guaranteed. Specifically, the Contractor shall have the responsibility for meeting the hot and cold weather concreting requirements as outlined in clause 9.9 of this specification and for postponing concreting whenever such requirements cannot be met or, based on weather forecast, probably cannot be met. Even if the above requirements are fulfilled, the Contractor has the responsibility of delivering concrete product that meets specified requirements.

9.11.2 Preparation for Concrete Placing

(1) Concrete shall not be placed until all formwork, installation of embedded parts, reinforcing steel, and surfaces against which concrete is to be cast have been accepted by the Engineer-in-Charge.

(2) All surfaces of forms and embedded items that have become encrusted with dried material from concrete previously placed shall be cleaned of all such material before the surrounding or adjacent concrete is placed.

(3) Concrete shall not be placed in any structure until all water entering the space to be filled with concrete has been properly cut off or diverted by pipes, or by other means, and carried out of the forms clear of the work. Water shall not be allowed to stand on any concrete surface until it has attained its final set. Water flow over the concrete, which may injure the surface finish, will not be allowed.

(4) Pipes, conduits, dowels, ribs, wiremesh, rockbolts and other items to be embedded in concrete shall be so positioned and supported prior to placement of concrete to be stable and provide sufficient clearance (50 mm min.) between said items and steel reinforcement to allow proper concreting. Securing such items in position by wiring or welding to reinforcement will not be permitted.

(5) Where excavated surfaces which are to form the foundations for structural concrete, are absorptive or likely to become otherwise unsuitable, or where shown on the Construction Drawings, the Contractor shall place a 'levelling / lean concrete' consisting of a layer of Class M10 concrete 50 to 100 mm thick, as directed by the Engineer-in-Charge, uniformly over the foundation such that the upper surface is at grade elevation. Blinding concrete shall be placed before installing reinforcement or formwork.

(6) Immediately before concreting, the forms and all other surfaces which will be in contact with the fresh concrete shall be cleaned of all loose material and debris including shavings, wood chips, sawdust, pieces of wire, nails, fragments of hardened concrete and mortar. Clean-out holes which may be needed for this purpose shall subsequently be securely closed in order to obtain the required surface finish.

(7) The use of compressed air for cleaning will be allowed only if adequate precautions are taken to avoid the deposition of suspended oil on construction joint surfaces, reinforcement or other items which are to be bonded to concrete.

(8) The Contractor shall provide such personnel and equipment so that the performance of the concrete work is in a satisfactory manner. The transporting and placing equipment shall be clean and in good condition, adequate, and properly arranged to proceed with the placing without undue delays. The number and condition of vibrators for use and standby shall be ample for the requirements during placement. The lighting system shall be sufficient to illuminate the inside of the forms when concrete is placed at night.

(9) The Contractor shall have protective coverings available for fresh concrete surfaces if there is a possibility of rain, hail, sleet or snow.

(10) Rock or other surfaces against which concrete is to be placed shall be clean and free from oil, standing or running water, mud, loose rock, objectionable coating, debris, and loose or unsound fragment. Faults, fissures and seams shall be cleaned to sound rock, and if directed, backfilled with dental concrete, shotcrete or dry-pack as appropriate.

(11) Immediately before concrete is placed, all surfaces shall be cleaned thoroughly by the use of high velocity air-water jets, sweeping with brooms, wet sandblasting, bush-hammering, or other satisfactory means including combinations of the above.

(12) Rock or other surface against which concrete is to be placed shall be kept wet for at least 12 hours during the 24-hour period prior to placing concrete and

shall be in a damp condition at the time of placing, with all pools of water removed.

(13) Before placing the concrete for tunnel lining the following requirements should be met:

a) The excavated cross section profile shall be carefully checked to ensure the minimum lining thickness requirements and if necessary it should be corrected,

b) All loose rock which has been trapped by the wiremesh covering over the excavated surface shall be cleared and the mesh be repaired and if necessary replaced,

c) All timber supports, large wooden wedges used during the initial assembly and erection of steel supports or otherwise shall be removed,

d) Inverts of tunnel and shafts shall be totally cleaned of debris leaving sound rock. Wherever required, the Contractor shall use mechanical tools to loosen and remove all loosened and blast damaged rock.

(14) Before any concrete is cast against previously placed concrete, the surface of the old concrete shall be prepared as described in clause 9.13 "Construction Joints in concrete structures".

9.11.3 Placing and Compaction

(1) Concrete shall be carefully placed in designated position. Where dense reinforcement or deep forms may cause segregation of concrete while placing, suitable methods shall be used to prevent segregation. The free fall of concrete shall not exceed 1.5 m.

(2) Concrete shall be placed directly in its permanent position and shall not be worked along the forms to that position. Vibrators shall not be used to move concrete laterally.

(3) The addition of water into concrete after batching to compensate for stiffening of the concrete before placing shall not be permitted.

(4) All concrete, with exception of concrete tunnel lining, shall be placed in continuous approximately horizontal layers. The thickness of the layers shall not exceed 400 mm for mass concrete, and 500 mm for structural and all other concrete. Each layer shall be soft when a new layer is placed upon it so that no seams or planes of weakness within the section can form, and the two layers shall be made monolithic by penetration of vibrators.

(5) The Engineer-in-Charge reserves the right to order a reduced thickness of layers where the layers as stated above cannot be placed in accordance with the requirements of these Specifications.

(6) Time interval between successive lifts of mass concrete shall be determined by the Engineer-in-Charge. Nevertheless a minimum of 72 hours shall elapse between successive lifts.

(7) No concrete shall be placed under water except where shown on the Construction Drawings or specifically so required by the Engineer-in-Charge.

No concrete shall be placed in running water. Water shall not be allowed to rise over freshly poured concrete until final set has been achieved.

(8) Each layer of concrete shall be consolidated to the maximum practicable density, be free from pockets of coarse aggregate, completely fill all recesses in forms and around embedded parts, and be free of all voids. The concrete shall be compacted and worked into all corners and angles of the forms, around reinforcement and embedded items without permitting the component concrete materials to segregate.

(9) No layer of concrete shall be placed until the previous layer in the same lift has been thoroughly consolidated. Each layer of concrete within a lift shall be covered with fresh concrete as soon as possible, but certainly within the period when the lower layer is still capable of being revibrated so that successive layers can be thoroughly worked together.

(10) The maximum permissible time between the placing successive layers in a pour shall not exceed initial setting time of cement or 45 minutes, whichever is less, and shall be reduced to suit the temperature, humidity and job conditions. Concrete shall not be piled up in the forms in a manner that causes movement of the unconsolidated concrete, or permits mortar to escape from the coarse aggregate.

(11) On proposal of the Contractor and with the Engineer-in-Charge's approval, the concrete lining in tunnel may be placed as kerb first, followed by overt and invert with construction joints normal to the axis of the tunnel.

(12) Concreting of lining shall be carried out by concrete pump using methods which do not cause segregation or requiring remixing of the concrete. The point of discharge when concreting the crown above the springing line shall be kept buried sufficiently to allow enough pressure to be built up to completely fill the crown including areas of overbreak in the crown if any.

(13) Concrete shall be consolidated with the aid of approved immersion type mechanical vibrators complying with IS: 2505 or electric or air driven vibrators operating at a speed of at least 7,000 cycles/minute when immersed in the concrete. The vibrating equipment shall at all times be adequate in number of units and power to penetrate concrete as it is being placed, to the satisfaction of the Engineer-in-Charge. Vibrators with flexible operating shafts shall be used for reinforced concrete and for concrete in restricted forms. At least one extra vibrator in working condition shall be constantly on hand at each point of placement for emergency use.

(14) Application of the vibrators shall be made systematically and at such intervals that the zones of influence overlap and the concrete is properly compacted.

(15) Every vibrator shall be operated in a near vertical position and the vibrating head shall be allowed to penetrate under the action of its own weight. In consolidating each layer of concrete, the vibrating head shall be allowed to penetrate and revibrate the concrete in the upper portion of the underlying layers. Extreme care shall be taken to ensure that the vibrators do not touch or disturb the reinforcing, embedded steel or forms.

(16) To ensure even and dense surfaces which are free from aggregate pockets, honeycombing or air holes, it may be necessary to supplement internal vibration

with hand-spading along the boundaries of the concrete and around embedded parts while the concrete is plastic under the vibratory action, should slip forms be used, the equipment and methods shall be such that the finished concrete will be well consolidated and homogeneous.

(17) Contractor shall use any or all of the above methods of consolidation, if required, to produce the necessary finish. Form vibrators shall not be used unless the forms are designed for form vibration and unless specifically authorised by the Engineer-in-Charge.

18) Whenever Engineer-in-Charge orders for the extraction of cores to confirm that all the voids have been properly filled behind the concrete lining of tunnels etc., the contractor shall extract the cores and the cores shall be placed in wooden boxes marked with correct sequence and designated location of extraction.

9.11.4 Pumping Concrete

(1) Positive displacement pumping or other approved methods may be used to place concrete in locations approved by the Engineer-in-Charge. The type and arrangement of equipment shall be subject to approval, and the equipment shall be operated only by experienced persons. Pneumatic placing will not be allowed.

(2) The equipment and its method of operation shall allow the concrete to enter the forms at a low velocity.

(3) Concrete pumps and auxiliary equipment shall be in good condition and shall be maintained as such throughout the duration of the work. Thorough washing down of all parts that come in contact with concrete shall be performed after each concreting operation.

(4) Pump lines shall consist of rigid steel pipe or flexible pipe made of rubber, spiral-wound flexible metal or plastic, or combination of both. Use of aluminium pipe for pump lines shall not be permitted. Couplings shall be leakproof and strong enough to withstand handling during erection and poor support along the lines. They shall provide a full internal cross section with no constrictions of the smooth flow of concrete.

(5) Immediately prior to the start of all concrete pumping, the pump and pump lines shall be primed by pumping an approved grout mixture through the equipment.

(6) Concrete pumping operations shall be planned in such a way that concrete does not set before the succeeding layer is placed thereon. An adequate supply of fresh concrete shall be provided at all times.

(7) When placing the concrete by pumping in tunnel lining, the sides of the lining shall be brought up evenly through windows prepared in the formwork and care shall be taken equal pressure is maintained on the formwork. The crown shall be filled through the slick line running along the top of the formwork. This line shall be deeply buried in the concrete at all times. Identification marks to indicate the depth of burial shall be provided. The buried pumpline shall be withdrawn from the form gradually as the placement is completed. Air boosters shall not be permitted until slick lines are buried at least 1.5 m into fresh concrete.

9.11.5 Concrete in Blockouts, Second Stage in Restricted Locations, etc.

(1) All concrete required to be placed in blockouts to permit the installation and adjustment of mechanical and other equipment, around formed holes and second stage concrete in other locations shall be included in respective concrete as described in these Specifications.

(2) The concrete surfaces of blockouts and first stage concrete at other locations shall be chipped and roughened as described herein before second stage concrete is placed at such locations.

(3) Exceptional care shall be taken to placing concrete in blockouts in order to ensure satisfactory bond with concrete previously placed and to secure complete contact with all metal works in the blockouts.

(4) The roughening of the first stage concrete surfaces shall be attained by chipping or sand blasting as approved by the Engineer-in-Charge and in such a manner as not to loosen, crack or shatter any part of concrete beyond the roughened surfaces.

(5) After being roughened, the surfaces of concrete shall be cleaned thoroughly of loose fragments, dirt and the objectionable substances and shall be sound and hard to ensure good mechanical bond between the existing and new concrete.

(6) Second stage concrete shall be placed in lifts of not more than 3.0 m and concrete placement rate shall not exceed 1.5 m per hour except as otherwise approved by the Engineer-in-Charge.

9.12 FINISHING OF CONCRETE

9.12.1 General

(1) The quality of the surface finish shall be in accordance with the requirements for the particular class of finish specified hereunder. The finished surfaces of concrete shall be free from areas of honeycombs, segregation, loss of cement or fine material, from damage due to stripping of forms, from bolt holes, abrupt irregularities caused by movement of forms or components, loose knots and similar features, and bulges or depressions in the general plane of the surface.

(2) Only one type of formwork shall be used for all parts of a concrete structure which is visible from any direction.

(3) The classes of finish shall be as shown on the Construction Drawings, Technical Specifications or as directed by the Engineer-in-Charge.

9.12.2 Formed Surfaces

(1) The classes of finish for formed surfaces are designated by the use of symbol F and the shape of the Formwork panels required for concrete work shall be either plane (F1, F2, F3) or curved (F1C, F2C, F3C).

(2) Surface finishes and other variations in finishing of concrete shall conform to the tolerances indicated below:

Type of finish	General areas of application and method of forming	Tolerances (in mm)
F1, F1C	Formed surfaces of construction joints and other surfaces, which will not be permanently exposed. The surface will require no treatment after form removal other than repair of defective concrete and specified curing, or treatment as specified for construction joints.	+25 -10
F2, F2C	All permanently exposed formed surfaces. Immediately on the removal of forms all unsightly ridges or fins shall be removed; all holes left by removal of ends of form rods shall be neatly filled with mortar and surfaces treated to meet the required tolerances by tooling and rubbing.	+10 -10
F3, F3C	Formed surfaces, which will be exposed to flowing water. These surfaces shall be hard, smooth and dense, free from offsets, pits, voids, air holes and irregularities, and shall be chipped, ground and thoroughly cleaned as necessary to conform to the required tolerances.	+3 -3

9.12.3 Unformed Surfaces

(1) The classes of finish for unformed concrete surfaces are designated by the use of symbol U and shall be finished by screeding, floating and trowelling.

(2) Surface finishes and other variations in finishing of concrete shall conform to the tolerances indicated below.

Type of finish	General areas of application and method of forming	Tolerances (in mm)
U1	Unformed, screeded surfaces, which will be covered by, fill materials. Finishing shall consist of sufficient levelling and screeding to produce an even, uniform surface meeting the required tolerance.	+10 -10
U2	Unformed surfaces not concealed by fill. Floating by means of hand or power-driven equipment shall be started as soon as the screeded surface has stiffened sufficiently, and shall be the minimum necessary to produce a surface that is free from screed marks and that is uniform in texture.	+5 -5

U3	Unformed, screeded surfaces, which will be exposed to flowing, water. This finish shall be applied by steel troweling after the concrete has hardened enough to prevent excess of fine materials and water from being worked to the surface, free from blemishes, ripples and trowel marks. After the surface has nearly hardened, it shall be trowelled once more until the surface is hard and glossy in appearance.	+3 -3

(3) Interior surfaces shall be sloped for drainage where shown on the Construction Drawings. Exterior surfaces, which will be exposed to the weather, shall be sloped for drainage even if there is no such indication on the Construction Drawings. In such case the slope shall be at least 2% but not exceed 3%.

9.12.4 Tolerances for general concrete structures

General Areas of Application		Tolerances in mm
Variations of the constructed line or outlines from established position in plan	In 6 metres In 12 metres In 24 metres or more	12 mm 20 mm 30 mm
Variations of dimensions to individual structural features from established position	In buried construction	Twice the above amount
Variations from the plumb, from the specified batter or from the curved surface of all structures, including the lines and the surfaces, walls and vertical joints	In 3 metres In 12 metres or more In buried construction	12 mm 30 mm Twice the above amount
Variations from the level or from the grades indicated on the drawing	In 3 metres In 12 metres or more In buried construction	6 mm 12 mm Twice the above amount
Variation in cross sectional dimensions of columns, beams, buttresses, piers and similar members and variation in the thickness of slabs, walls and similar members		-6 mm +12 mm
Variation from plumb and level for sills and side walls for gates and similar watertight joints	Not greater than:	3 mm/3 m

9.12.5 Bush Hammer Finish

Bush hammer finish shall be applied on the surfaces when required by the Engineer-in-Charge. Bush hammering shall not commence until at least one month after placement of concrete. The tool used for bush hammering shall be electrically driven and have a head 3 cm^2 with 16 pyramid shaped teeth. The surfaces shall be finished at a rate of 250 to 400 cm^2/minute indenting the concrete surface approximately 2 mm.

9.13 CONSTRUCTION JOINTS IN CONCRETE STRUCTURES

(1) Construction joints are defined as concrete surfaces on or against which concrete is to be placed and to which new concrete is to adhere and which have become so rigid that the new concrete cannot be incorporated integrally with that previously placed.

(2) Construction joints shall be located in the positions shown on the Construction Drawings or as required by the Engineer-in-Charge and the Contractor shall not be permitted to form any additional joints or deviate from the joints indicated on the Drawings, without the written authorisation of the Engineer-in-Charge. Necessary rearrangement of steel reinforcement arising from such modifications shall be to the Contractor's debit.

(3) Horizontal construction joints shall be arranged, wherever possible, to coincide with joints in the formwork.

(4) Joints at exposed surfaces of concrete shall be straight and continuous. Feather-edged construction joints will not be permitted.

(5) The faces of vertical joints shall be shuttered with expanded metal or other approved rough material. The expanded metal shall be removed as far as possible, before the adjacent lift is poured. If required, the surface shall be cleaned by wet sandblasting and roughened by light bush hammering.

(6) The surface of construction joints upon or against which new concrete is to be placed and to which new concrete is to adhere shall be clean, rough, and free of water when covered with fresh concrete. The laitance, loose or defective concrete and foreign material shall be removed from the surface of existing concrete. The previous concrete lift shall be saturated by water but surface dry when the successive lift is placed.

(7) The surface of the hardened concrete shall be cleaned and roughened by wet sandblasting and washing thoroughly with air-water jet. Care shall be taken to prevent undercutting of aggregate in the concrete during sandblasting.

(8) Wet-sandblasting equipment shall be operated at an air pressure of approximately 7 bars. Sand to be used for blasting shall be dense, hard, not easily broken and sufficiently dry.

(9) In lieu of wet-sandblasting the Contractor may propose high-pressure water blasting utilising pressures not less than 400 bars, provided that such high-pressure water blasting produce equivalent results to those obtainable by wet-sandblasting.

(10) The horizontal surfaces of construction joints may be treated by cutting with an air-water jets ("green-cutting"). This shall be performed after the initial set has taken place but before the concrete has become too hard for effective cutting. The fresh concrete surface shall be cut with air-water jets to remove all laitance and to expose clean, sound aggregate. After cutting, the surface shall be washed with clean water. Care shall be taken that the treated surface does not become contaminated before new concrete is placed upon it. Should the surface become contaminated that a satisfactory joint with new concrete is not ensured the Contractor shall clean it by means of wet sandblasting.

(11) Water used in cutting, washing and rinsing of concrete surfaces shall be disposed of in such a way that it does not stain, discolour or affect exposed surfaces of the structures.

(12) When necessary, as determined by the Engineer-in-Charge, structural concrete placement in forms shall be started with an oversanded mix with 20 mm maximum size aggregate, an extra 50 kg of cement per cubic meter and a 100 mm slump. This mix will be referred to as a starter mix and shall be placed approximately 50 mm thick.

(13) Disturbance of the surface at a joint during the early stages of hardening shall be avoided, and traffic on the concrete will not be permitted until the concrete has hardened sufficiently to withstand such treatment without injury.

(14) All construction joints shall be kept continuously moist until they are covered with concrete, provided that, if it becomes necessary to delay the placement of new concrete on or against a construction joint for an extended period, moist curing of the surface of the joint may be discontinued at the expiration of the regular prescribed curing period. If the moist curing is so discontinued, it shall be resumed not later than 24 hours prior to the placement of new concrete against the joints.

15) The High ribbed permanent formwork (expandable sheet type material) shall be used to form the construction joints in concrete structure wherever required to produce monolithic construction. The material for permanent high ribbed shall conform to BS EN 10142.

9.14 CURING AND PROTECTION OF CONCRETE

(1) Plant for curing and protection of concrete shall be available at the location of each concrete placement before concrete placement is started. The water used for curing shall meet the requirements for water used for mixing concrete. The curing water temperature shall not exceed 25˚C.

(2) Exposed surface of concrete which has been finished as specified shall be protected from the direct rays of the sun for at least 2 days after placing. Freshly placed concrete shall be protected from damage by rainfall.

(3) Exposed surfaces shall be kept moist or the moisture in the concrete shall be prevented from evaporating for at least 14 days after placing by means of continuous sprinkling or spraying with water or by other methods approved by the Engineer-in-Charge.

(4) Care shall be taken not to disturb the steel reinforcement projecting from any placement for at least 24 hours after the completion of such placement.

(5) The Contractor shall not move any load on concrete surfaces, which in the opinion of the Engineer-in-Charge have not attained sufficient strength. In case loads are required to be moved, the Engineer-in-Charge may permit Contractor to do so on condition that Contractor provides the means for protecting the concrete surface subject to approval of the Engineer-in-Charge.

(6) The Engineer-in-Charge may permit the use of curing by means of membrane forming compounds. Sealing compounds proposed by the Contractor will be subject to sampling and testing and will have to be approved by the Engineer-in-Charge.

(7) Curing compounds shall be applied according to the manufacturer's recommendations to provide a continuous uniform membrane over all area. Curing compounds shall be applied only after moist curing has been carried out for at least 24 hours. Curing membranes shall be protected from damage at all times.

(8) Curing compound shall not be used on any unformed surface where, in the opinion of the Engineer-in-Charge, the irregularities in that surface would prevent the membrane forming an effective seal, on any surface which has a temperature lower than manufacturer's recommended application temperature, on any surface where a bond is required for additional concrete, or where a bonded surface coating is to be applied. Where a curing compound is placed on a surface where a bond is required, it shall be removed by sand blasting or by other means satisfactory to the Engineer-in-Charge.

(9) Concrete poured in tunnels to form tunnel linings shall be cured by membrane curing, as described above. Curing compounds used in tunnels shall not contain solvents, which may create hazardous conditions.

(10) Curing compounds used for surfaces exposed to view shall degrade completely when exposed to air for more than 3 months. They are to remain at least 80% impermeable for 1 month after application.

9.15 REPAIR OF CONCRETE

9.15.1 General

(1) Repair of damaged or defective concrete shall be performed by skilled workmen only, and in the presence of the Engineer-in-Charge. No repair work shall be carried out until the Engineer-in-Charge has inspected the location of the proposed repair and accepted the method of repair proposed by the Contractor.

(2) Contractor shall correct all imperfections on the concrete surface as necessary to produce surface that conforms to the requirements specified.

(3) Where concrete is exposed to flowing water or to weather, porous and fractured concrete and surface concrete to which additions are required to bring it to prescribed lines shall be removed by chipping openings into the concrete a minimum of 75 mm below the reinforcing or to the depth required by the Engineer-in-Charge if sound concrete is not encountered at 75 mm. Repair

areas shall be formed and area filled with fresh concrete. If the concrete section to be repaired contains no reinforcement, concrete shall be chipped to a minimum depth of 100 mm.

(4) The chipped openings shall be sharp edged and keyed and shall be filled to the required lines with fresh concrete or patching mortar, as approved by the Engineer-in-Charge. Where concrete is used for filling, the chipped openings shall not be less than 75 mm in depth and the fresh concrete shall be reinforced and doweled to the surface of the openings, as directed by the Engineer-in-Charge.

(5) Dry pack mortar for patching shall consist of 1 part cementing material, 2 parts by volume of regular sand, and just enough water so that after thorough mixing of the ingredients the mortar will barely held together when compacted by squeezing with the hand. The mortar shall be fresh when placed, and any mortar that is not used within 1 hour after preparation shall be wasted. Just prior to mortar application, the surface to which the mortar is to bond shall be kept wet for at least 2 hours, and then scrubbed with a small quantity of cement grout using a wire brush.

(6) When repairs are more than 25 mm deep, the mortar shall be applied in layers not more than 20 mm thick to avoid sagging. After each layer, except the last is placed, it shall be thoroughly roughened by scratching with a trowel to provide an effective bond with the succeeding layers. The last or finishing layer shall be smoothened with a trowel to form a continuous surface with the surrounding concrete. All patches on exposed surface shall be neat and smooth and as nearly as possible of the same colour as the adjoining concrete. All patches shall be thoroughly bonded to the surfaces of the chipped openings, shall be cured to the satisfaction of the Engineer-in-Charge and shall be sound and free from shrinkage cracks and drummy areas.

(7) For concrete surfaces where high velocity flows may occur, and as required by the Engineer-in-Charge, repairs to surfaces having F3 and U3 finishes shall be bonded with an epoxy adhesive approved by the Engineer-in-Charge and used in accordance with the manufacturer's instructions.

(8) All repairs to the surface of concrete required for flowing water shall be ground smooth to meet the tolerances specified for that surface.

9.15.2 Sealing Work in Concrete Lining of Underground Structures

(1) The Contractor shall carry out sealing work to reduce water inflow and water losses through, and to guarantee the normal water-tightness of the concrete lining of underground structures according to criteria stated hereafter and as directed by the Engineer-in-Charge.

(2) The work shall consist of sealing the cold joints, construction joints, wherever specified, shrinkage cracks both vertical and horizontal, honeycombs, and poorly grouted or sealed grout holes. The work shall be performed intermittently, whenever water inflows are observed and measured, wide cracks are discovered (especially after performance of tunnel pressure testing), or when the future impermeability is, in the judgement of the Engineer-in-Charge doubtful.

(3) The sealing work shall necessarily be carried out when following phenomena are encountered:

a) Water inflow equals or exceeds 1 litre/min measured at each single inflow source,

b) Any water inflow from grout holes and through honeycombs is unacceptable,

c) Cracks or joints, regardless whether they are dry or wet, of width greater than:

- 0.2 mm in tunnels and shafts containing reinforcing steel

- 0.5 mm in unreinforced stretches of tunnels or shafts

d) Areas of porous concrete (e.g. due to poor vibration) where depth of porosity is obviously deeper than superficial.

(4) The sealing work shall be executed as follows:

a) Crack or joint 0.2-0.6 mm wide shall be repaired as stipulated in the Section "Drilling, Grouting and Pressure Relief Holes".

b) Crack or joint wider than 0.6 mm shall be repaired as under (1) above, followed by cutting a groove 25 x 25 mm along the joint or crack and subsequent filling with an epoxy mortar.

c) Wet joint may also be sealed by applying the "Oberhasli Method", which consists of cutting a groove as for the dry joint and by collecting the seepage water into one or several flexible plastic pipes. As soon as the groove is without running water shall be filled with a quick-setting mortar and, after its hardening, followed by pumping the cement-bentonite-water slurry through the plastic pipes.

d) Areas of porous concrete shall be grouted under high pressure (30 bar) with cement grout mix W/C=0.7, by weight, containing suitable water-reducing air-entraining admixture. Grout holes shall be drilled at 500 mm spacing into the rock. After grouting, the area shall be repaired with epoxy mortar.

e) Poorly Grout holes filled only with water/cement mix shall be redrilled up to 2/3 of the theoretical lining thickness and filled with dry-pack mortar.

9.15.3 Structural Repair Works/ Closure of grout holes with cementitious mortar

9.15.3.1 Cementitious Mortar

(1) The material shall be cementitious mortar conforming to EN 1504-3 (R4). The properties/ performance characteristics of the cementitious mortar are as follows:

SL NO.	PERFORMANCE CHARACTERISTIC	TEST METHOD	REQUIREMENT BASED ON EN:1504-3(R4)
1.	Compressive strength	EN:12190	≥ 45 MPa
2.	Chloride ion content	EN:1015-17	≤ 0.05%

3.	Adhesive bond	EN:1542	≥ 2.0 MPa
4.	Carbonation resistance	EN:13295	$d_k \leq$ control concrete [MC(0,45)]
5	Elastic modulus	EN:13412	≥ 20.0 GPa

9.15.3.2 Structural Repair Works

9.15.3.2.1 Surface Preperatio:

Remove loose, delaminated or unsound concrete to obtain a keyed surface by non-impact/ vibrating cleaning methods like compressed air/ high pressure water blast/ sand blast, chipping, wire brush or other means as per site requirement. Remove dust, micro fractured particles and foreign material from the repair area by pressure washing or other suitable means necessary to clean surface to obtain desired bond. If reinforcing steel is visible, the same shall be cleaned all around. The surface shall be prepared as per manufacturer's recommendation.

9.15.3.2.2 Execution

(1) Manufacturer's guidelines shall be followed for application procedure. The structural repair work of concrete (10mm - 50mm) on surface of concrete structures shall be performed with Cementitious Repair Mortar conforming to EN: 1504-3 (R4). The material shall also be suitable for application on vertical surface.

(2) The mix shall conform to manufacturer's specifications. The quantity of water shall conform to the recommended mix design of manufacturer. The water shall be measured with calibrated container. The ready to use mix shall not contain any lump of unwanted filler and shall be uniform in colour. Best results are achieved using a mechanical mortar mixer with low speed continuous blending. For small quantities of material a paddle mixer can be substituted.

(2) Saturate the area to be repaired with clean water. The surface must be mat-damp, but without standing water. Apply slurry coat/ scrape coat of repair mortar or primer onto the prepared wet surface as required. Thereafter apply full coat of repair mortar up to the desired thickness, line and level while previous coat is still wet within the specified time. The top surface should be smoothed with a trowel or finishing by float or sponge as soon as the mortar has begun to stiffen. However, the application of material shall conform to manufacturer's specifications.

(3) Curing for 3-7 days is essential to obtain optimum quality and durability of the repair mortar. For moist curing, apply continuous source of moisture by spraying or wet burlap and or other suitable means.

9.15.3.3 Closure of grout holes in Tunnel

Upon completion of grouting work each hole shall be filled with thick grout and connections not embedded in the concrete shall be removed. The drilled holes in the concrete lining shall be reamed or re-drilled to a 200mm depth

and cleaned with water, and the wet hole shall be filled with Cementitious Mortar conforming to EN 1504-3 (R4).

9.15.4 Epoxy mortar for repair of concrete (Based on ASTM C881 TYPE-IV CLASS C)

9.15.4.1 Material

The epoxy mortar shall comprise of epoxy binder and aggregate/filler.

(1) **Epoxy binder for Epoxy mortar**: Epoxy binder shall be 2-components epoxy resin bonding system (Resin & Hardener) conforming to ASTM C881 TYPE-IV CLASS C. The mechanical properties of Epoxy binder (Neat Resin System) shall be as below:

Sl No.	Performance Characteristics	Test Method	Requirement
1.	Compressive strength after 7 days	ASTM D-695	≥ 70 MPa
2.	Tensile strength after 7 days	ASTM D-638	≥ 50 MPa
3.	Bond Strength after 14 days	ASTM C-882	≥ 10 MPa

The epoxy-resin bonding systems for application to Portland cement concrete shall be applicable under humid conditions and bond to damp surfaces. The system shall be suitable for use during placement at temperature 15°C and above (Class C) as per manufacturer's recommendation.

(2) Aggregate/ filler for Epoxy mortar: Quartz sand/ filler material for use in preparation of mortar shall be dry, clean and well graded as per manufacturer's specification.

9.15.4.2 Surface preparation

Remove loose, delaminated or unsound concrete to obtain a keyed surface by non-impact/ vibrating cleaning methods like compressed air/ high pressure water blast, chipping, wire brush or other means as per site requirement. Remove dust, micro fractured particles and foreign materials from the repair area by pressure washing or other suitable means necessary to clean surface to obtain desired bond. If reinforcing steel is visible, the same shall be cleaned all around.

9.15.4.3 Execution

(1) The mix proportioning/ ratio of the components shall conform to manufacturer's specifications. These ratios shall be expressed by weight. Primer/ coating and mortar shall be prepared separately.

(2) Primer/ coating application: The respective material components i.e. resin and hardener shall be mixed by weight. Mixing shall be done for at least 3 minutes with a mechanical mixer to obtain a homogeneous mix and uniform

colour. Aeration while mixing shall be avoided. The whole mix shall be poured into a container and stirred for a minute to expel out the entrapped air. The primer shall be prepared upto that quantity which can be used within its pot life.

(3) Mortar application: First of all, the resin and hardener shall be mixed and then filler/ sand shall be added slowly until it achieves uniform consistency. Quantity of sand shall be 5-6 times the weight of epoxy binder (resin + hardener) or as per direction of Engineer-in-Charge.

(4) The material as per specification is suitable for application at temperature of 15˚C and above. If the temperature of the substrate concrete is lower than 15˚C, it should be heated to achieve the desired temperature by electric heater or any other suitable means. The prepared surface shall be primed with neat epoxy binder. For proper coverage, priming shall be kept as specified by the manufacturer. Primer coat shall be applied on the cleaned surface with brush or other suitable means. The coverage of primer coats shall be as specified by the manufacturer. Prepared epoxy mortar (with graded quartz sand) shall be placed before primer becomes tack-free. Epoxy mortar shall be placed using trowels in minimum thickness layer of 6mm or as specified by the manufacturer. The mortar shall be compacted and leveled with trowels.

(5) Subsequent layer of epoxy mortar shall be applied as per advice of Engineer-in-Charge and authorized applicator.

(6) Seal coat shall be applied by neat epoxy binder as per ratio/ coverage given by manufacturer, if required.

9.15.5 Crystalline material as water proofing treatment works

(1) Crystalline material comprising of proprietary active hydrophilic chemical is a permeability reducing admixture. The active ingredients of this material react with cement and water particles present in concrete to form calcium silicate hydrate (CSH) and pore blocking precipitates in the existing micro cracks and capillaries. The resulting crystalline deposits develop throughout the depth of concrete and become integral part with hydrated cement paste. The resulting concrete gets significantly increased resistance to water penetration under pressure. The hairline cracks if again develop, crystalline admixtures continue to activate in the presence of moisture and seal the additional gaps. It has been reported that once fully cured crystalline systems can withstand hydrostatic pressure of about 122m of head. This admixture is best suited under moist/ underwater conditions.

(2) The crystalline slurry are used for waterproofing treatment by applying to concrete structures like retaining walls, water tank, tunnels, surge shaft, etc. by mixing in ratio of 5:2 (5 parts integral crystalline slurry: 2 parts water) for vertical surfaces and 3:1 (3 parts integral crystalline slurry : 1 part water) for horizontal surfaces and applying the same from internal\external side with the help of synthetic fiber brush. The material shall meet the requirements as specified in ACI-212-3R-2010 i.e. by reducing permeability of concrete by more than 90% compared with control concrete as per DIN 1048 and resistant to 16 bar hydrostatic pressure on negative side. The crystalline slurry shall be capable

of self-healing of cracks up to a width of 0.50mm. The work shall be carried out all complete as per specification and the direction of the Engineer-in-Charge. The details of this product are available in the Delhi Schedule of Rates (Code no. 22.23).

(3) Crystalline mortar are used by mixing in the ratio of 4.5 : 1 (4.5 parts crystalline mortar : 1 part water) for the treatment of construction joints, cracks, tie rod holes and spalled & honeycombed surface of PCC/ RCC surface and underground structures like Dam~~Barrage, Head Regulator~~, Desilting Chamber ~~Basin~~, Intake structure, tunnels, basement, water tanks etc. to ensure water tightness. The crystalline mortar shall conform to the EN 1504-3 having compressive strength Class R4 > 45 MPa and adhesive bond strength Class R3 > 1.5 MPa. The work shall be carried out all complete as per specification and the direction of the Engineer-in-Charge. The details of this product are available in the Delhi Schedule of Rates (Code no. 22.25).

(4) Crystalline mortar used for sealing cracks and faulty construction joints, by preparing the surface, making U-shape groove size of 25x25mm and then priming the surface with integral crystalline slurry @0.05kg per running meter and while the surface is tacky then filling the groove upto top edge with crystalline mortar @1.50kg per running meter. Once crystalline mortar is touch dry then finally applying two coats of integral crystalline slurry @0.05kg per running meter per coat on treated surface.

(5) Crystalline mortar used for patching of tie rod holes, preparing tie rod hole surface and then priming the area with integral crystalline slurry @0.070kg per sqm and while the surface is tacky, repairing and then filling the tie rod holes with crystalline mortar @0.040kg per hole. The crystalline mortar shall be tightly rodded into tie rod holes or packed tightly (For 25x25x25 mm tie rod hole, use 0.040 kg to fill the hole).

9.16 PARTICULAR REQUIREMENTS FOR INDIVIDUAL CONCRETE STRUCTURES

9.16.1 Concrete in Dam Spillway Glacis and Bucket~~Barrage and Desilting Basin~~ Complex

1) Concrete used for construction of the dam spillway glacis & bucket ~~barrage & desilting basin~~ complex shall be as specified in the construction drawings, Technical specifications or as directed by Engineer-in-Charge.

2) Before placing any concrete in these structures, the foundation shall be wetted up to saturation and compacted to achieve a relative density of 80%. Any troughs or ditches in the foundation shall be filled with approved material and compacted to achieve the same relative density as in the adjoining areas of the foundation. A levelling concrete layer shall be placed before installing the reinforcement in the dam ~~barrage / head regulator/ desilting basin /~~ intake floors. In foundations, where the excavation below the theoretical lines and grades exceeds acceptable limits, as determined by the Engineer-in-Charge, the Contractor shall place levelling / lean unreinforced concrete of a grade approved by the Engineer-in-Charge over the foundation in such thickness that the upper

surface is at the theoretical grade elevation. Surface shall be roughened before placing the structural concrete.

3) While concreting the u/s & d/s floor of the dam~~barrage~~ and the other heavily reinforced structures, adequate precautions shall be taken by the contractor so that the concrete does not remain sticking to the bars. The reinforcing bars shall be cleaned of any concrete, mortar grout or laitance before they are embedded in concrete.

4) The contractor may be required to place lift dowel bars and these bars shall also be kept free of any concrete droppings on their surface. The reinforcing bars shall be cleaned immediately before placement of the next layer of concrete.

5) The water shall not be allowed to accumulate on the previous lift of poured concrete. The same shall be removed and the surface cleaned of any mud, clay or other objectionable material before concrete of the next lift started.

6) Suitable pumps shall be kept handy at the time of concreting, so as to remove any water that may accumulate on the surface irregularities and the surface shall be wiped dry.

7) No construction joints other than those shown on the construction drawings shall be allowed in the structures, unless otherwise approved or directed by the Engineer-in-Charge. In case such joint is permitted, additional steel reinforcement shall be placed across the joint and the joint surface shall be shuttered with expanded metal.

8) Contraction joints shall be executed at the distance shown on the drawings. The surface of the joints shall be painted with bituminous coat or other approved bond breaker.

9) All movement joints exposed to flowing water shall be chamfered 1:1 on upstream side and 1:8 on downstream side as the case may be.

10) The top layer of the spillway glacis and bucket concrete shall be terminated approximately 1000 mm below the final surface to provide room for placing the special concrete to increase the abrasion resistance of the structure. Similarly, in the walls which will come into contact with rapidly flowing water recesses will be blocked out to a depth of 300-500 mm and height of approximately 2 m.

11) This high performance concrete shall conform to clause 9.5.2 of this section.

12) The concrete surface finishes in the dam~~barrage & desilting basin~~ complex shall be F3, F3C, U3 and U3C. For surfaces in contact with high velocity water flow the compressible surface irregularities shall not exceed the following values:

	Abrupt	Gradual
Measured along a line parallel to flow direction	5 mm	10 mm
Measured along a line transverse to flow direction	3 mm	6 mm

13) Abrupt irregularities are offsets caused by displaced or misplaced from sheathing or lining or from sections, or by loose knots in forms or otherwise defective form lumber. They shall be tested by direct measurements.

14) Gradual irregularities are all other irregularities and shall be tested by a 2m long template. The templates will be a straight edge for plane surfaces or a “shaped” template for curved or warped surfaces.

15) Furthermore the following shall apply if not otherwise shown on the construction drawings or directed by Engineer-in-charge:
   a) Abrupt irregularities parallel to flow direction shall be eliminated completely by grinding to bevel of 1 to 20 ratio of height to length.
   b) Abrupt irregularities transverse to flow direction shall be eliminated completely by grinding to bevel of 1 to 50 ratio of height to length.

9.16.2 Concrete Gravity Structures

1) Concrete used for the construction of mass concrete gravity structures shall be class M15/A40 as specified in construction drawing or as directed by the Engineer-in-Charge. However, surface exposed to weathering and standing or flowing water shall be constructed of higher class concrete as indicated on the Construction Drawings. Where higher strength concrete is used, part of each lift will therefore normally be composed of two classes of concrete. Water-cement ratio shall not exceed 0.45.

2) Reinforcement shall be provided at the surfaces in contact with standing or flowing water and at all openings in mass concrete.

3) Mass concrete of retaining wall shall be water cured for at least 10 days unless otherwise directed by the Engineer-in-Charge. When curing compound is used as a bond breaking membrane at contraction joints, it shall be also considered acceptable in meeting the curing requirements.

4) Where the over break in excavation below the theoretical lines and grades exceeds acceptable limits, as determined by the Engineer-in-Charge, the Contractor shall place blinding unreinforced concrete class M15/A40 over the rock foundation in such thickness that the upper surface is at the theoretical grade elevation. Surface shall be roughened before placing the structural concrete.

9.16.3 Concrete Linings of Tunnels

(1) Concrete used for the construction of the linings of tunnels shall be as specified on the Construction Drawings or as directed by the Engineer-in-Charge.

(2) The Contractor's proposed method of concrete placement is subject to the approval of the Engineer-in-Charge.

(3) The vault and invert of the head race tunnel lining, as well as in the construction and/or permanent access adits shall be cast in separate operations. The Contractor shall propose the sequence of the casting operations. The proposed method of concrete placement is subject to the approval of the Engineer-in-Charge.

(4) The tunnel lining shall either be poured in sections or by "continuous pouring". If the Contractor wishes to use the latter method, then he shall first satisfy the Engineer-in-Charge that the concrete production, transport and placing equipment to be used has sufficient capacity to produce and handle the amount of concrete necessary for continuous pouring of the lining sections. In addition, the Contractor shall provide details of the steps to be taken in the event of an interruption in the concrete supply.

(6) The number of vertical construction joints shall be reduced to minimum. Inclined construction joints will have the naturally running slope of placed concrete. In addition to treatment as specified in aforesaid "Joints in Concrete Structures", in case of inclined construction joints, the concrete in the crown and the invert shall be removed prior to placing of the next stage to avoid an acute angled construction joints relative to the inside surface of the tunnel lining concrete. No mortar layer will be required on the inclined construction joints in tunnel lining.

(7) Prior to concreting, the rock surface shall be cleaned and shall be free from oil, mud, loose rock, objectionable coating, debris and loose or unsound fragments. All surfaces shall be cleaned with air-water jets or by other satisfactory means. Particular attention shall be given to the drainage of flowing, and the removal of standing water where concrete will be placed.

(8) The Engineer-in-Charge will determine the extent of the steel reinforcement required in the concrete lining, based on the results of the rock mechanics test, if any, performed in the excavated tunnel. Generally reinforcement will be used where weak rock and/or high permeability is encountered and crack control is required.

(9) At any point where an inspection (e.g. by coring or sounding) indicates that a cavity exists between concrete lining and the surrounding rock, as determined by the Engineer-in-Charge, the Contractor shall backfill the voids with grout at no additional cost to Employer. The grout mix and grouting pressures shall be as directed by the Engineer-in-Charge. After grouting, all grout holes shall be sealed.

9.16.4 Backfill Concrete

1) Backfill concrete in surface and underground works shall be placed for providing immediate support to the rock during excavation.

2) In the lined tunnels, where the extents of over breaks are not significant, the Engineer-in-Charge may direct the contractor to fill the gaps concurrently with the tunnel lining.

3) The backfill concrete to fill the over breaks behind steel ribs shall be of M15/A40 grade.

4) In order to confirm that the gaps have been completely filled or the desired thickness has been achieved as the case may be, the contractor shall take out the cores from the locations as directed by the Engineer-in-Charge.

5) From the coring, if it is established that the voids have not been completely filled the Engineer-in-Charge shall direct the contractor to fill the remaining voids with grouting at his own cost.

9.16.5 Concrete lining of Silt Flushing Tunnel

(1) Concrete used for the lining of the silt flushing tunnels shall be Class M 25/40 & M70/A20.

(2) The Contractor's proposed method of concrete placement is subject to the approval of the Engineer-in-Charge.

(3) The Contractor shall place high performance concrete obtained by adding silica fume.

9.16.6 Other Parts Embedded In Concrete

(1) Anchors, anchor bolts, structural shapes, plates shapes, plates for gates, hoists, valves, machinery etc. and other miscellaneous parts shall be installed in the concrete by the Contractor, as shown on the Construction Drawings or as required by the Engineer-in-Charge. Wherever practicable, anchors shall be installed before the concrete is placed. Except as otherwise specified, drilling and installation of anchors in the concrete after concrete is placed, will not be permitted. Before being placed in position, all anchors and embedded parts shall be thoroughly cleaned of rust, grease, paint, splashed concrete, or other coatings that will reduce bond. Where the installation of the anchors is not practicable before the concrete is placed, formed openings shall be provided, and the anchors grouted into the openings at a later time in a manner acceptable to the Engineer-in-Charge.

(2) Embedded anchors shall be supported during embedding and embedded so that the tolerances specified will not be exceeded. Care shall be taken not to disturb or displace embedded items during concrete placement.

(3) Concrete may be placed to embed items including grounding system, erected by other agencies in the locations and to the dimensions shown on the Construction Drawings or as required by the Engineer-in-Charge. The methods of placement and rates of placing concrete shall be subject to the approval of the Engineer-in-Charge. Care shall be exercised that such parts shall not be damaged or disturbed by placing operations.

(4) Unless otherwise specified the Contractor shall provide any foundation, wall or roof openings and coverings, concrete floor filling sleeves in foundations, inclusive of metal works supplied by other contractors. All adjustments to foundation levels, embedding, bedding and grouting works on foundations, and cementing works into walls and floors, shall be done by the Contractor but all levelling and adjustment of works in foundations shall be the responsibility of the E&M/HM contractor. Grouting shall be done by the Contractor under the supervision of the E&M/HM contractor who will also approve the grout mixes and grouting pressures.

9.16.7 Concrete in Blockouts for Equipment Embedding

(1) The Contractor shall form blockouts, place reinforcement and concrete as shown on the Construction Drawings or as directed by the Engineer-in-Charge, and in such manner as to ensure good bond with the existing concrete, to secure complete contact with the metalwork to be embedded in the blockout concrete and to avoid displacement of the metalwork.

(2) Blockout concrete shall include the concrete around second stage gate parts, sill beams and hydro-mechanical works etc.

(3) Except as otherwise specified the hydro-mechanical, mechanical and electrical equipment will be provided and installed by the suppliers in co-operation with the Contractor.

(4) Before placing concrete, all parts to be embedded shall be checked to ensure that they are firmly fixed in their required position. The surfaces of blockouts or holes shall be thoroughly cleaned and wetted. Oil or grease shall be removed by brushing and chipping of affected surfaces to a sufficient depth, or by application of approved chemicals and flushed with clear water.

(5) The parts to be embedded shall be cleaned of rust, mill scale, paint, oil or grease before they are set into place. Where bond between metal parts and concrete or grout is not desired, approved material such as flake graphite or paraffin shall be applied to the metal parts. The metal surfaces shall be wetted before placing the concrete or grout.

(6) Only self compacting Concrete containing approved admixtures shall be used for the concrete in second stage in blockouts for equipment embedding as shown on the Construction Drawings.

9.16.8 Grouting of the Equipment Bearing Plates and Anchors

(1) Limited spaces and small blockouts where equipment bearing plates, anchors, rails, etc., are placed shall be grouted under pressure.

(2) The grouting shall be performed using non-shrink cement-based grout or non-shrink epoxy grout as proposed by the Contractor and approved. All mixing and grouting shall be performed in accordance with the manufacturer's recommendations and shall be tested prior to grouting. Technical service by manufacturer shall be organised by the Contractor upon request by the Engineer-in-Charge.

(3) Before placing grout, the surfaces of the base concrete to which the grout will be bonded shall be roughened and cleaned of all laitance, loose or defective concrete, any coatings or other foreign material, followed by thorough washing with water.

(4) Forms for grouting shall be installed where necessary and care shall be taken that the grout fills all spaces under the plates leaving no voids. The exposed surfaces of the grout shall be cured as recommended by the manufacturer and no loads shall be applied until the grout has reached the design strength.

9.16.9 Concrete Plug in Construction Adits

(1) When no longer required for construction access purposes, the junctions of access adits with the head race tunnel, and other construction tunnels shall be plugged with concrete as shown on the Construction Drawings with or without provision of inspection gates (inspection gates wherever required are not in the scope of civil works contractor). The concrete shall be cast in stages if required.

2) The concrete shall be placed in sections with drainage pipes to allow the removal of ground and service water. No independent cooling system for limiting the temperature rise is foreseen as sufficient time is available for elapsing between placing of the individual concrete lifts.

3) The Contractor shall supply and install thermocouples including thermocouples junctions and extension wires in the fresh concrete, and perform temperature

measurement to monitor temperatures within the concrete mass. Based on these measurements the time for next concrete lift shall be determined by the Engineer-in-Charge.

4) Contact grouting of the completed plug will be required, and for this purpose a grouting pipes system shall be cast into the body of the plug. The pipe system shall consist of 2 longitudinal feeder pipes along the axis of the adit with vertical riser pipes butting up to the crown of the adit lining equipped with "Magnetite-type openings. The spacing of the riser pipes shall not be greater than 1 m. Grout injection shall be carried out as specified in Section "Drilling, Grouting and pressure relief holes".

9.16.10 Precast Concrete

(1) Precast concrete including precast concrete lagging for tunnels which has been dealt separately under section "Rock Support", precast guide wall for cut-off shall be produced in an enclosed area separate from other construction works.

(2) Precast units shall generally conform to the other parts of the same technical specifications where applicable and as required by the Engineer-in-Charge.

(3) Precast units shall be protected at all times from damage at the place of fabrication and during handling, storage and erection.

(4) Precast concrete units shall be placed in their correct relative location and temporarily braced and secured to prevent collapse or distortion of the structure until completion of the work to the satisfaction of the Engineer-in-Charge.

(5) Following removal of formwork, any hole, voids or other blemishes in the surfaces of precast concrete units which are to be exposed, shall be patched and a smooth rubbed finish provided. Rubbing shall be done with a corborumdum stone and a mixture of Portland cement and water.

9.16.11 Bridge near Dam area~~over Barrage & Head Regulator~~

(1) The bridge near Dam area~~over the Barrage & head Regulator~~ shall be constructed as simply supported structure comprising cast-in-situ elements. The typical composition is shown on the construction Drawings.

(2) Cast-in-situ bridge girders shall be placed on Elastomeric bearings pads in position and arrangement as shown on the Construction Drawings:

(3) Elastomeric bearings shall be laid on cement mortar pads having a minimum 28-days compressive strength of 30 N/mm^2 placed with a finished surface within 3 mm of the elevation shown on the Construction Drawings or as directed by the Engineer-in-Charge. The deviation from a straight edge laid across the bearing pad shall not exceed 2 mm.

(4) The Contractor shall furnish and install drain boxes for drainage of the surface water from the bridge as shown on the Construction Drawings or as directed by the Engineer-in-Charge. The drain boxes shall be made of galvanised steel plate with steel grating. PVC pipe 100 mm dia. shall be attached to each drain box.

9.17 MEASUREMENT AND PAYMENT

9.17.1 General

(1) Measurement for payment for each class of concrete including ~~concrete~~ Formwork ~~and formwork in~~formwork in surface structures, unless specified otherwise hereafter, will be of the volume placed within the lines, grades, and pay-limits shown on the Construction Drawings or as established at the Site by the Engineer-in-Charge.

(2) Unless otherwise stated, no payment will be made for concrete placed outside these limits, other than in additional excavation directed by the Engineer-in-Charge, and the measurement shall not include any filling of overbreak unless recognised as due to geological conditions conforming to the limits defined in other Sections of these Specifications.

(3) Payment will be made at the Unit Prices for different classes and types of concrete entered in the Bill of Quantities, which shall include, but not be limited to, the following:

a) Excavation, loading, transportation, crushing, screening, washing, blending, and storage of aggregates,

b) Batching, supply of mixing water, mixing, transportation, placing, and compacting the concrete,

c) Provision, delivery, transportation, storage and mixing of cement at the nominal content per different classes of concrete indicated in Sub-Section "Concrete Mix Design", and complying with all requirements specified.

d) Labour, tools and equipment for cleaning, and preparing surfaces prior to concreting,

e) Forming of the surfaces and treatment of construction joints including furnishing and spreading of mortar layers, or starter mixes before concrete placing,

f) Surface finishing including bush hammering,

g) Attaining the concrete temperature as specified, and hot and/or cold weather precautions,

h) Protection and curing of concrete,

i) Repair of defective concrete and removal of rejected concrete,

j) Communication system connecting the points of placing concrete with the relevant mixing plant or delivery equipment,

k) Furnishing the trial bays and panels, provision of material samples and all activities required in connection with the performance of the tests including their transportation to the testing laboratory.

(4) ~~(4)~~ All associated concrete works, such as removal of forms and repairs and finishing of concrete shall be completed as soon as practicable after concrete is placed. Concrete will not be considered for payment until all associated works have been completed to the satisfaction of the Engineer-in-Charge.

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(5) Rates of concrete shall be inclusive of formworks and no extra payment shall be made on account of formwork.

(6) Rates for tetrapod shall be inclusive of steel work for lifting hook and placement etc. as directed by Engineer-in-charge.

~~(5) Deleted.Measurement for payment and Payment for formwork and steel reinforcement are stipulated in other Sections of these Specifications.~~

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9.17.2 Concrete in the Dam Spillway Glacis and Bucket~~Barrage and Desilting Basin Complex~~

(1) Measurement for payment and payment will be made for each class of concrete specified as described under "General", with reduction of the volume for recesses for silica fume concrete.

(2) Measurement for payment of special wearing surface/erosion resistant high performance concrete will be of the volume placed. Payment will be made at the Unit Price per cubic meter entered in the Bill of Quantities which shall include the entire cost of preparation of contact surfaces with parent concrete, furnishing, mixing and casting of such concrete and any other related work.

(3) Measurement for payment for silica fume mixed into the concrete will be of the weight of the dosages as ordered by the Engineer-in-Charge. Payment will be made at the Unit Price per metric ton entered in the Bill of Quantities which shall include the entire cost of supply, handling, mixing of the silica fume or fibres and provision, operation and maintenance of equipment for mixing these into the concrete. Measurement and payment for levelling concrete in the dam~~barrage~~ will be of the cubic meter of the levelling course laid with the stipulated thickness as shown in the construction drawing and payment made at unit prices entered in the Bill of Quantities.

9.17.3 Concrete Lining of Tunnels

(1) Measurement for payment for concrete placed in the tunnel(s) lining and in the access adit(s) lining will be of the volume of concrete placed within the "B"-line shown on the Construction Drawings. Deductions from this volume will be made for the in-situ concrete or shotcrete placed earlier which will be paid for separately. The volume to be deducted will be calculated as area multiplied by the average layer thickness established by an approved method.

(2) Measurement for payment and payment will be made separately for the invert concrete and for concrete placed in the vault (overt) of the tunnels.

(3) Measurement for payment and payment will be made separately for the reinforced cement concrete placed in the tunnels.

(4) The Unit Prices shall include, in addition to works described under "General", the entire cost of the following:

a) Design, furnishing, maintenance, erection, and removal of steel and all other type of formwork including formworks for transitions and formwork as bulkhead for concreting in approved over break area.

b) Pumping of the concrete, including furnishing and mixing the necessary plasticiser,

c) Grouting materials for contact grouting in the crown of the tunnel, shaft and cavern.

d) Sealing of cracks, cold joints etc., where directed by the Engineer-in-Charge.

e) Provision and installation of thermocouples for temperature measuring.

f) Concrete in unapproved over breaks in tunnel Overt

g) Concrete beyond "B-Line" in the invert of tunnel/adit (Overbreak in the invert are not recognised.)

(5) Concrete placed beyond "B-Line" in the geologically accepted overbreaks in the overt of the tunnel will be paid at 75% of the Unit Prices quoted for concrete lining in the overt, when the concreting is done simultaneously and is of the same grade as of structural concrete lining.

(6) When backfill concrete (M15/A40) is placed behind steel ribs in geologically approved over breaks, the same shall be paid at the appropriate Unit Prices per cubic meter entered in the Bill of Quantities.

9.17.4 Backfill Concrete in Underground Excavation

(1) Where backfilling with concrete is directed by the Engineer-in-Charge, payment will be made for concrete placed beyond the "B"-line as backfill in geologically accepted overbreak and in additional excavation directed by the Engineer-in-Charge.

(2) The Unit Prices shall apply to class of concrete placed in geologically accepted overbreak and in additional excavation directed by the Engineer as follows:

a) Concrete placed simultaneously with concrete for the tunnel structural lining will be paid at the appropriate Unit Price for structural lining concrete,

b) Concrete placed independently of the tunnel structural lining will be paid at the appropriate Unit Price per cubic meter entered in the Bill of Quantities for filling of geologically accepted overbreak.

9.17.5 Backfill Concrete in Surface Excavation

(1) Where backfilling with concrete is directed by the Engineer-in-Charge, payment will be made for concrete placed as backfill in geologically accepted overbreak, dental excavation and in additional excavation directed by the Engineer-in-Charge.

(2) Payment will be made at the Unit Price entered in the Bill of Quantities for the concrete classes used, as appropriate.

9.17.6 Concrete Plug in Construction Adits

In addition to works described under "General", the entire cost of labour and material related to concreting in stages, cooling of concrete, and crown contact grouting shall also be included in the Unit Price of concrete entered in the Bill of Quantities for concrete plugs in access adit, including embedding the steel door

and steel lining in adit plug, which will be supplied and installed by other contractors.

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9.17.7 Second Stage Concrete and Concrete in Blockouts for Equipment embedding

(1) Measurement for payment of second stage concrete and concrete in blockouts will be of the volume of placed concrete. Only second stage concrete placed in spaces exceeding 0.10 m^3 in volume or 0.05 m^2 in cross section will be considered for payment. Concrete placed in blockouts or spaces less then stated above shall be deemed to be included in the Unit Price for concrete in the structure with which it is associated.

(2) Payment will be made at the Unit Price per cubic meter entered in the Bill of Quantities, which shall include, in addition to works included under "General", the entire cost of preparation of contact surfaces with parent concrete, furnishing of non-shrink agent where directed and any other related work.

9.17.8 Grouting of Equipment Bearing Plates and Anchors

(1) Measurement for payment for the non-shrink cement-based grout or non-shrink epoxy grout will be of the actual volume placed in the blockouts and under bearing plates.

(2) Payment will be made at the appropriate Unit Price per kilogram as entered in the Bill of Quantities. Technical service rendered by the manufacturer as needed, will not be separately reimbursed but will deemed to be included in the Unit Prices.

9.17.9 Precast Concrete

(1) Measurement for payment for precast concrete units will be of the volume of concrete used in the various types of precast concrete units, supplied and installed in the Permanent Works.

(2) Payment will be made at the appropriate Unit Price per cubic meter entered in the Bill of Quantities, which shall include, in addition to works described under "General", the entire cost of formwork, cement, admixtures, storage, transportation, and erection. Reinforcing steel is to be paid separately.

9.17.10 Concrete in Surface Works

(1) Measurement for payment of concrete placed in the surface works like u/s and d/s protection works, CC blocks etc area shall be of the volume of concrete placed in cubic meter as shown on construction drawings.

(2) Measurement for payment and payment shall be made at the appropriate unit price entered in the Bill of Quantities for the respective item of concrete.

9.18.11 Exclusions - Concrete

No separate measurement for payment or payment will be made for the following:

a) Any rounded or bevelled edges, fillets, scoring, chamfers, or any deduction made for voids or embedded items which are either less than 0.10 m^3 in volume or 0.05 m^2 in cross section. No allowance will be made for approved temporary openings, drains, embedded pipes, or recesses created by the Contractor for his own convenience during construction provided they are filled as directed,

b) Any collecting of seepage water or water inflow from rock surfaces and diverting it into the drainage systems as specified in the Section "Dewatering During Construction",

c) Any defective and wasted concrete; concrete which has to be removed and replaced due to Contractor's non-compliance with the Specifications or Engineer-in-Charge's directions, and all related cost shall be at the Contractor's expense,

d) Any concrete which the Contractor places or uses for his own installations or for his own convenience,

e) Developing alternative sources of aggregates by the Contractor and the resulting additional material testing,

f) Pumping of the concrete and plasticiser,

g) Any precast and precast-prestressed concrete units damaged by improper storing, handling or transportation,

h) Any pipe work or material incorporated into the work to aid in placement of concrete.

i) All types of formwork including steel formwork for concrete lining of the tunnels.

j) All formwork for CC Blocks

k) Backfill concrete in overbreak in surface and underground excavation except geologically approved overbreak

l) Coring required for establishing the efficacy of void filling as ordered by Engineer-in-Charge.

m) Form work for the tunnels.

n) For meeting the handing over requirements as contained herein for E&M and HM works.

9.17.12 Cement

(1) No separate payment will be made for the nominal cement content indicated in Sub-Section "Concrete Mix Design" for the respective class of concrete.

(2) In case the required minimum specified compressive strength of a particular concrete class cannot be reached, or is in excess of, with the cement content specified herein, the variation of cement content (increase or decrease) will be assessed separately and paid for or recovered as the case may be.

(3) Measurement for payment for variations of cement content used for concrete will be of the quantities, by weight, of cement approved for the different classes of concrete specified, and computed on the basis of the number of cubic meters of concrete measured and approved for payment. The amount of cement required per cubic meter of concrete of each class will be as established at trial mix stage or the approved modifications thereof as established by the Engineer-in-Charge in the course of concrete work.

(4) The aforesaid variations in cement shall be paid for or recovered as the case may be at the rates indicated in the Bill of Quantities which shall include the extra cost of provision, delivery, transportation, storage, mixing and complying with all requirements specified.

(5) No measurement for payment or payment will be made for cement used for:

a) Contractor's own convenience,

b) Used for defective and wasted concrete,

c) Concrete placed outside of the concrete paylines (e.g. for filling the overbreak other than approved overbreak due to geological conditions) or required as a result of careless excavation.

d) Concrete produced with overuse of admixture.

(6) No extra measurement for payment or payment will be made for cement used in precast concrete units and the cost thereof shall be included in the appropriate Unit Prices for such concrete elements.

9.17.13 Admixtures

(1) Measurement for payment for air-entraining and water-reducing admixtures will be of the weight or volume of the agreed dosages established at trial mix stages or the approved modifications thereof, for different classes of concrete, and computed on the basis of the number of cubic meters of concrete measured and approved for payment.

(2) Payment will be made at the applicable Unit Price per kilogram entered in the Bill of Quantities, which shall include the entire cost of supply, handling, storage, and dispersing.

(3) No extra payment will be made for other kinds of admixtures for concrete such as accelerators and non-shrink agents.

(4) No payment will be made for admixtures used for Contractor's convenience only.

9.17.14 Tests

(1) All cost associated with testing as described in this Section shall be borne by the Contractor, who shall make allowance for such expense in the Unit Prices for the concrete work. These shall include, but not be limited to, the following :

a) The costs for all tests to be carried out prior to the start of concrete work, whether carried out at Site or elsewhere,

b) Routine tests for quality control during the execution of the concrete work carried out by the Contractor as specified herein and as directed,

c) Other tests required during execution of the work to be carried out by an approved test laboratory(ies),

d) Preparation, storage, handling, curing and delivery of samples to a laboratory designated by the Engineer-in-Charge, if so required for additional independent testing.

(2) Should the Contractor fail to adhere to his testing program, all test deemed necessary by the Engineer to check concrete work will be performed by the Engineer-in-Charge or a laboratory assigned by him, at Contractor's expense.

9.17.15 High Performance Concrete

(1) Measurement for payment of high performance concrete will be of the volume placed. Payment will be made at the Unit Price per cubic meter entered in the Bill of Quantities, which shall include, the entire cost of preparation of contact surfaces with parent concrete, furnishing, mixing and casting of such concrete and any other related work.

(2) Measurement for payment for silica fume and Super plasticizer mixed into the concrete will be of the weight of the dosages as ordered by the Engineer-in-Charge. Payment will be made at the Unit Price per metric ton entered in the Bill of Quantities, which shall include the entire cost of supply, handling, mixing of the silica fume and Super plasticizer and provision, operation and maintenance of equipment for mixing these into the concrete.

9.17.16 Structural Repair Works/ Closure of grout holes with cementitious mortar

(1) The measurement for payment of mortar and its application shall be made as per the actual consumption of cementitious mortar material (in dry) in weight.

(2) Payment shall be made at the rates quoted by the contractor for a particular item contained in the Bill of quantities.

(3) The rates of the all items in bill of quantities shall be inclusive of cost of all materials, Labour, surface preparation, re-drilling and cleaning of holes, carriage, staging, scaffolding, jhullas and cost of providing safety measures etc including diversion of seepage water by means of soil filled gunny bags or by any method suggested by the Engineer-in-Charge and nothing extra shall be paid on this account.

9.17.17 Epoxy mortar for repair of concrete

(1) Payment shall be made at the rates quoted by the contractor for a particular item contained in the Bill of quantities.

(2) The rates of the items in bill of quantities shall be inclusive of cost of labour, surface preparation, carriage, staging, scaffolding, jhullas and cost of providing safety measures and application etc including diversion of seepage water by

means of soil filled gunny bags or by any method suggested by the Engineer-in-Charge and nothing extra shall be paid on this account.

9.17.18 Crystalline material water proofing treatment works

(1) Measurement for payment for application of integral crystalline slurry for waterproofing treatment shall be made for the actual surface areas.

(2) Measurement for payment for application of integral crystalline mortar for waterproofing treatment shall be made for the liner metre entered in Bill of Quantity.

(3) Payment shall be made at the rates quoted by the contractor for a particular item contained in the Bill of quantities.

(4) The rates of the items in bill of quantities shall be inclusive of cost of labour, surface preparation, carriage, staging, scaffolding, and application including making U-shape groove size as mentioned in clause 9.15.5 cost of providing safety measures etc including diversion of seepage water by means of soil filled gunny bags or by any method suggested by the Engineer-in-Charge and nothing extra shall be paid on this account.

END OF SECTION B.9

SECTION B.9A

REINFORCED/PLAIN CEMENT CONCRETE CUTTING AND DEMOLITION & DISMANTLING

List of Contents

SECTION B.9A

REINFORCED/PLAIN CEMENT CONCRETE CUTTING AND DEMOLITION & DISMANTLING

9A.1 SCOPE OF WORK

(1) The Works provided for in this specification consist of furnishing all plant, labour, material, equipment and services necessary for planning and design of cutting and demolition & dismantling of reinforced/plain cement concrete of the Dam, Spillway glacis, ~~already constructed upstream floor of the barrage for joining with cut-off wall, head regulator near the Barrage area and part of desilting basin/ head regulator to form stabilising side walls,~~ cutting of the pile wall near the cut & cover of the Intake tunnel, stacking of scrap/salvaged steel and disposal of all unserviceable materials. ~~Demolition/ dismantling of the existing head regulator adjacent to the Barrage Bay No 4 is required for the construction of the Bay No 5 & modified head regulator. The required portion of existing head regulator and desilting basin shall be dismantled carefully without affecting the existing concrete on the adjacent part. The depth of concrete cutting with or without reinforcement may vary upto about 22m near the head regulator and upto about 10m near the desilting basin.~~

(2) This Section covers the following items:

a) Cutting of concrete members using diamond wire saw

b) Cutting of concrete members using diamond wall saw

c) Demolition & dismantling of separated concrete by mechanical means

d) Breaking of existing concrete for modification and reuse of structure

(3) The design of the concrete cutting works, equipment, working procedures, accuracy, submittals and approvals shall be performed to the dimensions as shown in the construction drawings or otherwise as directed by the Engineer-in-Charge. The equipment and accessories must be capable of safely, speedily and efficiently cutting the concrete to the design requirements at the project site. Sufficient units of equipment must be provided to keep to the agreed construction schedule. The concrete cutting works shall include:

- Cutting of reinforced/plain concrete members by way of using diamond wire saw system through the existing contraction joint and the intact concrete or cutting of concrete by way of using wall saw system to separate the reusable part of existing structure from the part to be demolished/dismantled,
- Demolition of old concrete shall be carried out to the lines and grades as shown in the construction drawings. Demolition and dismantling of separated concrete shall be exercised with utmost care to avoid any damage to concrete beyond lines and grades as shown in the construction drawings.
- Removal of the muck from dismantled/demolished material with all its lifts and leads upto the designated dumping area,

- Cleaning of area.

(4) The Contractor shall cooperate with all other agencies related to the construction of Permanent Works where the material or equipment is to be installed to, or embedded in the concrete structures or excavation or other protection works.

(5) The approval given by the Engineer-in-Charge to the Contractor's plants and equipment or their operation or of any construction methods shall not relieve the Contractor of his full responsibility for the proper and safe execution of work or any obligations under this Contract.

(6) The Contractor shall carryout all works as mentioned in the scope as above. All works shall be executed to the satisfaction of the Engineer-in-Charge.

(7) Only specialised Sub-Contractors will be accepted to carry out these works. The Contractor's representative in charge of supervising the execution of the works, and his foremen, shall have proven experience in concrete cutting, dismantling and demolition.

9A.2 STANDARDS

(1) Unless otherwise specified, the standards and recommendations of the Indian Standards Code of Practice IS: 4130, CPWD specifications shall be followed in respect of all materials, equipment and performances.

(2) In case of differences between the Indian Standards and the Specification given herein, this Specification shall take precedence.

(3) In case there are procedures or methods etc. for which an Indian Standard has not yet been issued, other generally well-known Standards shall be accepted as substitutes, such as the British Standards (BS), the European Standards (EN), the German Industrial Standards (DIN), or Hongkong Standards or those of the American Society of Testing and Materials (ASTM) or equivalent.

9A.3 SUBMITTALS

(1) Submittals listed herein are related to items which require the consent of the Engineer-in-charge and are to be made by the Contractor before the appropriate work may proceed.

(2) The Contractor shall submit detailed plans and descriptions of all the following matters related to the deconstruction (cutting, demolition & dismantling) of the existing concrete structures:

a) the credentials of the specialised subcontractor and suitably qualified personnel who will be in charge of the concrete cutting works, dismantling, demolition and breaking works for reuse as specified;

b) a fully detailed Concrete Saw cutting Method Statement which shall include as a minimum the following information:

- the detailed working sequence for saw cutting of reinforced/plain cement concrete using wire saw system or wall saw system including

the durations of each of the saw cutting activities;

- the method of setting out the cut sections, and the preparation of the working platforms;
- details of the method of cutting/drilling technique(s) to be applied, for the structural components which may be cut, including the type and rating data of the rig(s), the types and sizes of drilling tools to be employed, the types and extents of supports to be applied, etc.;
- the type of wire saw or wall saw to be used, method, depth and cleaning;
- stability of the adjacent structures/ wall, compliance with the specified tolerances;
- methods of collection and safe disposal of the sawing slurry from the cutting location in accordance with the environmental requirements of the Contract;
- all activities involved in the formation of the joint between the saw cutting of the old concrete and new concrete in the ~~desilting basin/ head regulator~~/ dam~~barrage~~/ cut and cover near intake.

c) a fully detailed Method Statement for the Demolition & Dismantling of concrete which shall include as a minimum the following information is requested:

- the detailed methodology to form the separated concrete which is to be demolished so that the vibrations are not transferred through the concrete medium to the reusable part of the parent concrete.
- the detailed working sequence of the dismantling and demolition including the excavation sequencing from the separated location, lifting of cut sections, and breaking up in to smaller or disposal at the specified location or as directed by Engineer-in-charge.
- the emergency arrangements, which should include equipment for the rescue of injured persons.
- assessing whether the proposed methods and sequence of demolition or breaking up can be executed without causing unpremeditated collapse of the whole or part of the structure, and

d) Design Method Proposal showing site specific complete stability calculations for various stages & methods of cutting and demolition & dismantling including design assumptions, and all dimensional and structural details, tender stage drawings shall be submitted alongwith the tender document for approval of the Engineer-in-charge.

(3) In accordance with the requirements of Section 9A.3.2 of the Specification, but in any case not later than 28 days prior to the commencement of the concrete cutting works, demolition & dismantling, the Contractor shall submit to the Engineer-in-charge for approval the complete set of detailed construction drawings for these works.

(4) Not later than 28 days prior to the commencement of the concrete cutting works and demolition & dismantling, the Contractor shall submit to the Engineer-in-charge for approval the following documents, in accordance with the requirements of the Specification, related to these works:

- name of the equipment manufacturers;
- certificates of compliance with all requirements of the governing standards and specifications;

(5) During the period of deconstruction of the existing concrete structures, the Contractor shall submit a daily report to the Engineer-in-charge.

9A.4 SUBMISSION OF ALTERNATE SYSTEMS FOR APPROVAL

(1) Alternate systems if any, shall be included in the submission of the tender for the Engineer-in-charge's review. If the design is agreed in principle, the alternate system shall be included in the contract documents.

(2) In principle, acceptance of a design submission does not relieve the Contractor in any way from providing an anchor system of adequate performance and consistent with the specification.

9A.5 SAW CUTTING, DISMANTLING AND DEMOLITION

9A.5.1 GENERAL

(1) The term **Dismantling** implies carefully separating the parts without damage and removing. This may consist of dismantling one or more parts of the existing structure as shown in the drawing or as specified by the Engineer-in-charge.

(2) The term **Demolition** implies breaking up. This shall consist of demolishing whole or part of work including all relevant items as shown in the drawing or as specified by the Engineer-in-charge.

(3) The term **Separated concrete** in this section implies the part of concrete separated from the parent concrete by way of saw cutting so that no transfer of vibration takes place through the concrete medium from one part to the other part during process of demolition.

(4) The tenderer is deemed to have inspected the structures for dismantling/demolition and acquainted himself with their condition. The dismantling/demolition shall be done carefully, without causing any damage to the reusable existing concrete structures or property of other agencies. He shall be liable for any damage to structures or equipment caused by his operations.

(5) All concrete saw cutting and demolition/dismantling of concrete shall be performed using methods and techniques that will produce smooth surfaces with minimum overbreak and fracturing beyond the lines and grades or limits of excavation shown on

the Construction Drawings, or as required by Engineer-in-Charge, and will preserve the structural integrity. All precautions shall be taken by the Contractor to achieve this result and also preserve, in a soundest possible and undisturbed condition all the materials beyond the limits of the excavation of lines and grades shown on the drawings. Particular care shall be exercised where vertical or near vertical faces are required.

(6) The contractor will clear all loose material of concrete existing on the surface of walls. The Contractor will arrange all types of staging and scaffoldings required for the purpose of saw cutting, lifting, demolition/dismantling and breaking of old concrete.

(7) All type of dust/clay lying on the surface will be removed with the help of compressed air and water jet. Surface roughening of the intact concrete shall be generally done by sand blasting. However, other methods may be applied in localized areas with the approval of Engineer-in-charge.

(8) Water shall be sprinkled on work sites by contractor to ensure dust free atmosphere.

9A.5.2 SAW CUTTING

(1) Saw cutting is suitable for alteration and additional works where accuracy in the cutting is important and the tolerance to noise and vibration is very limited. It can be used to cut concrete elements into blocks or segments. Saw cutting generally includes conventional disc wall saw and wire saw.

(2) Wire saw cutting comprises a special steel wire often impregnated with diamond beads to increase its cutting ability. The wire saw method is a suitable application for projects that require precision and total control of demolition work. A hole shall first be pre-drilled for the passage of the diamond wire, the wire cutting operation follows. Because of its flexibility, it may be used in areas which are difficult to reach. The wire is driven by electric motors fitted with drive wheels in an S-configuration.

(3) Wall sawing is generally used when disturbance of the surrounding material must be kept to a minimum. A diamond or carbide wheel is used to abrasively cut a kerf through the concrete. The blades can cut through reinforcing rods although the rods tend to break off the blade diamonds. The blade is rotated by an air or hydraulic motor. For most applications the saw will be mounted on a guide which also supports the saw's weight. The operator manually advances the blade into the work. The dust produced by the abrasive cutting is controlled using a water spray. The abrasive blade produces no vibration, shock, smoke, sparks, or slag and is relatively quiet.

(4) The sawing and drilling operations require large amounts of water to cool down the blade which cuts through the concrete at high speed. Provision shall be made to provide a water source for the operation and for the disposal of the cooling water.

9A.5.3 CUTTING AND LIFTING

(1) Cutting and lifting involve the initial cutting of the existing reinforced/plain cement concrete structure i.e. foundations, pedestals, piers, walls & piles shall be done with vibration free diamond wire saw or diamond wall saw in the intact concrete to the lines & grades as shown in the construction drawings or at the designated/proposed contraction joint to separate the existing concrete structure. Any further cutting required for separation into individual blocks or segments, and then lifting the blocks by crane for further demolition into smaller pieces shall be carried out by the contractor as per his design/ convenience, at no additional cost, before hauling and removal of muck/debris. The typical procedures for cutting and lifting are summarised in the following:

a) Prior to cutting, the structural stability of the remaining structure shall be checked;

b) The structural element to be removed shall be secured, either by temporary supports or by tie wires connected to lifting appliances. The lifting appliances must have adequate capacity to support the weight of the structural section. The wire strength shall not be less than 4 times the anticipated loads;

c) After cutting, the structural element shall be lowered to the designated area in a controlled manner. Free falling shall be avoided.

9A.5.4 DEMOLITION AND DISMANTLING

(1) Prior to start of demolition & dismantling, the part of the structure to be demolished shall be separated from the existing reusable part of structure. The separated concrete shall not transfer the vibration through the concrete medium to the reusable part of the structure.

(2) Demolition and dismantling of the separated concrete by mechanical means (using concrete cutters etc.) includes all solid concrete in place which cannot be removed / loosened by barring or wedging, removal of all concrete, as well as any existing structural concrete / foundation made of concrete or masonry placed in mortar which cannot be removed during common excavation or by ripping.

(3) The choice of demolition method depends on the project conditions, site constraints, sensitivity of the neighbourhood and availability of equipment. The method, including detail procedures, shall be designed to accommodate the specific project requirements. In general, demolition should be carried out in the reverse order of construction, as far as appropriate.

(4) For reinforced concrete, cuttings may be performed by pneumatic concrete breaker/hammer for the concrete and cutters could be used for the reinforcements. Alternatively the reinforced concrete walls may be cut by saw cutting; and shall be

lifted away. Markings such as ribbons, paints or other appropriate means shall be used to identify the propped area and limits of the mechanical plant movement. The extent of the propping or machine arm shall be determined based on the anticipated operation and the site conditions. The structural elements shall be broken down gradually or by alternate methods. Demolition shall be performed with extreme caution.

(5) The crane shall be properly tested, examined and operated in accordance with the requisite regulations. The operating area shall be blocked off during the lifting operation. Approval shall be obtained prior to the operation if temporary road closure is required.

9A.5.5 BREAKING OF EXISTING CONCRETE FOR MODIFICATION AND REUSE OF STRUCTURE

(1) The breaking of existing concrete for modification and reuse of structure shall imply breaking/chipping upto a depth of 200mm of the existing structure for modification and reuse of vertical, inclined or horizontal surfaces.

(2) The breaking of existing concrete under this clause need not be isolated from the parent concrete to form separated concrete. However, the vibrations generated during this process should not affect the integrity of the parent concrete or create cracks to affect the reusability. The work shall be carried out through active vibration reduction enabled tools.

9A.5.6 PRECAUTIONS

(1) The demolition shall always be well planned before hand and shall generally be done in reverse order of the one in which the structure was constructed. The operations shall be got approved from the Engineer-in-charge before starting the work. Due care shall be taken to maintain the safety measures prescribed in IS 4130.

(2) Attention should be paid to the principles of the structural design to determine which parts of the structure depend on each other to maintain overall stability.

(3) Necessary precautions shall be taken to keep noise and dust nuisance to the minimum. All work needs to be done under the direction of Engineer-in-charge. Helmets, goggle, safety belts, etc, should be used whenever required and as directed by the Engineer-in-charge. The demolition work shall be proceeded with in such a way that it causes the least damage and nuisance to the adjoining structure.

(4) Dismantling shall be done in a systematic manner. Chisels and cutters shall be used carefully as directed. The dismantled articles shall be removed or lowered to the ground (and not thrown) and then properly demolished or disposed as directed by the Engineer-in-charge.

(5) Screens shall be used where necessary to prevent injuries due to falling pieces.

(6) Safety belts shall be used by labourers while working at higher level to prevent falling from the structure.

(7) First-aid equipment shall be got available at all demolition works of any magnitude.

(8) The contractor shall be solely responsible for any accident, damage or injury caused to any of his employees or owner during the execution of the work.

9A.6 DISPOSAL OF EXCAVATED/ SAW CUT/ DISMANTLED/ DEMOLISHED MATERIALS

(1) Excavated unserviceable materials generated during the course of the work from saw cut/dismantled/demolished concrete shall be disposed off in the spoil area or in areas designated by the Engineer-in-Charge. The Contractor shall be responsible for the stability of all fills, embankments and stockpiles created by the disposal of excavated materials/saw cut/dismantled/demolished.

(2) The spoil tips shall be located where they will not interfere with the natural flow of streams or rivers, with construction operations in the borrow and quarry areas, with reservoir operation, with flow of water to or from spillway or outlet works, or with accessibility to the Site.

(3) Excavated materials and saw cut/dismantled/demolished concrete shall be transported to the disposal areas in such a way that spillage onto roads etc. is avoided. Any materials which, despite the Contractor taking reasonable care, does fall onto roads etc. shall be promptly cleared and removed by the Contractor.

(4) No rock and unserviceable material shall be dumped into any rivers or creeks.

(5) The Contractor shall be liable for any damage to Temporary or Permanent Works or to third parties and their property caused by inadequate drainage of the spoil or stockpile areas.

(6) The contractor shall ensure and take necessary measures to effect dust abatement on the roads from excavation location till dumping yards. He shall employ water sprinklers on these roads for the same. Engineer-in-Charge shall deploy such sprinklers at the cost of contractor in case the same are not deployed by the contractor, so as to ensure dust free environment.

9A.7 MEASUREMENT AND PAYMENT

9A.7.1 General

(1) Measurement for payment for different types of diamond saw cutting, demolition & dismantling and breaking of the concrete will be as entered in the Bill of Quantities,

within the lines, grades, and pay-limits shown on the Construction Drawings or as established at the Site by the Engineer-in-Charge.

(2) Payment will be made at the Unit Prices for different types of diamond saw cutting, demolition & dismantling and breaking of the concrete entered in the Bill of Quantities, which shall include, but not be limited to, the following:

a) Planning and design of cutting, demolition & dismantling of reinforced/plain cement concrete of the already existing concrete and drilling of holes for wire saw or installation of rails, etc. for wall saw cutting.

b) Excavation, loading, transportation, crushing, supply of water for cutting, demolition & dismantling tools, stacking and disposal of demolished/malba materials,

c) Labour, tools and equipment for cutting, demolition & dismantling and breaking of the concrete, cleaning, and preparing surfaces during execution of the work,

d) Providing formwork including supports & scaffolding, supply of compressed air, cooling water and illumination etc.

e) Communication system connecting the points of cutting, demolition & dismantling and breaking of the concrete with the relevant operators, control units, plant or equipment.

(3) All work making access to the construction site, arrangement of illumination as required, compressed air, electric power etc. shall be in the scope of the contractor and no separate payment shall be made in this regard.

(4) No separate payment shall be made for cutting other than as shown in the approved construction drawings for cutting/demolition & dismantling and breaking of the concrete. The contractor may at his own cost carry out additional wire saw /wall saw cutting for his own convenience for demolition & dismantling of separated concrete with the approval of the Engineer-in-charge.

(5) Damages caused to any other structure during cutting, demolition & dismantling and breaking of the concrete shall be rectified by the contractor at his own cost failing which, such rectification work shall be carried out and cost incurred in doing so, will be recovered from the contractor.

(6) The scrap/salvage steel obtained from cutting and demolition & dismantling of reinforced concrete shall be taken over by the contractor free of cost. This scrap/salvaged steel shall not be used in the works and it shall be disposed by the contractor at the earliest.

9A.7.2 Measurement and Payment of Cutting of concrete members by Diamond Wire Saw through existing Contraction Joint

(1) Measurement for payment of cutting of reinforced/plain concrete members by diamond wire saw through existing contraction joint shall be of the area 'in sqm' of concrete cut within the lines, grades, profile/ final surface as shown on the construction drawings or as established at the site by the Engineer-in-Charge.

(2) Payment shall be made at the appropriate unit price entered in the Bill of Quantities for respective item of cutting of reinforced concrete members by diamond wire saw through existing contraction joint.

(3) No separate payment shall be made for providing formwork including supports & scaffolding, supply of compressed air, water and illumination etc. for cutting of the concrete.

9A.7.3 Measurement and Payment of Cutting of concrete members by Diamond Wire Saw through Intact Concrete

(1) Measurement for payment of cutting of reinforced/plain concrete members by diamond wire saw through intact concrete shall be of the area 'in sqm' of concrete cut within the lines, grades, profile/ final surface as shown on the construction drawings or as established at the site by the Engineer-in-Charge.

(2) The measurement for payment shall be only of the area of the existing concrete which is being exposed for reusage after integration with the new concrete.

(3) Payment shall be made at the appropriate unit price entered in the Bill of Quantities for respective item of cutting of reinforced concrete members by diamond wire saw through intact concrete.

(4) No separate payment shall be made for providing formwork including supports & scaffolding, supply of compressed air, water and illumination etc. for cutting of the concrete.

9A.7.4 Measurement and Payment of Cutting of concrete members using diamond wall saw

(1) Measurement for payment of cutting of reinforced/plain concrete members by diamond wall saw shall be of the area 'in sqm' of concrete cut within the lines, grades, profile/ final surface as shown on the construction drawings or as established at the site by the Engineer-in-Charge.

(2) The measurement for payment shall be only of the area of the existing concrete which is being exposed for reusage after integration with the new concrete.

(3) Payment shall be made at the appropriate unit price entered in the Bill of Quantities for respective item of cutting of reinforced concrete members by diamond wall saw.

(4) No separate payment shall be made for providing formwork including supports & scaffolding, supply of compressed air, water and illumination etc. for cutting of the concrete.

9A.7.5 Measurement and Payment of Demolition and dismantling of the separated concrete by mechanical means

(1) Measurement for payment of demolition and dismantling of the separated concrete by mechanical means shall be of the volume 'in cum' of in-situ existing solid concrete material removed within the lines, grades, profile/ final surface as shown on the construction drawings or as established at the site by the Engineer-in-Charge.

(2) Payment shall be made at the appropriate unit price entered in the Bill of Quantities for respective item of demolition and dismantling of the separated concrete by mechanical means shall be of the volume 'in cum' of in-situ concrete.

(3) No separate payment shall be made for providing formwork including supports & scaffolding, supply of compressed air, water and illumination etc. for demolition and dismantling of the concrete.

(4) No separate payment shall be made for cutting other than as shown in the approved construction drawings for cutting/demolition & dismantling and breaking of the concrete. The contractor may at his own cost carry out additional wire saw /wall saw cutting for his own convenience for demolition & dismantling of separated concrete with the approval of the Engineer-in-charge.

9A.7.6 Measurement and Payment of Breaking of existing concrete for modification and reuse of structure

(1) Measurement for payment of breaking of existing concrete for modification and reuse of structure (i.e. breaking/chipping upto a depth of 200mm of the existing structure as per sub-section 9A.5.5) shall be of the volume 'in cum' of in-situ concrete within the lines, grades, profile/ final surface as shown on the construction drawings or as established at the site by the Engineer-in-Charge.

(2) Payment shall be made at the appropriate unit price entered in the Bill of Quantities for respective item of breaking of existing concrete for modification and reuse of structure shall be of the volume 'in cum' of in-situ concrete.

(3) For the purpose of measurements, offsets shall be taken normal to the required

profile at appropriate intervals before and after breaking of existing concrete at that point.

(4) No separate payment shall be made for providing formwork including supports & scaffolding, cleaning of concrete & reinforcement, supply of compressed air, illumination etc. for breaking of the existing concrete for modification and reuse of structure.

9A.7.7 Exclusions

(1) All costs of dewatering and keeping the surface excavation sites dry will be as specified in the Section "B.1 Dewatering during Construction".

(2) No extra measurement for payment or payment will be made for the following:

a) Extra work caused by the Contractor's negligence in setting-out the structures and slopes.

b) Surveys to verify the original surface, or for recording the top of the concrete surface.

c) Additional/ excess cutting using wire saw & wall saw required for contractor’s convenience other than as shown in the approved construction drawings.

d) Measures for dust abatement. Provision and cleaning of drain ditches on the berms

e) Removal of the materials resulting from any slides or overbreak caused by Contractor's inappropriate working methods and for the additional materials required to fill the voids so created.

f) Additional work of removing material, backfilling voids with approved material, and installing additional supports where overbreak due to Contractor's poor working methods or negligence.

g) Excess excavation required for Contractor's convenience and the resulting additional backfilling with approved materials.

h) Additional work resulting from the Contractor changing slopes without prior approval by the Engineer-in-Charge. In such event, payment will be made only to the lines and grades shown on the Construction Drawings.

i) Excavation which is incidental to the contractor’s installation.

j) Shoring, bracing, and supporting of excavation & dismantling surfaces. Clearing, grubbing and stripping in the spoil and stockpile areas.

k) Draining, shaping, and trimming the dumped material in the spoil tips to the lines and grades as directed or approved by the Engineer-in-Charge.

END OF SECTION B.9A

SECTION B.9B

REPAIR/REHABILITATION AND MODIFICATION OF CONCRETE

List of Contents

SECTION B.9B

REPAIR/REHABILITATION AND MODIFICATION OF CONCRETE

9B.1 SCOPE OF WORK

1) The works provided for in this specification consist of furnishing all plant, labour, material, equipment and services related to repair, rehabilitation and modification of concrete works including designing, supplying and fixing rebars,waterstop & tor steel anchors in existing concrete structure, drilling & cleaning of holes, anchoring, grouting, cutting/ welding of reinforcement works etc. in dam~~barrage~~ and desilting basin complex area.
2) Only specialised Contractors/Agencies as mentioned/specified in the tender document having experience of similar nature and possesses qualified and experienced work force will be accepted to carry out these works.
3) The work shall be performed to the location and dimensions as shown in the drawings or as otherwise directed by the Engineer-in-Charge.
4) The contractor has to submit a proposal showing its construction planning, scheduling, quality control and monitoring plan for the execution of the work.
5) The approval given by the Engineer-in-Charge to the Contractor's work shall not relieve the Contractor of his full responsibility for the proper and safe execution of concrete work or any obligations under this Contract.

9B.2 STANDARDS

1) The standards and recommendations of the Indian Standards Code of Practice shall be followed in respect of all materials, equipment and performances.
2) In case of difference between Indian Standard and specifications given herein, this specification shall take precedence.
3) In case there are procedures or methods etc. for which an Indian Standard has not been issued other non-standards shall be accepted as substitute such as European standard (EN), British Standard (BS), the German Industrial Standard (DIN), or those of the American Society of Testing and Materials (ASTM) etc. in this order of preferences.

9B.3 SUBMITTALS

9B.3.1 Submittals Before Construction

1) Submittals listed herein are related to items, which require the consent of the Engineer-in-Charge and are to be submitted by the Contractor before the appropriate work may proceed.
2) With his tender, the Contractor shall submit detailed plans and descriptions of all the following matters related to the rebaring, waterstop & tor steel anchors work:
    a) Name and references of specialised contractors to be employed for rebaring, waterstop & tor steel anchors works in the existing concrete structure.

b) Detailed site specific documents including Design & Construction methodology of the work need to be submitted by the Contractor with Tender documents.

c) Name and experience records of specialist staff who will engage in rebaring, waterstop & tor steel anchors works in the existing concrete structure.

d) Equipments to be used: Full description (type and capacity) and drawings for the necessary equipments to be used in rebaring, waterstop & tor steel anchors works in the existing concrete structure.

e) Sampling and testing of materials: List and details of equipment with detailed programme for sampling and testing of materials to be used for rebaring, waterstop & tor steel anchors works in existing concrete structure. Qualifications and experience of the Contractor's proposed personnel.

f) Program of work and detailed working procedures and sequences (method statements).

3) Within 28 days from the date of issue of Notice to Commence, but before procuring or mobilising the equipment to the Site, the Contractor shall update the data listed above, and any subsequent amendments and additions to them shall have to be agreed to by the Engineer-in-Charge and the Contractor.

4) The Contractor shall request certificates from the suppliers for each consignment of materials to be incorporated in the Works and submit them to the Engineer-in-Charge for approval. These certificates shall state the grade and quality of the materials in the consignment and the results of all tests carried out thereon.

5) At least 56 days in advance of Repair/Rehabilation and modification of concrete work being carried out at the Site, the Contractor shall submit to the Engineer-in-Charge following notifications.

a) System, methods and equipment for fixing rebars, water stops and tor steel anchors in already existing concrete.

b) The details covering the properties and performance, including the certified copies of reports of all tests made by the manufacturers.

9B.3.2 Submittals During Construction

1) The Contractor shall submit to the Engineer-in-Charge for approval a weekly work programme and plan indicating details of work to be executed. This weekly programme shall be submitted to the Engineer-in-Charge not later than Wednesday of the previous week for his acceptance prior to the commencement of the work.
2) At least 56 days in advance of the start of work, the Contractor shall submit the design memo for the assigned work for approval from the Engineer-in-Charge.
3) Before commencement of any work, the Contractor shall prepare a checklist describing all significant preparations for the specified work and submit this list to the Engineer-in-Charge who, after approving it, will instruct the Contractor in writing to commence the work.

4) The Contractor shall keep and make available to the Engineer-in-Charge records of the date, amount, and storage location of each delivery of the part of the Works in which it was used and shall provide facilities for checking the same.
5) During the performance of the work, the Contractor shall keep a diary where he shall record the construction procedures related to work. This diary shall be made available to the Engineer-in-Charge upon request. The records shall contain at least the following:
    a) Commencement and termination of work of various parts of the structures,
    b) Quantities and quality of materials provided, and the storage from which they were drawn,
    c) Personnel employed during various stages of the work and name of the responsible inspector or foreman,
    g) Equipment used,
    h) Directives received from the Engineer-in-Charge,
    i) Any special material or procedures employed.
6) The Engineer-in-Charge reserves the right to require any additional information deemed necessary to be included in the submitted documents.

9B.4 FIXING REBARS IN ALREADY CAST CONCRETE

1) The dia & spacing of holes to be drilled in the existing concrete for fixing rebars shall be designed by the contractor and approved by Engineer-in-Charge. The length of the rebars embedded into existing concrete shall not be less than 40 times the diameter of rebar.
2) Scanner shall be used in existing structural members to detect location, spacing, cover & diameter of reinforcement etc.
3) Drilling of hole shall be carried out using diamond core method or any other suitable method as approved by Engineer-in-Charge. Special precaution shall be necessary to ensure that holes are drilled straight, the drilled process does not spall or otherwise damage the existing concrete or the existing reinforcement or other embedment.
4) Drilling through existing reinforcement or other embedded materials shall not be undertaken prior to order of Engineer-in-Charge.
5) Cleaning of the hole shall be done with either wire-brush or air blow-out or by using hollow drill bit with air suction.
6) Injection of Epoxy based chemical of reputed brand, suitable for rebaring, in ratio as recommended by manufacturer and approved by Engineer-in-Charge. The Epoxy Based chemical shall conform to ETA TR023 / EAD 330087 or any other national/international standard approved, with a mechanical dispenser, in wet/dry/underwater conditions for variable diameters. Piston plug method or equivalent suiting the site conditions shall be deployed for epoxy grouting.
7) The system should be made of two components, resin and hardener. The chemical should have certification/ approvals/ test reports for ETA, usage in diamond drilled cored holes and water tightness.

8) The chemical bond should perform better than concrete and steel under fatigue load conditions.
9) The installation and the setting instructions should be strictly followed as per the manufacturer's recommendations.

9B.5 FIXING OF WATERSTOP IN THE EXISTING CONCRETE STRUCTURE

9B.5.1 Material

1) Waterstops shall conform to Clause 12.5.1 of Section B.12 Waterstops and Joints.
2) The epoxy mortar shall conform to Clause 9.15.4 of Section B9 Concrete.
3) The epoxy grout shall conform to epoxy binder as mentioned in Clause 9.15.4.1 of Section B9 Concrete.

9B.5.2 Execution

1) The interface of existing concrete structure and the new concrete structure shall be sealed with water stops as shown in construction drawings.
2) A groove 155mm deep & 30 mm wide for 300mm wide waterstop and a groove 80 mm deep & 30mm wide for 150mm wide waterstop shall be drilled in the existing concrete to insert the water stop.
3) The groove shall be cleaned with either wire-brush or air blow-out or by using hollow drill bit with air suction.
4) The cracked / delaminated zones of the existing concrete structure shall be cleaned and area shall be demarcated. Mild chipping shall be done to remove loose concrete and packers for injection grouting shall be installed followed by the cleaning of the surface again.
5) A bonding coat shall be applied over chipped area and left for an hour.
6) The surface shall be sealed using epoxy mortar to prevent the epoxy from leaking out before it has gelled.
7) Injection grouting shall be done with grout pump and its ancillary arrangement to fill cracks / voids of the structure in accordance with Clause 9.15.4 of section B9 Concrete.
8) The spacing of injection grouting shall not exceed 250mm c/c throughout the length of waterstop.

9B.6 FIXING TOR STEEL ANCHORS IN THE EXISTING CONCRETE

9B.6.1 Surface Preparation

1) All type of dust/clay lying on the surface will be removed with the help of compressed air or high pressure water blast. After chipping/chiseling of concrete up to desired size and depth the concrete surface shall be got inspected by the representative of the Engineer-in-Charge. The contractor shall remove all the chipped materials to the suitable disposal site and shall keep the area clean.

9B.6.2 Anchoring

1) Anchorage shall comprise of 25mm diameter Fe500 deformed steel bars conforming to Section B.11 Reinforcing Steel, embedded in 32mm diameter holes in the substrata or as shown in the drawings and shall be fixed in place with epoxy grout conforming to ASTM C881 Type IV, Class C. Spacing of anchorage shall be 1m c/c staggered or as per drawing and as per the directions of the Engineer-in-Charge. Diameter of anchorage, length and spacing may vary to suit site conditions.
2) The surface of the anchor bars shall be clean of rust, scale, dirt or other foreign matter.
3) Holes drilled for anchor bars shall be kept plugged until just prior to commencement of grouting operations. Before grouting, each hole shall be thoroughly flushed with water and cleaned with compressed air.
4) Water shall be removed from the hole before grouting. If the hole cannot be kept dry during grouting, the grout shall be introduced into the end of the hole through a pipe, which shall be gradually withdrawn as the hole is filled.
5) The depth of anchor into old concrete shall be 500mm. The anchor at the top shall be bent at 90 degree and shall be placed towards d/s direction along the flow.
6) Grouting material for anchor shall be two parts solvent free moisture insensitive epoxy resin which can be easily placed in the full depth of drilled hole. Bond strength (moist cure) of the bonding material shall be 10 MPa and shall be tested in accordance to ASTM C882. Certified quality test reports from the manufacturer in this regard shall be submitted by the contractor.
7) Drilling in old concrete will be carried out by the contractor with the help of pneumatic jackhammers /equivalent means to the desired depth. The drilling of holes shall be done in such a way that the hole is exactly normal to the finished surface of concrete.
8) The hole shall be filled upto 350mm depth with grouting material and thereafter the anchor shall be inserted into the hole before the initial set of the grout. This will ensure that some of the grout comes out of hole, when the anchor is inserted. The bar shall be vibrated or tapped in order to ensure good contact between the steel surface and the grout.
9) The scaffoldings and safety measurements required for doing drilling shall be arranged by the Contractor with no additional cost.
10) Anchors bars shall be protected after installations in such a manner as to prevent any movement until the grout has hardened. The Contractor shall replace any bars found to be loose after the grout has set.

9B.7 MEASUREMENT AND PAYMENTS

9B.7.1 FIXING REBARS IN ALREADY CAST CONCRETE

1) For the rebaring, payment shall be made in no. of rebars fixed in already cast concrete as entered in Bill of Quantities and as per the design submitted by the contractor and approved by the Engineer-in-Charge. The cost shall include the cost of designing, scanning, drilling & cleaning of holes, fixing of rebars,

equipment, labour, testing, monitoring and all other related activities for installation of rebars.

2) The measurement and payment of reinforcement used for rebaring shall be done separately in accordance with Clause 11.10 of Section B11 Reinforcing Steel.

9B.7.2 FIXING OF WATERSTOP IN THE EXISTING CONCRETE STRUCTURE

1) Measurement for payment for PVC waterstop will be made in unit per linear meter placed. Payment will be made at the appropriate Unit Price entered in the Bill of Quantities, which shall include the plant and labour for groove cutting and installation of PVC waterstop as specified, all temporary protection of the joints from damage and cost of providing safety measures and application of epoxy mortar including diversion of seepage water by means of soil filled gunny bags or by any method suggested by the Engineer-in-Charge and nothing extra shall be paid on this account.
2) The measurement for two-components epoxy binder (resin & hardener) conforming to ASTM C881 Type IV, Class C as per technical specification shall be measured in Kg actually used for filling of the hole as per specification.
3) The measurement for well graded quartz sand/filler for use in epoxy mortar as per technical specification shall be measured in Kg actually used for filling of the hole as per specification.

9B.7.3 FIXING TOR STEEL ANCHORS IN THE EXISTING CONCRETE

1) The measurement for surface preparation of old concrete shall be measured in square metre of the projected area along the profile.
2) The measurement for drilling for anchors shall be measured in running meters for the actual depth drilled into the old concrete and shall include washing and cleaning of the holes.
3) The measurement for epoxy resin of approved make for grouting of anchor bars shall be measured in Kg actually used for filling of the hole as per specification.
4) The measurement and payment of reinforcing steel and anchors including cost of supply, cutting, fixing, binding, welding and holding etc shall be made in weight in Kg for the actual length placed.

END OF SECTION B.9B

SECTION B.15

BUILDING AND ARCHITECTURAL WORKS

List of Contents

SECTION 15

BUILDING AND ARCHITECTURAL WORKS

15.1 SCOPE OF WORK

1) The work under this Section includes design, all labour, materials, equipment and performance of all operations required for the execution of the finishing and architectural works inside or outside of buildings, rooms or chambers as per Annexure-I to be constructed under this Contract.

2) This Section covers the following items:

   a) Masonry walls

   b) Wall, floor and roof finishes

   c) Tile works

   d) False ceiling

   e) Bituminous waterproofing membranes

   f) Doors and louvers

   g) Windows and sunblinds

   h) Glass and glazing

   i) Painting works

   j) Carpentry and joinery

   k) Caulking and damp-proofing

   l) Perforations and cuts in the finished concrete and masonry

   m) Temporary closures and protection

3) The building and architectural works not specified herein shall be defined by the Contractor during the course of the Work.

4) All materials and equipment which will become a part of the Permanent Works shall be new and of good quality.

5) If the Specification and Annexures do not contain particulars of materials and works which are obviously necessary for the proper completion of the work and the intention to include such is nevertheless to be inferred, all such materials and works shall be supplied and executed by the Contractor and shall be reimbursable.

6) Similarly, the Contractor shall supply, place and attach to the structure all timber, metal or other accessories necessary for the proper completion of the work.

7) The Contractor shall provide and fix all incidental flashings, damp proofing, weather seals or other approved materials necessary to render the buildings completely watertight and weatherproof.

8) The Contractor shall furnish, erect and maintain during the work as required all scaffolding, walkways and other temporary structures required for the execution of the works.

9) The Contractor shall collect and dispose of all material, debris and rubbish as it accumulates from time to time as the work proceeds. On completion of this work, the Contractor shall thoroughly clean interior and exterior of the buildings and the other works.

10) No architectural works shall be taken up unless the relevant architectural drawings for the same have been approved by Engineer-in-Charge.

15.2 SUBMITTALS

1) The contractor shall propose an experienced architect (preferably experienced in architectural services related to hydroelectric projects) to the Engineer-in-charge for approval at least 180 days prior to start of work, who shall be responsible for the following:

   a) Planning and detailing of architectural works of dam complex based upon the general layouts given by the owner and the technical specifications.

   b) Preparing shop and detailed drawings and measuring schedules for the building and submit to Engineer-in-Charge for approval.

   c) Providing expert advice to the owner on patented products like wall finishes, doors and windows and other related material.

   d) Work as a coordinator between contractor and the owner in respect of architectural works.

   e) Coordinate with water supply consultant for design/layout of sanitary items, water supply and sewerage system.

   f) Assist the owner in the supervision of architectural work being executed by the contractor and suggest changes as required.

2) The Contractor shall prepare and submit for approval at least 28 days prior to the date he wishes to place or confirm purchase order:

   a) Lists and schedules of materials to be purchased,

   b) Manufacturers' catalogues for the various items specified in this Section,

   c) Samples of materials and hardware with specimens of workmanship,

   d) Colour and finish for the various items specified in this Section.

15.3 NOMINAL SIZES

The Contractor shall allow for variations between nominal sizes and actual sizes where such variation is within the required tolerances or is normal trade practice.

15.4 FINISHING WORKS

Finishing work shall not commence until each or all of the following conditions have been met to the satisfaction of the Engineer-in-Charge:

1) The area concerned and such adjacent areas, which may affect the finishing work, have been weatherproofed,

2) All construction including installation of permanent plant, fittings and equipment has been completed,

3) The concrete or other materials have dried out sufficiently. The Engineer-in-Charge may request a test for dryness to be performed by the Contractor.

15.5 MASONRY WALLS

15.5.1 General

1) The Contractor shall construct masonry walls where shown on the Construction Drawings or as directed by the Engineer-in-Charge. All masonry walls shall be constructed after the structural concrete work has been completed.

2) The work shall include, but not limited to, the brickwork.

15.5.2 Materials

1) Masonry units shall be bricks units. The Contractor shall submit samples of bricks to the Engineer-in-Charge for approval.

2) Cement, sand and water shall be as specified in the relevant section of "Concrete".

3) Masonry units shall have a moisture content (expressed as a percentage of total absorption) of not more than 30% at time of delivery. Units made from cinder aggregate shall not be used.

4) All bricks shall be adapted to the wall thickness and approved by the Engineer-in-Charge.

5) All bricks shall be uniform in size and shape, deep red in colour and sufficiently well burnt. They shall be clean and free from flaws, cracks and under burnt lumps or defects of any kind. The bricks may be local product available in the vicinity of the Site, but the quality shall conform to a standard acceptable to the Engineer-in-Charge.

6) The mortar shall be thoroughly mixed until uniform in colour and shall be used before it has taken initial set. Mortar, which has partially set, shall not be used, nor shall more water be added to it.

15.5.3 Execution

1) The masonry units shall be laid on horizontal courses, true to line and plumb, and vertical joints shall be staggered with respect to those in the courses next above and below. No broken bricks and blocks, except as are required as closures for the proper sizing of courses, cracked or misshapen bricks will be used in the works. Corners, and at edges of framed openings, bricks shall have finished return ends. All exposed bricks, which are to be cut, shall be cut with a carborundum wheel.

2) All units shall be laid with full buttered ends and side joints, and shall be shoved to bear on a full bed of mortar. All joints shall be 10 mm and cut flush, except that joints in areas to be plastered shall be raked 7 mm to provide a mechanical joint for the scratch coat. After initial set exposed joints shall be burlap rubbed.

3) The bricks shall be dampened before scratch or setting bed is placed. The thickness of mortar setting bed shall not exceed 20 mm.

4) The masonry units shall be stored on platforms to prevent contact with soil and water and shall be covered with non-staining tarpaulins for protection against the elements.

15.6 WALL, FLOOR AND ROOF FINISHES

15.6.1 General

1) The Contractor shall install finishes on walls, floors and roofs according to his shop drawings as approved by the Engineer-in-Charge.

2) The work shall include, but not limited to, the following :

a) Plastering

b) Floor finish

c) Roof finish (cement mortar)

d) Special floor finish (Granolithic concrete)

15.6.2 Materials

1) Cement, sand and water shall be as specified in the relevant section of "Concrete".

2) Waterproofing and epoxy resin shall be approved by the Engineer-in-Charge and shall be used in perfect accordance with the manufacturer's instructions.

3) The mortar shall be thoroughly mixed until uniform in colour and shall be used before it has taken initial set. Mortar, which has partially set, shall not be used, nor shall more water be added.

4) The cement mortars shall be composed as follows:

a)	For wall plastering:	350 kg cement per 1 m^3 and water,
b)	For flooring finish:	500 kg cement per 1 m^3 and water,
c)	For waterproofing of floor & walls:	600 Kg cement 1 m^3 sand and water, and waterproofing agent in accordance with the manufacturer's instructions,
d)	For roof finish:	450kg cement per 1 m^3 sand and water.

15.6.3 Execution

1) Concrete surfaces, which are to receive a rendering coat, shall be roughened, scratched and free from all laitance, scum. Loose carbonate scale, loose aggregate, dirt and other foreign matter and shall be kept thoroughly wet for 24 hours prior to the application of mortar.

2) All masonry and concrete surfaces to which cement mortar is to be applied without furring shall receive one coat of an epoxy resin type bonding agent or other agent approved by the Engineer-in-Charge.

3) The various finishes shall be executed as follows:

a) Exterior wall plastering

On exterior wall plaster shall be applied, by hand or mechanically, to a total thickness of 25 mm.

b) Interior wall plastering

On interior walls plaster shall be applied by hand or mechanically, to a total thickness of 15 mm.

15.7 TILE WORKS – FLOORS AND WALLS

15.7.1 General

1) The Contractor shall install tiles on walls and floors as given in ***Annex-I (Room schedule)*** and according to his shop drawings as approved by the Engineer-in-Charge.

2) The work shall include, but not limited to, the following:

a) Ceramic wall tiles

b) Vitrified glazed ceramic tiles

c) Vitrified ceramic tiles

d) Kota stone

e) Pre-polished granite tiles

3) The Contractor shall submit samples of tiles for approval by the Engineer-in-Charge with respect to quality and colour. Tile samples shall include the manufacturers full colour and texture range of the series specified by the Engineer-in-Charge. The detailed execution procedure has been highlighted in ***Annex-II***.

15.8 FALSE CEILING

The contractor shall provide false ceiling in the Dam~~Barrage~~ control room /building.

15.8.1 General

1) Supply and installation of materials and installation of suspension system components, hangers and fastening devices.

2) Supply and installation of materials and installation of ceilings tiles and panels.

3) Supply and installation of sound absorbent materials.

The detailed execution of false ceiling is enclosed in ***Annex-III.***

15.9 BITUMINOUS WATERPROOFING MEMBRANES

15.9.1 General

1) The Contractor shall supply and install bituminous waterproof membranes on roofs and floors with or without thermal insulation as directed by the Engineer-in-Charge.

2) Membranes on roofs shall include protective mortar, roof drain and downspouts.

15.9.2 Materials

1) Bituminous waterproof roofing shall consist of 3-ply built-up roofing layers applied as follows:

3-ply built-up roofing

Asphalt primer	0.4 l/m^2
Asphalt compound	1.5 kg/m^2
1st layer felt	39 kg / 42 m^2 roll
Asphalt compound	1.5 kg/m^2
2nd layer felt square meshed	35 kg / 21 m^2
or perforated fibreglass felt	28 kg / 10 m^2 roll
Asphalt compound	2.0 kg/m^2
3rd layer felt	35 kg / 21 m^2 roll
Asphalt compound	2.1 kg/m^2
Plastic sheet protection	one layer

15.9.3 Thermal Insulation

1) Thermal insulation shall be provided in the form of thermal insulation panels laid directly on the bituminous roofing felt covering the cement mortar screed. The thermal insulation material shall in turn be covered with a second layer of bituminous roofing felt.

2) Panels for thermal insulation shall be of synthetic insulating material having a density of approximately 30 kilograms per cubic meter. The panels shall have a thickness of 30 mm. organic material like cork shall not be permitted. Consideration shall be given to the chemical composition of panels, with regard to any possible chemical reaction with bitumen.

3) Insulating panels shall be laid with staggered joints and with their joints coated with bituminous paint. They shall then be covered by a layer of bituminous roofing felt. Joints in bituminous roofing felt shall consist of a minimum overlap of 100 mm sealed with a layer of hot bituminous paste. Roofing felt shall be laid such that it overlaps the insulation layer and joins with the roofing felt beneath the insulation

layer. The 2 layers of felt shall be joined together to completely surround and seal the insulation layer on all sides and edges.

15.9.4 Execution

1) Concrete roof slabs shall be prepared to receive bituminous 3-ply built up roofing by first laying a 1:3 cement mortar to form the slopes. The thickness of the screed shall vary between 20 mm (minimum) and 120 mm (maximum) thickness. The surface of the concrete slab prior to the laying of the screed shall be prepared in accordance with the requirements for concrete construction joints as specified in Section "Concrete". After laying, the surface of the cement mortar screed shall be compacted with a screed board prior to receiving a wood float finish. External and internal angles shall be finished with a rounded surface of minimum radius 50 mm. The cement mortar screed shall be allowed to cure for a minimum period of 3 weeks before covering with the specified insulation and waterproofing layers.

2) A layer of bituminous roofing felt, thermal insulation panels and a second layer of bituminous roofing felt shall be placed over the cement mortar screed as specified above.

3) 3-ply built-up roofing shall then be applied follows:

   a) Asphalt primer shall be evenly applied in accordance with the manufactures recommendations over the surface of the bituminous roofing felt covering the thermal insulation panels. Asphalt compound shall then be evenly poured and sprayed over the asphalt primer. Compound heated to a temperature exceeding 140 degree C above the melting point shall not be used.

   b) Asphalt felt, roofing and special roofing shall be laid over each respective asphalt compound with care to avoid bulges. The sides and ends of these sheets shall be provided with an overlap of at least 90 mm. The joints shall be completely watertight.

   c) The whole surface shall be covered by plastic sheet protection in order to allow the movement of the top protective mortar screed without damaging the 3-ply built-up roofing. Care shall be exercised when carrying out roofing work surrounding anchor bolts, parapets and roof drains to prevent leakage.

4) The top protective screed shall be placed in two 25 mm thick layers with wire mesh laid in between. Wire mesh shall consist of 0.9 mm diameter galvanised steel wire with a mesh size of 25 mm or similar approved.

15.9.5 Roof Drain

1) The roof drain shall be made of cast iron, heat coated with asphalt. Care shall be exercised in fitting the surrounding waterproofing works to the drains for preventing any damage to the waterproofing membrane. Caulking shall be applied as required.

2) Roof drain grates shall be convex in profile at least as high as the pipe diameter and the total area of the openings of the gratings shall be 1.5 times the cross sectional area of the drain pipe. Grates shall be fixed with non-corrosive screws.

3) Roof drain shall have two flanges. The bottom flange shall be integral with the drain body and shall be set to the top surface of the surrounding concrete. The top

flange shall be adjustable to permit this flange to be set to the finished roof elevation. The two flanges shall be provided to allow seepage to drain from beneath the top flange.

15.9.6 Downspout

1) Downspouts shall be provided as shown on the construction drawings or as directed by Engineer-in-Charge. Downspouts shall be 100 mm in diameter polyvinyl chloride pipes provided with adaptable fittings. The downspouts shall be securely fixed to the walls with steel ring suspenders at adequate intervals.

2) Flexible joints shall be synthetic rubber, 4-ply approximately 80 cm in length and shall be provided at expansion joint of each downspout. The flexible joints shall be tightly connected to both ends of the downspouts with adequate metal bands.

15.10 ALUMINIUM DOORS, WINDOWS AND ROLLING SHUTTERS

15.10.1 Aluminium Doors

15.10.1.1 General

1) The Contractor shall supply and install aluminium doors as required. They shall be installed in accordance with approved Contractor's shop drawings.

2) All aluminium doors, frames and hardware shall be to the approval of the Engineer-in-Charge.

15.10.1.2 Fabrication

1) Prior to fabricating or ordering the aluminium doors, the Contractor shall check the actual dimensions and shape of existing concrete openings.

2) The detailed execution of Aluminium doors and windows is enclosed in ***Annex-IV***.

15.10.2 Rolling Shutters

15.10.2.1 Fabrication

1) The contractor shall supply and install steel rolling shutters as required. These shall be installed in accordance with contractor's approved shop drawings.

2) Prior to fabrication or order of the rolling shutters the contractor shall check the actual dimensions of existing openings.

3) The rolling shutter shall be of approved make, made of required size of M.S. laths interlocked together through their entire length and jointed together at the end by end locks mounted on specifically designed pipe shaft with brackets, side guides and arrangement for inside and outside locking with push and pull operation complete including wire springs and M.S. top cover of required thickness.

4) The rolling shutter may also required to be fitted with motorised arrangement and related works.

15.11 GLASS AND GLAZING

15.11.1 Materials

1) Each glass sheet shall bear the manufacturer's label showing its grade, thickness and type. Labels shall remain until the glass has been set and inspected.

2) When glass is not cut to size by the manufacturer, the contractor shall furnish an affidavit certifying the grade, thickness, type and manufacturer of the glass supplied.

3) Glass shall be heat-tempered, safety glass 16 kg/m^2 and of 6 mm thickness, free from any distortion or imperfection.

4) Sealant and glazing compound shall be compatible with the frame as recommended by the manufacturer.

5) Glazing beads and seals shall be black neoprene or vinyl chloride.

15.11.2 Installation

1) All single glass panels shall be accurately shop-cut to size of opening with allowances for maximum grip on all edges. Concealed edges of glass shall be clean, straight cut and free from chips and fissures. Glass shall be set with equal bearing on entire width of pane and shall not move nor rattle.

2) Glass and glazing system shall be installed complete with all stops, blocks, channels, beads, sealants and glass to form a watertight installation in accordance with the manufacturer's recommendation.

3) After installation, all exterior glazing shall be given a leak test by flooding the glazing from bottom to top using 20 mm hose with nozzle. Any defective work shall be repaired or replaced by the Contractor to the satisfaction of the Engineer-in-Charge.

4) All glass shall be cleaned at the completion of the work. Any defective, cracked or scratched glass shall be replaced.

15.12 PAINTING WORKS

15.12.1 General

1) The work includes preparing and painting various surfaces as directed by the Engineer-in-Charge, including protection and finish painting of metal surfaces, except those metal surfaces specified under the Technical Specifications for equipment supplied by others.

2) The Contractor shall provide all labour, materials, supplies, equipment and scaffolding to perform all operations necessary to complete the work.

15.12.2 Materials

1) Colour of paints shall be in accordance with the colour schemes selected by the Engineer-in-Charge. Exact tones of the colour selected shall be in accordance with the samples supplied and applied on test areas in the Works approved by the Engineer-in-Charge.

2) All paint materials shall be delivered to the Site in their original containers, with labels intact and seals unbroken. All paints shall be of well known registered brands.

3) All tinting colours and thinning materials shall be of the same brand as the oil paint specified for the particular area. Tinting colours for oil paint shall be colours-in-oil, ground in pure linseed oil of the best grade.

4) With the exception of ready mixed materials in original containers, all mixing shall be done at the Site.

5) The Contractor is responsible to ensure that the storage and handling of paint material complies with the requirements of pertinent codes and fire regulations. Proper containers placed outside of the building shall be provided and used for painting wastes, which shall be properly disposed of or removed from the premises at the close of each day's work. No plumbing fixture shall be used for this purpose.

6) The Contractor shall provide for the purpose of maintenance one unopened 4-liter can of each type and each colour of paint used, on completion of the work.

15.12.3 Preparation of Surfaces

1) Concrete and masonry work shall be left for one month and any surface defects repaired before painting.

2) Cracks, holes and other defects in plaster shall be filled or patched with an approved filling compound. The filling shall finish flush with and in the same plane as the adjoining surface. Where patches in cement plaster are required, the surfaces shall be coated with an approved bonding agent, the defects filled with an approved mortar mix for patching, and the patched areas finished to match the texture of the cement plaster. Plaster surfaces that will be painted for the first time shall be uniformly coated with a solution composed of 1 kg of zinc sulphate to 4 litres of water, to which shall be added 28 g of dry sienna to each 4 litres of zinc sulphate solution. 24 hours after application of the zinc sulphate solution, the surfaces shall be thoroughly washed with clear water and allowed to dry thoroughly.

3) Metal surfaces to be painted shall be clean and thoroughly dry before painting. Rust, loose scale, oil, grease and dirt shall be removed with approved solvents, wire brushing or sanding. Metal welds and blisters shall be ground and sanded smooth, pits and dents filled and imperfections corrected so as to leave a smooth surface.

4) Wood surfaces to receive paint shall be cleaned of all dirt, grease, dust or any other deleterious matter. All surfaces shall be thoroughly sanded and all nail holes, cracks and any other defects shall be coloured to match the colour of the finish paint. The finish surfaces shall be smooth, level and uniform, free from any stains and shall be uniform in colour and shade.

5) The Contractor shall be responsible for and shall rectify any surface finish which in the opinion of the Engineer-in-Charge is unsatisfactory to receive paint.

15.12.4 Workmanship

1) All paint shall be applied by brush unless spray painting or other method is specifically approved by the Engineer-in-Charge. Spray-painting equipment shall be adequate for the work to be performed and shall have suitable air pressure and paint flow controls.

2) Material shall be applied in accordance with the manufacturer's printed directions. Any thinning that may be required shall be added only with the approval of the Engineer-in-Charge and then with an approved type of thinner and in the amount recommended by the paint manufacturer.

3) One litre of paint as originally supplied by the manufacturer shall not cover a greater area when applied by spray gun than when applied unthinned by brush. Deficiencies in film thickness shall be corrected by the application of additional coat(s). Application on masonry surfaces may vary according to surface texture but in no case shall the manufacturer's coverage rate be exceeded. On porous surfaces, it shall be the Contractor's responsibility to achieve a finish comparable to the manufacturer's coverage rate by decreasing the coverage or applying additional coats of paint.

4) Painting shall be equal in quality to the samples as submitted to and approved by the Engineer-in-Charge.

5) The Contractor shall remove all lighting fixture, including canopies, surface hardware and similar items before painting; safely store them and replace them when painting is complete. Dripped, spilled or splattered paint shall be cleaned up promptly. Drop cloths shall be laid to completely cover flooring and all other work items during painting, and shall remain in position until the paint work is dry, finished and inspected.

6) The premises shall at all times be kept free from an accumulation of waste material and rubbish. On completion of the painting, all tools, scaffolding and surplus materials shall be removed from and about the building, ready for inspection by the Engineer-in-Charge.

7) Painting shall not be done in the rain, fog or mist, or at any other time considered unsuitable by the Engineer-in-Charge.

8) All the surrounding works shall be protected in a suitable manner from paint drops and overspray. All smeared and damaged surfaces shall be cleaned or repaired to the satisfaction of the Engineer-in-Charge.

15.13 CARPENTRY AND JOINERY

15.13.1 General

1) The work to be done under this Section includes the furnishing of all labour, materials, equipment, tools and other incidentals for all carpentry and joinery works, complete as directed by the Engineer-in-Charge. Shop drawings showing all essential dimensions and details of construction for millwork shall be submitted to the Engineer-in-Charge for approval before actual construction.

2) All carpentry and joinery works shall be performed and completed in a workmanlike manner in accordance with generally accepted modern practice in carpentry, notwithstanding any omission from these Specifications.

3) Lumber and woodwork shall be covered and protected from the elements until used. Buildings shall be thoroughly dry before the finish is placed on them. As far as practicable, nailing shall be done in concealed places, and all nails in exposed woodwork shall be set.

4) All lumber shall be surfaced on four sides. Exterior and interior shall be dressed and smooth. Finishing woodwork shall be hand-smoothed and sanded at the site as necessary to produce the proper finish. All dents on surfaces and counter sunk nails or screws shall be filled with acceptable wood filler before sanding of surfaces.

5) When practicable, millwork shall be fabricated in the shop, doweled, mortised and sanded to a smooth surface, and delivered to the site ready to be secured in place.

6) All cuttings, framings and fittings necessary for the accommodation of other works shall be provided.

15.13.2 Materials

1) All lumber to be incorporated into the Works shall be sound stock delivered dry and fully protected at all times from injury and dampness. Kinked, split, knotted, broken, insect bored, or otherwise damaged pieces will not be allowed.

2) Gradation shall be select, defined as selected lumber, generally clear, high quality, of good appearance, and suitable for use without waste and for natural finish.

3) Cabinets, closets and other wood furniture shall be constructed as shown on the shop drawings. Toilet partitions and doors shall be pre-fabricated units. The Contractor shall prepare shop drawings and submit them for approval.

4) Nails shall be smooth shank, zinc-coated steel wire nails.

5) Putty for woodwork shall be of the color to match wood finish where exposed, and shall be subject to the approval of the Engineer-in-Charge.

6) Glue shall be approved phenol-resorcinol base glue.

15.13.3 Seats, Slats, Cabinets and Toilet Partitions

Doors, slats, cabinets, shall be installed as shown on the approved shop drawings complete with all necessary hardware. All fastenings shall be concealed where practicable. Counters and cabinets shall be fitted neatly with a high degree of craftsmanship, installed in a rigid and substantial manner and scribed to joining

surfaces. Prefabricated toilet partitions and doors shall be provided with a 300 mm floor clearance.

15.13.4 Miscellaneous Wood Formwork

1) Miscellaneous wood formwork as may be required for the completion of the work shall be provided by the Contractor.

2) Exterior and interior staging shall be erected by the Contractor, and maintained in safe condition.

3) Edges of sills, projected masonry courses, concrete steps, and masonry liable to be damaged during construction shall be protected with temporary wooden covers.

15.13.5 Dimensions

The sizes shown for wood on the drawings are the nominal sizes. All dressed lumber after planning shall not vary from the indicated dimensions by more than ±10%. Thickness and width of lumber shall be uniform throughout its length. Lumber shall not be delivered to the Site in lengths shorter than 2.5 m.

15.13.6 Wooden Built-in Parts

1) For the wooden components which will be concealed after installation, e.g. built-in cupboards, wardrobes or wall linings, either the type of wood specified for the unconcealed structural components (spruce, fir, pine or wood of at least equal quality) or an equally suitable material may be used at the Contractor's own choice, unless otherwise specified.

2) The timber shall be in a suitable condition so that the components made of it will neither crack, warp nor twist.

3) The moisture content of timber assemblies when leaving the manufacturer's works shall be as follows (referred to the over dry weight):

- 8 - 12 % for interior finish components
- 10 - 15 % for structural parts in permanent connection with the outside air.

Proof of this moisture content shall be furnished to the Engineer-in-Charge.

15.14 CAULKING AND DAMP PROOFING

15.14.1 General

The Contractor shall supply all labour, materials and equipment necessary to complete the caulking and damp proofing of the buildings. The work shall consist of, but not be limited to the following:

a) Masonry control and expansion joints,

b) Caulking for roof penetrations and masonry wall openings such as for windows and doors,

c) Damp proofing the outside surfaces of all exterior concrete hollow block.

15.14.2 Materials

1) Joint backing shall be polyethylene foam, neoprene or butyl rope. Oakum, bituminous or impregnated metals will not be permitted.

2) Caulking material shall be elastic, non-corrosive and water resistant polysulphide liquid polymer which when set shall be firm but not brittle. It shall be delivered in original sealed containers and applied in accordance with the manufacturer's directions. The color shall be grey and the material characteristics shall permit concave tooling when in place.

3) Damp-proofing shall be of a clear silicon formulation for application to exterior masonry surfaces.

15.14.3 Caulking and Jointing

1) Application of caulking material shall be done in accordance with the manufacturer's directions, and only by tradesmen fully experienced in this type of work.

2) Joints, reglets and openings to be caulked shall be clean, dry and free of dust and foreign matter, and a joint cleaner shall be used where necessary. Deep joints shall be packed tightly with joint backing to not less than 10 mm from the surface. Joint backing shall be provided by the caulking material supplier, and joint primer applied as required by the manufacturer's instructions.

3) Excess caulking material shall be cleaned from all surfaces adjacent to and in proximity of the work area, and the joint left smooth and clean.

15.14.4 Damp-proofing

1) Surface shall be cleaned of oil, dirt and foreign matter, and prepared in accordance with the manufacturer's instructions before application of the damp proofing material. The concrete shall have been completely cured and the surface kept dry at the time of application.

2) Surfaces shall receive two heavy coats of damp proofing. The first coat shall be carefully applied so that untreated air-bubble depressions in the surface shall be completely filled and the second coat shall ensure a 100% coating of the surface. Particular care shall be taken to apply the damp proofing at all construction and other joints.

15.15 MEASUREMENT AND PAYMENT

1) Payment for building and architectural works will be made as lump sums entered in the Bill of Quantities, provided for the Dam~~Barrage~~ control building, DG set room & Gate operation chamber (SFT). The lump sum quoted shall include the entire cost of rendering Architectural design and supervision services, labour, furnishing of materials and installation for various architectural items described in these

technical specifications including brick masonry, cement plasters, flooring, railings, doors, windows and all necessary sanitary items.

2) Payment for the Lump sum will be made proportionally according to the progress of the work as estimated by the Engineer-in-Charge.

15.16 EXCLUSIONS

1) Concrete, formwork and reinforcement for the construction of buildings shall be paid separately and not included in the Lump Sum for Building and Architectural works.

2) All lighting and illumination works for dam control building shall be paid for under Section B.20 “E&M Equipments” and not included in the Lump Sum for building and architectural works.

END OF SECTION B.15

SECTION B.17

SLOPE PROTECTION

List of Content

SECTION 17

SLOPE PROTECTION

17.1 SCOPE OF WORK

1) Work under this Section include all labour, materials, equipment and services required to protect the slopes either excavated or those of embankments, backfills, nallah training works and for protection works (like boulder wire crates, Random Rubble masonary wall etc.) for the dumped material in the spoil tips.

2) This Section covers the following Engineering and Bio-engineering measures:

   a) Engineering measures

      i) Rock paving
      ii) Stone Pitching
      iii) Gabions
      iv) Random Rubble Masonry walls
      v) Precast Concrete blocks

   b) Bio-Engineering measures

      i) Wattling Trenches
      ii) Mulching/ Plantation of grass / shrubs
      iii) Jute- Geo textile
      iv) Balli Benching
      v) Bamboo Piling

3) The Contractor shall place the various items specified herein as protection to slopes or lining to ditches to the lines and thicknesses and in the locations shown on the Construction Drawings, or as directed by the Engineer-in-Charge.

4) Excavation, Concrete, Sprayed concrete, rock anchors, wire mesh, and drainage work, which may also be required for the slope protection, are specified in other Sections of these Specifications.

17.2 ENGINEERING MEASURES

17.2.1 GABIONS

17.2.1.1 Mechanically Woven Double-Twisted Hexagonal Wire Mesh Gabions

17.2.1.1.1 General

1) The work includes all labour, materials, equipment, placement, testing and services to be carried out by the contractor under this contract.

2) The work with mechanical woven double twisted hexagonal wire mesh shall be performed as per drawing or as directed by the Engineer-in-Charge.

17.2.1.1.2 Material

1) The gabion shall be prefabricated cuboids made up of mechanically woven double twisted hexagonal wire mesh. The wire mesh used for the gabions shall be fabricated with zinc coated steel wire. The wire mesh shall be a non-raveling mesh made by twisting continuous pairs of wires through three one-half turns (known as double twisted) to form hexagonal shaped openings which are then interconnected to adjacent wires to form hexagonal openings. The material properties and other details shall conform to IS: 16014.

2) The gabions will be of sizes 2m x 1m x 1m with one diaphragm. These prefabricated gabions shall be placed in-situ filling with boulder at desired location as directed by the Engineer-in-Charge.

i) The material shall have the following physical & mechanical properties:

Sl. No.	Property	Test Method	Unit	Value
I	**Physical Properties**			
1.	Material & Structure	Double twisted hexagonal steel soft wire mesh zinc coated.		
2.	Mesh type			10 x 12
3.	Mesh opening		mm	100 x 120
4.	Nominal mesh size		mm	100
5.	Dia of wire • Mesh • Edge/ Selvedge • Lacing	IS: 280	 mm mm mm	 3.0 3.9 2.2
II	**Mechanical Properties**			
1.	Tensile Strength of wire, edge/ selvedge & lacing wire	IS: 1608	MPa	350-550
2.	Elongation at break		%	10% (min.)
3.	Zinc coating • Mesh • Edge/ Selvedge • Lacing	IS: 16014 para 12.2 (IS: 4826/ IS: 12757)	 g/m^2 g/m^2 g/m^2	 270 280 240
4.	Mesh Panel Strength • Parallel to twist • Perpendicular to twist	IS: 16014 para 12.1	 kN/m kN/m	 40 20.5

Prior to procuring or dispatch of the materials to site, the contractor shall submit to the Engineer-in-Charge the reputed third party certified quality test reports from manufacturer in respect of the above physical/ mechanical properties of steel wire mesh gabions.

ii) Testing shall be carried out according to IS: 16014.

iii) The tests shall be got carried out by the manufacturer at a laboratory with adequate facilities and a certificate in this regard needs to be provided. Samples of the material for testing shall be taken in each lot of 500 gabions. Minimum one set of samples shall be taken, if the quantity of gabions is less than 500 nos. The test results of the sample shall be the average value of the 3 specimen selected randomly from the lot. At least testing of one lot shall be witnessed by a representative of Project.

3) Fill materials shall comprise of boulders that are clean, dense, sound and resistant to abrasion and shall be free from cracks, seams and other defects that would increase their susceptibility to destruction by erosive action. Boulders shall be well graded in size.

4) The size of boulder used in the gabion should not be lesser than 1.5 times the opening size of the mesh of the gabion and not greater than 1/4th to 1/3rd of the width/ height (whichever is less) of the gabion. The weight of individual boulder inside the gabion should be around 20 to 40 kg.

5) The contractor shall specify in his bid and subsequently also if required by the Engineer-in-Charge, the source from which the materials is obtained. In case the specified source is not acceptable, the contractor shall be required to substitute source from the acceptable source. Additional suppliers and change in supplier shall be subject to the approval of Engineer-in-Charge.

6) The Engineer-in-Charge reserves the right to acquire any additional information deemed necessary to be included in the submitted documents.

17.2.1.1.3 Execution

1) Gabions shall be in-situ assembled, connected together and filled with boulders as shown in the drawings or as directed by Engineer-in-Charge and described herein.

2) Foundation surfaces upon which gabions are to be placed shall be made reasonably smooth and even, loose or unwanted materials or excessive high spots removed and depressions/ voids filled with small rock fragments up to desired grades.

3) Gabions shall be secured in position by tying to adjacent gabions and where laid on slopes, these shall be fixed to the slope surface by 2 m long hardwood stakes/ steel angles driven through the gabions into the ground. The same shall be removed after installation. Internal galvanized wire tension rods shall be provided to reduce distortion of the cages.

4) Gabions shall be filled with boulders. During filling operation good hand packing & boulder placement is required to minimize voids. The exposed faces of vertical structures may be carefully hand placed to give a neat, flat and compact appearance. Cells shall be filled in stages so that local deformation may be avoided, i.e. at no time shall any cell be filled to a depth exceeding (0.30 m) higher than the adjoining cell. It is also recommended to slightly overfill the baskets to allow for settlement of boulders. Gabions shall be filled in three

layers. Once full, the cage lid shall be placed in position and securely tied with lacing wire or rings around its whole perimeter.

17.2.1.2 Polypropylene (Pp) Rope Gabion

17.2.1.2.1 General

1) The work includes all labour, materials, equipment, placement, testing and services to be carried out by the contractor under this contract.

2) The work shall be performed as per drawing or as directed by the Engineer-in-Charge.

17.2.1.2.2 Material

1) PP rope Gabions shall be prefabricated collapsible cuboids in which ropes are woven in continuous net. Material of rope shall be of polypropylene with adequate UV stabilizer. The weight of tar in PP rope may vary from 5%-10%. The polymer rope gabions will be of sizes 2m x 1m x 1m with mesh size of 100mm x 100mm with/ without provision of slings. These gabions may be in-situ assembled along with boulder filling at desired location or assembled at suitable nearby location, pre-filled with boulders and placed at desired location as directed by the Engineer-in-Charge.

   Prior to procuring or dispatch of the materials to site, the contractor shall submit to the Engineer-in-Charge the certified quality test reports from manufacturer in respect of following physical/ mechanical properties of Polypropylene rope tarred gabions, which is as per table below:

Sl. No.	Properties	Specifications
1.	Material of rope	Polypropylene with adequate UV stabilizer
2.	Mesh opening size	100 mm x 100 mm
3.	Construction of net	Woven joint at the intersection of ropes
4.	Diameter & structure of rope	9 mm dia 4-strand shroud laid
5.	Linear density of rope	40 ktex (gm/m) with a tolerance of ± 8%
6.	Min breaking strength of rope	1550 kg
7.	Thermal stability	Refer note at (c) below.

a) Testing for diameter & lay of rope and linear density at Sl. Nos. (4) & (5) respectively shall be carried out as per procedures stipulated in IS 7071 (Part 1 to 3) Ropes and Cordages – Method of Physical Test.

b) Breaking strength of rope at Sl. No. (6) shall be determined according to the test procedures as stipulated in IS: 7071 (Part 4) : Method of Physical Test for Ropes and Cordages (Breaking Load and elongation at break).

c) For testing of thermal stability of rope at Sl. No. (7), an eye-spliced specimen of minimum 1000mm effective length shall be used for test. The rope will be immersed in hot water bath maintained at 45°C for three hours. The temperature of the bath shall be maintained between 44˚C to 46˚C. After a period of three

hours the rope shall be taken out and tested for breaking force within ten minutes as per IS: 7071 (Part IV). The residual strength of the rope after subjection to immersion in hot water bath shall have 90% of the original breaking force of the rope.

The tests shall be got carried out by the manufacturer at a laboratory with adequate facilities and a certificate in this regard needs to be provided. Samples of the material for testing shall be taken in each lot of 500 gabions. Minimum one set of samples shall be taken, if the quantity of gabions is less than 500 nos. The test results of the sample shall be the average value of the 3 specimen selected randomly from the lot. At least testing of one lot shall be witnessed by a representative of project.

2) Fill materials shall comprise of cobbles, boulders or rock fragments that are clean, dense, sound and resistant to abrasion. Cobbles and rocks fragments shall be free from cracks, seams and other defects that would increase their susceptibility to destruction by erosive action. Individual cobbles, boulders or rock fragments (rounded) shall be well graded in size.

   The size of boulder used in the gabion should not be lesser than 1.5 times the opening size of the mesh of the gabion and not greater than $1/4^{th}$ to $1/3^{rd}$ of the width/ height (whichever is less) of the gabion. The weight of individual boulder inside the gabion should be around 20 to 40 kg.

   The contractor shall specify in his bid and subsequently also if required by the Engineer-in-Charge, the source from which the materials is obtained. In case the specified source is not acceptable, the contractor shall be required to substitute source from the acceptable source. Additional suppliers and change in supplier shall be subject to the approval of Engineer-in-Charge.

3) The Engineer-in-Charge reserves the right to require any additional information deemed necessary to be included in the submitted documents.

17.2.1.2.3 Execution

1) Gabions shall be assembled, connected together and filled with boulders as shown in the drawings or as directed by Engineer-in-Charge and described herein.

2) Foundation surfaces upon which gabions are to be placed shall be made reasonably smooth and even, loose or unwanted materials or excessive high spots removed and depressions/ voids filled with small rock fragments up to desired grades.

3) In situ laid gabions shall be secured in position by tying to adjacent gabions with polymer rope and where laid on slopes, these shall be fixed to the slope surface by 2 m long hardwood stakes/ steel angles driven through the gabions into the ground. The same shall be removed after installation.

4) Gabions shall be filled with cobbles, boulders or rock fragments. During filling operation good hand packing & stone placement is required to minimize voids. The exposed faces of vertical structures may be carefully hand placed to give a

neat, flat and compact appearance. Cells shall be filled in stages so that local deformation may be avoided, i.e. at no time shall any cell be filled to a depth exceeding (0.30 m) higher than the adjoining cell. It is also recommended to slightly overfill the baskets to allow for settlement of rock. Gabions shall be filled in three layers. Once full, the cage lid shall be placed in position and securely tied with polymer ropes around its whole perimeter.

5) These gabions may be in-situ assembled along with boulder filling at desired location or assembled at suitable nearby location, pre-filled with boulders and placed at desired location by suitable method as directed by Engineer-in-Charge.

6) Further, gabions to be added, either above or adjacent to those already placed, if possible shall be securely and continuously tied to existing gabions along all edges of contact.

17.2.2 RANDOM RUBBLE MASONRY

17.2.2.1 Wet Masonry wall

1) The Contractor shall construct wet masonry walls (or random rubble masonry) for slope protection to the lines and in locations shown on the Construction Drawings or as directed by the Engineer-in-Charge.

2) The stone for masonry walls shall be natural or crushed stone having sufficient strength and durability required for its use, not less than 150 mm thick. The rock shall be of suitable colour and appearance as determined by the Engineer-in-Charge. The rocks in the exposed face shall be approximately flat.

3) Mortar for masonry walls shall comprise 3 parts of clean fine aggregate to one part of cement by volume. Fine aggregate and cement shall comply with the requirements specified in the Section "Concrete".

4) Stones shall be moistened and hand-placed with un-coursed close joints onto a bedding of 200 mm thick drainage and 150 mm thick filter layers. Spaces between stones shall be filled with mortar. Surface joints shall be finished struck.

5) Weepholes of 50 mm dia. PVC pipe shall be installed through the wall to the pattern shown on the Construction Drawings or as directed by the Engineer-in-Charge. The upper surface of the walls shall be finished smooth with trowelled layer of 10 cm capping concrete.

6) After completion of a section of masonry walls, it shall be cured with water for a minimum of 72 hours.

17.2.2.2 Dry Masonry wall

1) For certain sections of wall, only dry masonry may be required, In such case, stones shall not be filled with mortar.

17.2.3 GRADED FILTER BELOW CC BLOCKS

17.2.3.1 GENERAL

On the upstream and downstream of Dam~~barrage~~, the graded filter shall be provided under CC blocks. The graded filter consisting of layers of Coarse sand, Graded shingle and boulders, as per drawings or instructions of the Engineer-In-Charge. The thickness of layers and gradation of material shall be as shown in the drawings.

17.2.3.2 FILTER MATERIALS

The grades filter would consist of layers of the following:-

i) Coarse sand
ii) Graded Shingle including pea-gravel.
iii) Boulders/Stone

Coarse sand in the graded filter shall consist of clean well graded sand from 0.25mm to 4.75 mm, Graded shingle in the filter shall consist of well graded gravel from 5mm to 7.5mm size. Coarse sand as well as shingle in the filter shall not contain more than 5 percent (five percent) of materials finer than 0.074mm. The boulders in the Graded filter shall not weigh less than 14kg. The grain size dimension of sand and shingle mentioned above are only approximate and are given for the general guidance of the contractor.

The grain size range and gradation of the material in each layer should be such as to satisfy the usual filter criteria as per I.S. Specifications with respect to the layers with which it is in contact. The Engineer- In-Charge reserves the rights to modify the grain size range of the sand as well as shingle. He may also split the layers of the graded Shingle into more than one if, in his judgment, one layer does not adequately satisfy the filter criteria. Nothing extra on account of the above modification shall be payable to the contractor nor shall any reduction in the tendered rates to be made on this account.

17.2.3.3 LAYING

a) Before starting laying of graded filter or boulder the sub grade shall be levelled to the required elevations. The filter material shall be screened thoroughly if necessary to remove any earth, clay and other organic impurities. The boulder shall be composed of good, hard, tough stone of the sizes as indicated in drawings or as directed by Engineer- In-Charge. The sand and shingle shall be well graded. Materials shall be got approved by the Engineer- In-Charge before use.

b) The filter materials shall be laid in the layers of thickness as directed by the Engineer- In-Charge. Each layer shall be well packed before subsequent Layers are laid. Special care shall have to be taken by the contractor to ensure that there is no mixing of ant two layers of filter materials. Care should also be taken by the contractor after laying of the filter to suitably protect the entry of under laying materials by covering with gunny base etc. Till the CC Blocks is laid.

17.2.3.4 FILLING GAPS BETWEEN BLOCKS

a) Filling and packing with well graded shingle shall be done in the gap between cement concrete blocks laid over the graded filter.

b) Before filling the gaps, these shall be cleared of all undesirable materials and washed. They shall then be filled and well packed flush with the top of the concrete blocks.

17.3 BIO-ENGINEERING MEASURES

17.3.1 Mulching/ Plantation of grass/shrubs

1) Seeds of plants/ mulching which can grow on the existing slopes shall be mixed with fertile soil and fertilizer and spread on the slopes stabilized by wattling trenches, Jute Geo-textiles, bailey benching or bamboo piling.

2) The type, method and timing of mulching and planting of grass shall be decided in consultation with the agronomist of the area as approved by the Engineer-in-Charge.

3) The plants/shrubs shall be fast growing and deep rooted.

17.3.2 Jute Geo-Textile

Open weave Jute geo-textile (730 gsm) shall be used for slope stabilization to reduce the velocity of surface run-off and to prevent the erosion of topsoil of the slope. Jute being agro-mulching and having high moisture absorption capacity will ensure fast growth of vegetation.

17.3.3 Balli Benching

1) The wooden posts of about 10 to 12 cm diameter shall be driven into the slope about 1m into the ground and 10 to 15 cm left out above ground.

2) The spacing of the driven wooden posts shall be about 1 to 2m as decided by the Engineer-in-Charge.

3) This measure alone or together with slope surface protection measures shall be used to increase the sliding resistance of the slopes.

17.3.4 Bamboo Piling

A group of 5 to 7 bamboos each of approx. 4 to 6 cm diameter shall be driven into the ground very close to each other and tied together with half bamboo and jute tie ropes. They shall be around 1m inside the ground and 1m above the ground.

17.4 MEASUREMENT AND PAYMENT

17.4.1 Mechanically woven double-twisted hexagonal wire mesh

1) Measurement and payment for furnishing and placing the steel wire mesh gabions shall be in cubic meter ~~numbers of specified size~~ and mode of its placement as given below:

   a. ~~Total nos. of~~ Ggabion of size 2m x 1m x 1m with one diaphragm along with in-situ filling of boulders and/ or rock fragments and placing at specified location. ~~Payment will be made~~ for gabions in cum including complete in all respect entered in the Bill of Quantities~~.~~

   ~~b. Boulders shall be measured separately to the size of gabions. Measurement for payment for the filling with boulders will be of the volume of placed gabions. However, for payment purpose, a 15% volume shall be deducted from the volume of gabions to account for voids. Payment will be made at the unit price per cubic meter entered in the bill of quantities.~~

2) The unit price includes entire cost of supply, storage & transportation of gabions, filling of boulders/rock fragments, wires/ rings for tying the lids & panels and placing the gabions cast in situ complete in all respect as directed by Engineer-in-Charge. Testing shall be carried out by the manufacturer at no additional cost.

17.4.2 Polypropylene (PP) rope gabion

1) Measurement and payment for furnishing and placing the polypropylene rope gabions with/ without slings (as per site condition) shall be in ~~numbers of~~cubic meter ~~specified size~~ and mode of its placement as given below:

   a) Total nos. of Polypropylene rope gabion of size 2m x 1m x 1m in 2 compartments of 1m each with in-situ filling of boulders and/ or rock fragments and placing at specified location. ~~Payment will be made for PP gabions at the unit price per number~~in cubic meter including complete in all ~~respect~~ entered in the Bill of Quantities~~.~~

   ~~b) Boulders shall be measured separately to the size of gabions. Measurement for payment for the filling with boulders will be of the volume of placed gabions. However, for payment purpose, a 15% volume shall be deducted from the volume of gabions to account for voids. Payment will be made at the unit price per cubic meter entered in the bill of quantities.~~

2) The unit price includes entire cost of supply & storage of polypropylene rope gabions, filling of boulders/rock fragments, polymer ropes for tying the lids, polymer ropes for tying adjacent gabions and placing the gabions cast in situ complete in all respects ~~or~~ as directed by Engineer-in-Charge ~~as the case may be~~. Testing shall be carried out by the manufacturer at no additional cost.

3) No separate payment shall be made towards transportation of gabions, slings and placement of gabions by mechanical means, if required.

17.4.3 Wet Random Rubble Masonry Walls

1) Measurement for payment for the wet masonry walls will be of the volume of walls, placed to the lines and thicknesses shown on the Construction Drawings or those determined by the Engineer-in-Charge. Payment will be made at the Unit Price per cubic meter entered in the Bill of Quantities, which shall include

for the cost of furnishing, handling, transportation, and placing of rocks, mortar, capping concrete and drainage and filter layers.

2) Foundation excavation, blinding concrete and weepholes will be measured for payment separately and paid for at the appropriate Unit Prices provided in other Sections of these Specifications.

17.4.4 Dry Random Rubble Masonry Walls

1) Measurement for payment for the dry masonry walls will be of the volume of masonry placed.

17.4.5 Graded Filter

1) The quantities of various constituents of the graded filter, payable to contractor, shall be accessed on the basis of actual measurements of the overall dimension of the constituents as laid in situ, without any destruction for voids. In case, however , the thickness of any layer in the graded filter, as actually laid, is in excess of that specified in the drawings, the thickness of the layer measured for the purpose of payment will be limited to that provided in the drawing or as per direction of Engineer- In-Charge.

2) Payment shall be made at the unit price per cum entered in the Bill of Quantities which shall include all labour, equipment, stockpiling, loading-unloading & transportation and materials required for the preparation, segregating, grading, blending and mixing, wetting or drying of the materials in order to obtain the required gradation, moisture content and other properties, of the material.

17.4.6 Mulching/ Plantation of grass/shrubs

Measurement for payment for the Mulching/ Plantation of grass/shrubs will be of the area treated in situ. Payment will be made at the Unit Price per square meter entered in the Bill of Quantities which shall include all labour and materials including handling, transportation, and placing complete in all respects.

17.4.7 Jute Geo-textile

Measurement for payment for the Jute Geo-textile will be of the area treated in situ. Payment will be made at the Unit Price per square meter entered in the Bill of Quantities which shall include all labour and materials including handling, transportation, and placing complete in all respects.

17.4.8 Balli Benching

1) Measurement for payment will be made of the number of posts driven in ground to the lines and arrangements shown on the construction drawings or those determined by the Engineer-in-Charge.

2) Payment shall be made at the unit price per number entered in the Bill of Quantities, which shall include the cost of labour, material including handling, transportation, storage and placing complete in all respects.

17.4.9 Bamboo Piling

1) Measurement for payment will be made of the Numbers of posts driven in ground to the lines and arrangements shown on the construction drawings or those determined by the Engineer-in-Charge.

2) Payment shall be made at the unit price per number entered in the Bill of Quantities, which shall include the cost of labour, material including handling, transportation storage and placing complete in all respects.

17.4.10 EXCLUSIONS

1) No separate measurement and payment shall be made for the wirecrates/Gabions laid by the contractor at access roads to quarries and borrow areas, for the installation of contractor's stationary plants and other infrastructural establishment and the cost thereof is deemed to be included in the respective unit rates.

2) No separate measurement and payment shall be made for the Rock paving, concrete blocks and /or Masonry walls constructed by the contractor at access roads to quarries and borrow areas, for the installation of contractor's stationary plants and other infrastructural establishment and the cost thereof is deemed to be included in the respective unit rates.

END OF SECTION B.17

SECTION B.18

MONITORING INSTRUMENTS

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SECTION B.18

MONITORING INSTRUMENTS

18.1 SCOPE OF WORK

18.1.1 General

1) The Contractor shall supply, install, calibrate, test, survey and maintain instrumentation in the structures specified in this Section or as directed by the Engineer-in-Charge. He shall supply and install all ancillary measuring equipment and construct terminal structures, protective surrounds for instrument, excavate pits and trenches, drill holes, install pipes and fittings and cast concrete where required..

2) The Contractor shall calibrate, test, survey and maintain the already installed instrumentation in the structures as specified in this Section or as directed by the Engineer-in-Charge. He shall supply and install all ancillary measuring equipment and construct terminal structures, protective surroundings for instruments, excavate pits and trenches, drill holes, install pipes and fittings, and cast concrete where required.

3) The extent, type, and location of the individual instruments shall be shown on the Drawings. The number and location of the instruments may be altered by the Engineer-in-Charge during the construction period, according to the requirements.

4) The Contract Documents give only the numbers, general type, and general arrangement of the instruments to be supplied by the Contractor.

5) Instruments shall be preferably vibrating wire type. All instrumentation operating on electrical or hydraulic systems shall be accompanied by individual test certificates, and shall be tested in the presence of the Engineer-in-Charge prior to installation, unless specifically stated otherwise.

6) All instruments shall be installed to the lines and elevations shown on the Construction Drawings or as established by the Engineer-in-Charge as the work progresses during construction.

7) The installation of instruments may interfere with the overall construction progress. The Contractor shall make provision for any such interference in his construction planning. He will not be entitled to any compensation or extension of the Time for Completion by reason of any such delays, including repair and replacement of damaged instruments.

8) No instruments or any of their components shall be purchased prior to Engineer-in-Charge's approval on the manufacturer’s name and model number of the offered instrument. However, approval by the Engineer-in-Charge of the Contractor's proposals and drawings or data shall not relieve the Contractor from his sole responsibility to meet all the requirements under this Contract.

9) All instruments shall be guaranteed against defect in installation/manufacturing for at least 18 months from the date of supply or 12 months from the date of embedment/installation which ever is later. All defective instruments during the period of guarantee shall be replaced by the contractor at no cost to NHPC. However the buried defective instruments shall not be returned to the contractor.

10) All the instruments shall be supplied with at least 3 copies of instruction manuals explaining installation procedures, guidelines, necessary protection measures and necessary maintenance requirements etc. complete in all respects.

11) The entire work of supply, installation, calibration, testing, and maintenance of instruments shall be carried out by a specialist agency having experience, equipment and technology for execution of these works and under strict quality control.

18.1.2 Measuring devices

Instrumentation and monitoring for Surface/Underground works includes the following:

a) Automatic Weather Station
b) Piezometers
c) Joint Meters
d) Stress Meter
e) Strain Meter
f) No-stress Strain Meter
g) Temperature Gauges
h) Water Level recorder
i) Surface Settlement Point
j) Uplift Measuring Device
k) Strong Motion Accelerograph
l) Load Cells – Electrical Type
m) Multiple Point Bore Hole Extensometer – Electrical Type
n) Optical Targets
o) Readout Unit for Electrical Instruments
p) Data Acquisition System and Web based Data Monitoring Services

18.2 SUBMITTALS

1) The contractor shall submit with his bid general information on the instrumentation he proposes to install, manufacturer's name and model number including additional equipment, read out units or probes which may be necessary for the instruments he proposes to use.

2) Within 112 days after the day of receipt of the Notification of Award, the Contractor shall submit details of the instruments (manufacturer's name and model number) proposed for the installation. These shall be consistent with the general information on the instrumentation submitted by the Contractor with his Tender as well as with any modifications subsequently agreed to by the Engineer-in-Charge and the Contractor, and shall include:

   a) Detailed description of all instrumentation, cabling and accessories including any ancillary measuring equipment he proposes to install

   b) Evidence of the successful performance of the instrumentation proposed for installation

   c) Manufacturer's instructions for the installation, testing and operation of the instruments

   d) Schedule of monitoring of instruments.

   e) Details of the layout of all equipment and accessories to be installed in each switch-box and terminal structure

   f) Details of the terminal structures, concrete surrounds, recesses in concrete structures, etc. proposed for the installation of instrumentation and switch-boxes

3) Not less than 28 days before the anticipated date of installing any instrumentation, the Contractor shall submit details of construction procedures to be employed in the vicinity of the instrument installation, and the programmed sequence of events for this work including details of all labour, construction plant and materials to be used.

4) During the execution of the Works, the Contractor shall submit any further details regarding the instrumentation required by the Engineer-in-Charge. The Contractor shall prepare surveys and furnish "as-built" drawings for all installed instruments.

18.3 SKILLED PERSONNEL

1) The whole of the instrumentation work shall be carried out under the direct supervision of the manufacturer's Resident Engineer, approved by the Engineer-in-Charge, and employed by the Instrument manufacturer reporting to the Contractor's Site Manager. The Resident Engineer employed by the instrument manufacturer shall be the one who is well experienced in all types of instrumentation and installation work and who understands the purpose and function of all instruments being installed. He shall be posted at site during the entire period of construction.

2) Installation and calibration of measurement instrumentation shall be carried out by the Resident Engineer or manufacturer's other skilled technicians, acceptable to the Engineer-in-Charge, well experienced in the installation of instruments and who have a thorough understanding of the purpose and function of the particular instruments being installed.

18.4 INSTALLATION

1) The Contractor shall get the instruments installed and calibrated by the manufacturer's skilled technicians in conformance to the manufacturer's instructions and shall, where necessary, expose all partially installed instruments, cables and tubes to continue their installation, including carrying out all survey work required to locate such instruments. The Resident Engineer employed by the instrument manufacturer shall be present during the entire process of construction. The contractor shall submit a certificate issued by the manufacturer regarding the installation of instruments as per the instrument's manual, to the Engineer-in-Charge. The Contractor shall tag all cables and tubes with identification tags approved by the Engineer-in-Charge to provide continuous identification.

2) Instrumentation shall be installed and calibrated in the presence of the Engineer-in-Charge, and when he considers it desirable, instruments shall be installed only during daylight hours. At all times, the Contractor shall ensure that adequate lighting is available, whether by natural or artificial means, to ensure proper execution of the work.

3) Cables and tubes shall be installed in the maximum lengths practicable. Splicing and coupling, if essential, shall be performed in accordance with the manufacturer's recommendations. Calibration readings shall be taken prior to and immediately after splicing. Open ends of all incomplete lines of tubing and casing shall be kept plugged or sealed and the Contractor shall at all times during installation keep the insides of casings and tubes free from foreign matter. Cables and tubes shall be identified by suitable tags fastened at regular intervals throughout their length. Cables and tubes shall be protected from mechanical damage and their tags preserved throughout the construction process by the Contractor.

4) The instruments shall be put in operation at the earliest practicable period during construction in order to obtain information pertaining to the performance of the underground caverns, shaft etc.

18.5 CARE OF INSTRUMENTATION

1) The Contractor shall protect all instruments and connections from damage and displacement during the progress of the work. If damage or displacement of the instruments or connections occurs during the progress of the work, they shall be repaired or replaced immediately by the Contractor.

2) The Contractor shall be fully responsible for the maintenance and repair of all instrumentation for the duration of the contract period.

3) The contractor shall recalibrate instruments at the frequency/ period as specified by manufacturer/ or Engineer-in-Charge.

18.6 READING INSTRUMENTS

1) An initial set of readings on all instruments installed at any particular elevation will be taken prior to and immediately after their installation, and the Contractor shall not place concrete over the instruments or tubes or cables at this location until these readings have been taken and found to be in order.

2) The Contractor, after consultation with the Engineer-in-Charge, shall program his work and make all necessary arrangements to record the reading of instruments as soon as possible after their installation. Such arrangements shall include, where necessary, the provision of temporary read out points.

18.7 INSTRUMENTATION AND MONITORING FOR SURFACE/ UNDERGROUND WORKS

18.7.1 General

1) The Contractor shall supply and install the measuring devices, carry out additional excavation, drilling, construct concrete or mortar pads, backfilling with concrete, perform the measurement, and record the readings at frequency/ period specified by Engineer-in-Charge for the following:

a) Automatic Weather Station
b) Piezometers
c) Joint Meters
d) Stress Meter
e) Strain Meter
f) No-stress Strain Meter
g) Temperature Gauges
h) Water Level recorder
i) Surface Settlement Point
j) Uplift Measuring Device
k) Strong Motion Accelerograph
l) Load Cells – Electrical Type
m) Multiple Point Bore Hole Extensometer – Electrical Type
n) Optical Targets
o) Cables
p) Cable Splicing kit
q) Readout Unit for Electrical Instruments

r) Data Acquisition System and Web Based Data Monitoring Services

2) The measuring devices to be provided shall be manufactured by a reputed manufacturer with proven record and acceptable to the Engineer-in-Charge.

3) Investigations listed elsewhere in this section shall be carried out during excavation work at the locations and time intervals as directed by the Engineer-in-Charge. Contractor's personnel experienced and trained in rock mechanics testing and recording the readings shall perform the testing. All testing to be undertaken shall be done under direct supervision of the Engineer-in-Charge, who will interpret the results. Should the Contractor not have the persons required on his staff, he shall engage a specialised geotechnical firm as his subcontractor, subject to approval by the Engineer-in-Charge.

4) The Contractor shall take utmost care in preserving the factor and initial reading of each instrument and in the recording and analysis of the subsequent readings and prevent mixing of readings from different instruments.

5) During execution of the works, the contractor shall observe, record and submit readings of all the instruments in specified format along with analysis of observed data and at specified frequency/ period to the Engineer-in-Charge.

6) The Contractor shall make provisions in his planned excavation activities to enable the performance of the rock mechanics testing to be carried out concurrently with the underground excavation without disruption or delay. No extension of time for the Completion of Works will be granted to the Contractor due to the performance of such testing.

18.7.2 Automatic Weather Station

1) The Automatic weather station (AWS) must permit to record automatically and continuously the following meteorological data:

- Wind Speed
- Air temperature
- Rainfall
- Relative Humidity

2) The sensors of the AWS shall meet the following requirements:

<u>Wind Speed Sensor</u>

Range:	0.5 to 100 m/s
Resolution:	0.5 m/s

<u>Air Temperature Sensor</u>

Range:	-15°C to +49°C
Resolution:	0.1°C

Rainfall Sensor

Maximum:	10 mm/min
Resolution:	0.02 mm

Relative Humidity Sensor

Range:	5% to 99%
Resolution:	0.1%

3) The sampling interval shall be adjustable from 1 to 3 hours.

4) All the sensors must be operated with solar cells with provision for power module.

5) The station must have the facility for transmitting real time data through VHF radio link, as requested for installations in remote areas.

6) The data-storing unit of the AWS shall have the facility to store all data for a period of at least 31 days and shall permit instant display of data.

7) The Contractor shall supply and install a complete AWS including all instrument shelters and including a standby data-storing unit

18.7.3 Pore Pressure Gauges (Piezometers)

1) Pore pressure gauges shall measure the pore water pressures in the locations shown on the Drawings or as directed by the Engineer-in-Charge.

2) Pore pressure cells gauges shall be vibrating wire piezometer, as approved by the Engineer-in-Charge. The sensors should be properly sealed with electron beam welding.

3) The pore pressure gauges shall have the following characteristics:

Measuring range	0-1Mpa
Accuracy	± 0.5% of range

4) The cells shall be installed in boreholes at elevations as shown in the Drawings.

5) Pore pressure meters shall be provided with over voltage surge arrestor to protect the vibrating wire gauge against damage from lightning. A 3,000 Ohm (25˚C) R-T matched thermistor to be incorporated in the sensor for temperature sensing and for temperature - zero reading correlation.

6) In one bore hole, only one pore pressure cell shall be installed. After the hole has been prepared, the cell shall be placed and embedded with grouting using a 10:3 cement Bentonite mixture.

7) The end of the cables shall be kept during construction in protective boxes and later permanently installed in the terminal structures or switchboxes.

8) For tunnels, pore pressure gauges generally as per above specifications shall be installed in boreholes behind shotcrete or concrete lining or where directed by the Engineer-in-Charge.

9) At the beginning, the reading shall be taken daily. Later, weekly readings shall be taken till the cessation of any movement or until the Engineer-in-Charge permits termination.

10) The transducers shall be provided with a measuring cable of 20 m length

18.7.4 Joint Meter and Temperature Gauge

18.7.4.1 General

1) The Contractor shall supply, install, calibrate, test, and maintain: jointmeters and temperature gauges shown on the Drawings or as directed by the Engineer-in-Charge.

2) All meters attached to the external surfaces of the structure shall be provided with heavy permanent stainless steel covers to prevent damage of the instruments.

3) The Contractor shall also supply approved reliable and robust portable readout devices for the measurements of the above instruments.

4) Instruments shall be adjusted to settings determined by the Engineer-in-Charge.

5) Instruments shall include temperature measuring device for measuring the temperature of the instruments for temperature correction.

18.7.4.2 Perimetric Joint Meters

1) Perimetric jointmeters are required to measure movements of the Dam~~Barrage~~ block joint. Measurements shall be made in three perpendicular directions:

- Normal to the joint to measure joint opening or closing
- Parallel to the joint to measure joint shear in the plane of the concrete face
- Parallel to the joint to measure joint shear normal to the concrete face

Perimetric jointmeters shall be of standard market quality, as approved by the Engineer-in-charge.

2) The jointmeters shall be durable and strong and shall have the following characteristics:

– Minimum range	100 mm
Accuracy	± 0.1 mm
Resolution	0.01 mm

3) Adequate provision shall be made to avoid shear on the jointmeter due to movement normal to the axis of the meter.

4) The jointmeters and extension rods shall be protected against falling debris by heavy stainless steel covers. The measurement cables will be routed to readout box installed, as shown on the Drawings, from where the readings shall be taken.

18.7.4.3 Linear Joint Meters

1) Vibrating wire linear joint meter is required to measure the relative displacement and joint opening of two adjacent blocks in the axis of the joint metre.

2) The instrument shall be stable for long time and it shall be water and corrosion resistant.

3) It shall be suitable for remote reading, scanning and data logging.

4) It shall be fitted with Thermister for temperature monitoring and temperature-zero reading correlation.

5) It shall be fitted with appropriate device to protect it against damage from lightning.

6) It shall have following characteristics:

Range	30 mm (0-30mm)
Sensitivity	0.1mm with read-out unit
Accuracy	+ 2% fs
Operating temperature	-10°C to 70°C
Sensitivity	0.1% fs with read-out unit
Gage length	55 mm
Material	Stainless steel body and phosphor bronze bellow, hermetically sealed by welding with vacuum inside sensor.
Size	Approximately 44 mm overall diameter x 260 mm length.

18.7.4.4 Temperature gauges

1) Temperature gauges are required to measure the internal temperature of mass concrete in different concrete lifts during the initial period of mass concreting. It will be required to monitor the temperatures in concrete structures or where directed by the Engineer-in-Charge upto a period of one year from the date of installation in the concrete or completion of works. These meters are in addition to those the Contractor may need to control the placement temperature of the concrete.

2) Temperature gauges shall be of standard market quality, as approved by the Engineer-in-charge.

3) The temperature gauges shall have the following characteristics:

Type	Vibrating wire type
Minimum range	-10°C to +80°C
Accuracy	±0.2°C
Resolution	0.1°C

18.7.5 Stress Meter, Strain Meter, No-stress Strain Meter

18.7.5.1 Stress Meter

The stressmeter with thermister for temperature measurement shall be vibrating wire type for embedment in the concrete dam~~barrage~~ and other structures with following specifications:

Measuring range	0 – 20 kg/cm²
Accuracy	± 1% or better
Operational temp range	0-70 ºC or better

Each instrument shall be supplied with at least 10 m long factory fitted cable

18.7.5.2 Strain Meter

Strainmeter rosette unit shall comprise of 5 vibrating wire strainmeter suitable for embedment in concrete including a support to permit installation and measurement at 0º, 45º, 90º and 135º and one normal to this plane.

Measuring range	± 1000 microstrains
Accuracy	± 1% or better
Operational temp range	0-70 ºc or better

Each instrument shall be supplied with at least 10 m long factory fitted cable.

18.7.5.3 No-Stress Strain Meter

Measuring range	± 1000 microstrains
Accuracy	± 1% or better
Operational temp range	0-70 ºc or better
Container	"Double wall container" with outer wall of 2 mm thick mild steel and inner wall of 1 mm thick copper. The gap between the wall shall be 50 mm ± 5 mm.

The strain meter shall be vibrating wire type suitable for embedment in concrete.

Each instrument shall be supplied with at least 10 m long factory fitted cable.

18.7.6 Water Level Recorder

1) The Contractor shall supply and install water level Recorder, at the dam~~barrage~~ reservoir at location determined by the Engineer-in-Charge.
2) The height range to be covered by the Water level recorder shall be 50 metres.
3) The water level recorder must permit to record automatically and continuously the reservoir level.
4) The station must have the facility for transmitting real time data through VHF radio link, as requested for installations in remote areas.
5) The data-storing unit of water level recorder shall have the facility to store all data for a period of at least 06 month and shall permit instant display of data.
6) Water level recorder shall be of standard market quality, as approved by the Engineer-in-charge.

18.7.7 Surface Settlement Points

1) The Contractor shall supply, install, and survey all surface settlement points; including survey pins, pipes, pipe fittings, lockable cap, and concrete; as shown on the Drawings. Surface settlement points shall be used to measure the horizontal and vertical movements of the dam embankment surface, the dam crest (top of parapet wall), concrete structures and abutments.
2) Survey pins shall be of stainless steel of 15 mm diameter and 250 mm long. Pipes and fittings for settlement points shall be of galvanised mild steel, and of the shape and size as shown on the Drawings.
3) Surface settlement points shall be installed as soon as possible after placement of concrete or fill at the locations where settlement points are required.
4) Immediately after installation of any point, its position and level shall be precisely surveyed. The level and coordinates shall be computed and submitted in writing to the Engineer-in-Charge within 48 hours of installation.

18.7.8 Uplift Measuring Device

1) Mechanical type Uplift measuring devices shall be installed on top of boreholes.

2) They shall consist of tubes connected to the borehole, a valve to release the pressure and to measure the discharge and a readout manometer. The manometer shall permit readings up to 10 bars with an accuracy of 0.05 bars or better.

18.7.9 Strong Motion Accelerograph

1) The Strong motion accelerographs shall be supplied and installed by the contractor at locations indicated on the drawings or as determined by the Engineer-in-Charge to record the response of the structure. Generally the instruments shall be located one each on the either flanks one in the body or over the dam~~barrage~~. These instruments will record events of all ground acceleration above an adjustable threshold limit based upon STA/LTA (to be provided by Engineer-in-Charge.

2) The accelerograph shall comprises of 3 no. triaxial sensors with digitizers and 1 no.common data acquisition system The system to have long term stability, proven dependency and reliability. It shall also have an output cable for connection to a desktop computer for data processing.

3) Short haul modem pairs with suitable length of unshielded pair of twisted telephone cable for connection between the modems to be provided if distance between any accelerometer and data acquisition and storage module exceeds the allowance limit.

4) Suitable software for PC shall be supplied for retrieving data from the seismic data acquisition module, plotting the data on display screen as well as providing a hard copy of record.

   Strong motion accelerograph system should meet the following specifications:

   a) Triaxial strong motion sensor with digitizer (3 no.)

      Sensor system type 3-axis (orthogonal) strong motion force feedback Accelerometer.

      Bandwidth DC to 100 Hz (-3dB). The frequency response curve should not show any spurious response within the specified bandwidth.

Full Scale output	± 2g
Digitizer ADC resolution	24 bits
Dynamic range	>165 dB >140 dB for 0.005-0.05 Hz >127 dB for 3-30Hz
Linearity	± 0.1% of FS

Cross axis rejection	0.001 g/g
Operating temperature range	-20 to 70 □C
System Power supply	10-28 V DC either directly or through a suitable power supply adaptor from 230 V, 50 Hz AC mains
Current at 12 V DC	185 mA
Calibration controls	Independent signal & enable lines Exposed on sensor connector
Optional output controls	Remote offset zeroing
Optional low pass corner	50,100 or 200 Hz Hard anodized aluminium case Mil –spec connectors
Housing	Weatherproof housing suitable for outdoor installation

b) Seismic Data Acquisition and Processing System (1 no)

Communication technologies supported	RS 232,RS 422, PCMICAmodem, Ethernet (10BaseT/100BaseT), Wireless LAN (802, 11b)
Internet technologies supported	TCP/IP PPP HTTP, HTTPS server
Form factors	Stand –alone-3 ports
Port types	Data in/out, modem, console (user – configurable)
Flash memory	512 MB
On board disk type	USB
Filing system	Hot – swappable, journalling, Windows, FAT 32 compatible
Direct disk recording formats	GCF, miniSEED
External storage	USB storage with 15 GB USB stick
Operating temperature range	-40 to 60 □C with managed disk heating
System power supply	10-35 V DC either directly or through a suitable power supply adaptor from 230 V, 50 Hz AC mains
Power consumption	<0.75W + power pass –through

Operating system	Ultra low power variant of familiar Linux

18.7.10 Load Cells

1) Load cells of electronic resistance strain gauge type shall be installed to monitor the behaviour of rock bolts installed.
2) The load cells shall have the following characteristics:

Capacity:	300 kN or 1200 kN as specified in the Bill of Quantities.
Overload capacity:	50 % of Full scale
Accuracy:	1 % of range
Material of Element	Stainless steel
Welding	Hermetically sealed by electron beam welding resulting in a vacuum of around 1/1000 Torr inside the sensor.
Suitable for	25, 32 or 36 mm diameter rockbolts as specified by Engineer-in-Charge
Remote electrical read out	Suitable for resistance strain gauge type sensor

3) At the beginning, the readings shall be taken daily. Later, weekly readings shall be taken till the cessation of any movement or until the Engineer-in-Charge permits termination.
4) Each load cell shall be supplied with a cable of 20 m length.

18.7.11 Convergence Measurement Including Optical Techniques

1) Convergence measurement shall be performed in underground excavation works to determine the relative displacement of opposite measuring points placed around the excavation perimeter.
2) The measuring points shall consist of the convergence bolts made of stainless steel pins mounted on a short reinforcing bar grouted into predrilled hole.
3) The distance changes between the opposite convergences bolts shall be measured by means connected to the bolts and tensioned between them. Change of length shall be read on a digital gauge. Accuracy of the measurement shall be 1mm.

4) The convergence bolts shall be installed within the heading zone after the installation of supports. At the beginning, the measurement shall be carried out daily. Later, weekly readings shall be taken for several months up to the cessation of any movement but latest when the placing of the concrete lining commences.

5) Convergence measuring tape: It is required for measuring distance for "Convergence measuring points. It shall be temperature resistant, water resistant and tear resistant and length not less than 30 meter. The digital gauge shall be calibrated on their corresponding calibration devices before and after each measurement. Digital readout shall be in metric unit and the readings shall be displayed in 5-digit LCD.

6) Optical Targets: Optical Methods of convergence monitoring comprises of optical bireflex targets. A convergence bolt of 170 mm length and 12 mm od with 3/8" pipe thread stud shall be securely attached to the exposed rock or shotcrete surface. The bolt shall be provided with a plastic cap with a breaking point serving as an adapter for the mounting of a reflector with a marked center point. This device shall be designed for high precision measurements with two axes of rotation and to be observable from both sides. The manufacturing accuracy of the fully machined bireflex target must be so as to achieve an over all accuracy of ± 1 mm within the measuring section. The targets must be replaceable without loss of accuracy

   The optical targets shall be monitored by the Contractor's precision Total Station for any convergence within the tunnel.

18.7.12 Multipoint Bore-Hole Extensometers

1) These extensometers shall be installed in suface/underground excavation to measure displacements in the rock mass surrounding the excavation.

2) The extensometers shall be installed in the boreholes drilled radially on a plane perpendicular to the centreline of the underground structure. The exact location of each measuring section will be determined by the Engineer-in-Charge.

3) The extensometers to be installed shall be of single point or three-point type with stainless steel or fibre glass rods. The borehole diameter shall be 50 mm diameter for single point and 76 mm for three-point extensometers. The measuring heads shall be installed in recesses excavated around the collar prior to the drilling of the hole and shall be protected from damage by a cover plate.

4) Single point extensometers will generally have a length of 6 to 10m, on average 8m. Three point extensometers will have a typical rod length of 4, 7 and 10m or 5, 10 and 15m. However, different rod lengths may have to be supplied to suit specific site conditions as specified in the Bill of Quantities.

5) Reading of the extensometer shall be done with electrical vibrating wire type sensors with a provision to take readings mechanically with the help of a digital depth gauge of 0.01 mm scale division. At the beginning, the readings shall be taken daily. Later, weekly readings shall be taken till the cessation of any movement or until the Engineer-in-Charge permits termination but latest when the placing of the concrete lining commences. The readings so taken along with report (comprising of data observed, analysis of data etc.) shall be reported to the Engineer-in-Charge.

18.7.13 Sensor Networking Systems

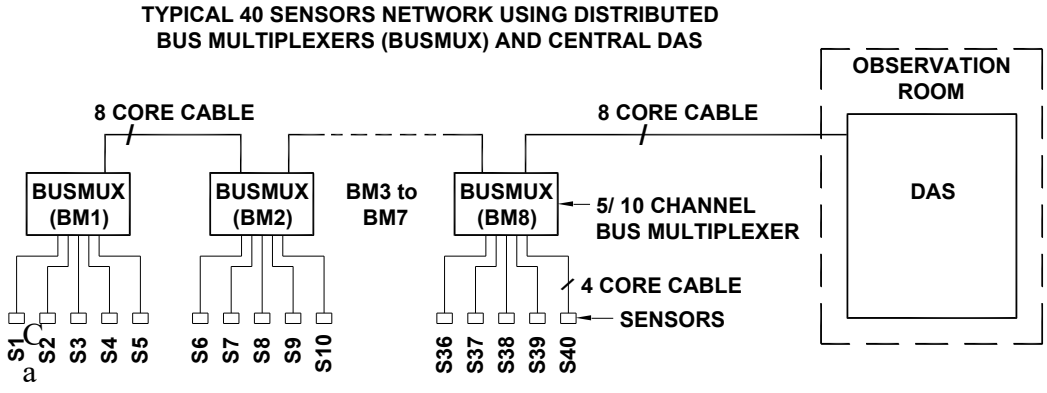
Sensor networking shall be accomplished by using bus multiplexer system such that cumbersome handling of heavy cables leading to the DAS is avoided.

Accordingly, cabling shall be done based on the following practices with detailed cable routing drawings prepared by the designer/instrumentation supplier and approved by the Engineer-in-Charge:

Bus Multiplexer System: Cluster of sensors shall be connected to individual bus multiplexers placed near the sensors. Several bus multiplexers shall in turn be connected to the Data Acquisition System through a single 8-wire bus cable (8-core cable with water blocking compound). A typical arrangement in which 40 sensors are connected to the DAS through a single 8 core cable is shown here:

18.7. 14 Cables

1)



C
a
b

les shall be generally be of following types

a) 4 core cable- It shall have 7/0.25 annealed tinned copper, twisted pairs in red/black, green/white, with water blocking aluminium foil, 0.3 mm galvanized iron wire braid armoured, overall polythene sheathed, overall diameter of around 11 mm and weight of around 0.12 kg/m.

b) 6 core cable- It shall have 7/0.25 annealed tinned copper, twisted pairs in red/black, green/white, blue/grey with water blocking aluminium foil, 0.3 mm galvanized iron wire braid armoured, overall polythene

sheathed, overall diameter of around 11.5 mm and weight of around 0.14 kg/m.

c) 8 core cable- It shall have 7/0.25 annealed tinned copper, twisted pairs with water blocking aluminium foil, 0.3 mm galvanized iron wire braid armoured, overall polythene sheathed, overall diameter of around 12.5 mm and weight of around 0.16 kg/m.

d) 12 core cable- It shall have 7/0.25 annealed tinned copper, twisted pairs with water blocking aluminium foil, 0.3 mm galvanized iron wire braid armoured, overall polythene sheathed, overall diameter of around 14 mm and weight of around 0.40 kg/m.

e) 20 core cable- It shall have 7/0.25 annealed tinned copper, twisted pairs with water blocking aluminium foil, 0.3 mm galvanized iron wire braid armoured, overall polythene sheathed, overall diameter of around 16 mm and weight of around 0.30 kg/m.

f) 40 core cable- It shall have 7/0.25 annealed tinned copper, twisted pairs with water blocking aluminium foil, 0.3 mm galvanized iron wire braid armoured, overall polythene sheathed, overall diameter of around 19.8 mm and weight of around 0.60 kg/m.

2) Special cables, where required, for various gauges shall be of standard market quality, as approved by the Engineer-in-Charge.

18.7.15 Cable Splicing Kit

For joining two ends of 4/6 core cables, cable splicing kit shall be used. It shall be of material-AISI 304 stainless steel and suitable to make a water resistance sealed heavy duty joint between the two cables. It shall be supplied with requisite amount of cable jointing compound.

For joining two ends of 12/20/40 core cables, a suitable junction box (LB) shall be used. It shall be of material-aluminium with powder coating and shall have a suitable PCB with screwed terminals. It shall be filled with cable sealing compound to be supplied along with the JB.

18.7.16 Readout Unit for Electrical Instruments

1) For all electrical instruments, the Contractor shall supply portable readout units suitable to read digitally in engineering units all cabled instruments and store data with time and date. The readout units should be light, robust and durable.

2) Detailed specifications of read out units for vibrating wire sensors should be as follows:

Type	**Portable, microprocessor based, programmable battery operated digital indicator.**
Suitable	For all types of vibrating wire sensors and 3K thermistors.

Display	In time period and also in engineering units (like μ strain, kg/cm^2, mm, kgf, tf, deg., ^oC etc.). In the engineering mode display, the read-out should be capable of being set to a resolution of up to two decimal points.
Calibration coefficients	The digital indicator should be capable of storing the calibration coefficients of around two hundred fifty vibrating wire transducers by an internal non-volatile RAM.
Data Entry	Shall be through a sealed membrane key-pad
Data download to computer	A RS-232C port for down loading data to a computer or a printer to be provided.
Data Storage	The vibrating wire transducers indicator should have an internal non-volatile memory with sufficient capacity to store around 4,500 date and time stamped readings from around 500 programmed transducers in any combination.
Non-linearity corrections	The indicator should have the capability of storing three polynomial coefficients of each sensor for applying non-linearity corrections.
Enclosure	The indicator should be suitable for field use and housed in a sturdy portable enclosure.
Power	An internal rechargeable sealed maintenance free battery to be used to provide power to the indicator. A fully charged new battery should provide more than 40 hours of operation on a single charge
Battery Charger	To be provided to charge the internal battery from 230 V AC mains.

3) Detailed specifications of read out unit for strain gauge based Load Cells shall be as under:

Type	**Portable, microprocessor based, programmable battery operated digital indicator.**
Display	In engineering units (mm). In the engineering mode display, the read-out should be capable of being set to a resolution of up to two decimal points.
Calibration coefficients	The digital indicator should be capable of storing the calibration coefficients of around hundred transducers by an internal non-volatile RAM.
Data Entry	Shall be through a sealed membrane key-pad
Data	A RS-232C port for down loading data to a computer or a

download to computer	printer to be provided.
Data Storage	The read-out unit should have an internal non-volatile memory with sufficient capacity to store around 720 date and time stamped readings from around 100 programmed transducers in any combination.
Enclosure	The indicator should be suitable for field use and housed in a sturdy portable enclosure.
Power	An internal rechargeable sealed maintenance free battery to be used to provide power to the indicator. A fully charged new battery should provide more than 40 hours of operation on a single charge.
Battery Charger	To be provided to charge the internal battery from 230 V AC mains.

18.7.17 Data Acquisition System and Web Based Data Monitoring Services

A stand alone Data Acquisition System (DAS) shall be provided based on Campbell Scientific's measurement and control module or equivalent for real time on line and automatic scanning and recording of all electronic sensors. The DAS shall be complete with all required hardware and software components including power supply units, control and communication modules, input cards signal conditioners, interface devices, surge protector. All the DAS hardware components shall be housed in a cabinet. The system shall be suitable for unattended continuous operation in harsh environment. One number PC based operator cum engineering station shall be provided by the contractor along with 0.5 KVA UPS with battery back up.

The scan rate shall be programmable from few times a second to once every few hours. The system shall have memory to store at least 60,000 data points. The measurement and control module shall provide sensor measurement, communication, data reduction, data/program storage and control functions. It shall have a battery backed clock. The system should have provision that data can be down loaded through an appropriate software to any standard PC or a laptop. It shall have powerful instruction set, in standard software to enable the system for generation of math functions, max., min., average, histograms etc. The software shall enable display of sections of the structure showing location of instruments along with instrument tag number or identification number such that when the particular instrument on a section on which it is installed is clicked, data recorded for the instrument is displayed on the screen.

The contractor shall be responsible for data management and presentation till the end of his defect liability period for the project. For this purpose, the instrumentation manufacturer shall provide Web Based Data Monitoring

Service (WDMS). The user shall be able to interact with the software using their web browser, when connected to the internet, from anywhere in the world. It should allow multiple authorized users at different locations to view any data, graphs or reports from the same project site simultaneously using a popular web browser like Microsoft internet explorer or Mozilla Fire fox amongst others.

18.7.18 Laboratory tests

1) Point load index and uniaxial compression tests shall be performed by the Contractor for determination of the intact rock strength and modulus. Tests will utilise core samples obtained from test drill holes performed in the tunnels, shaft or cavern.

2) The samples to be tested for point load strength shall be determined by the Engineer-in-Charge. Approximately 50 samples may be tested.

3) Core samples equipped with resistance type strain gauges will be loaded in uniaxial compression for calculation of the elastic modulus and strength. Approximately 10 samples may be tested.

18.7.19 Micro-Seismic Surveys

1) Seismic refraction measurements within the underground sites shall be performed by the Engineer-in-Charge however, the preparatory works as defined below shall be done by the contractor.

2) The Contractor shall carry out the preparatory works necessary for the series of seismic refraction measurements consisting of several lines. For each of the lines, the Contractor shall drill holes not exceeding 50 cm depth using percussion drilling at approximately 1 m centres and install steel bars as impact points. In general, holes shall be drilled in the tunnel/ Cavern walls, but where directed by the Engineer-in-Charge, they may be drilled also in the tunnel invert or roof.

18.7.20 Tunnel Mapping

1) Concurrently with excavation, the Engineer-in-Charge will map the geological conditions along the tunnels and prepare relevant drawings.

2) The Contractor shall provide adequate lighting, ventilation, and reasonable access for tunnel mapping. Cleaning and washing of the tunnel walls and crown will be necessary and the contractor shall carry out the same at no extra cost to the NHPC.

3) The mapping of the tunnel may interfere with the overall construction progress. The Contractor shall make provision for such interference in his construction planning. He will not be entitled to any compensation or extension of the Time for Completion by reason of any such delays.

18.7.21 Tunnel Seismic Prediction Test

1) Tunnel Seismic Prediction (TSP) is a helpful tool for prediction of geological conditions as well as groundwater conditions ahead of the tunnel face. Tunnel Seismic Prediction (TSP) investigation may be carried out in a good rockmass for better signal penetration necessary for obtaining better results. Tunnel Seismic Prediction (TSP) is capable for predicting ground conditions about 150 m ahead of face.

2) Tunnel Seismic Prediction (TSP) shall be performed by Contractor as and when required depending on site condition. Provision of 3D Tunnel Seismic Prediction (TSP) for 5 occasions/numbers in HRT shall be kept.

3) The Contractor shall carry out the preparatory works necessary for Tunnel Seismic Prediction test. Preparatory work consists, drilling 24 Shot holes of about 38-45 mm diameter, 1.5-2.0m deep, having inclination of 10°-20° downwards with a spacing of 1.5m. The drilling shall be done starting from as close as possible from the face on either of the tunnel wall & shall be drilled about 1.5m above the invert level.

The receiver boreholes required for 3D TSP are 4Nos. These receiver boreholes are of dia 50 mm, 2.05 m long with an inclination 5°-10° upwards shall be drilled in both side walls for fixing the receivers with special epoxy cartridges 15-20m away from last shot hole. Exact geometry will be finalized as per site conditions.

18.8 MEASUREMENT AND PAYMENT

18.8.1 General

1) The drill holes, where required for installation of instrumentation shall be measured and paid separately under the section “Drilling, Grouting & Pressure Relief holes”

2) The Unit Prices for instrumentation entered in the Bill of Quantities shall include the supply, installation, calibration, testing, surveying, repairing and maintaining of all instruments, ancillary and cables, including protective steel covers, tubes and tube protections, required to perform the specified measurements.

3) The Unit Prices shall also include for forming all necessary recesses in concrete, all necessary trench and pit excavation, foundation preparation, temporary and permanent protection of instruments and ancillary equipment by surrounding with selected material or by other approved method, and maintaining easy access to all readout points. No deduction will be made for the volume occupied by the instruments and instrument protection when measuring the embankment material for payment.

4) The readout units for electrical equipments shall be paid separately.

5) The Contractor shall include in his Unit Prices any additional readout equipment, which may be necessary for reading the instruments he proposes to use.

6) Measurement for payment and payment for the portable readout units shall be made in nos. as entered in the bill of quantities.

7) The payment for all work required for performing 3D tunnel seismic prediction testing will be made at the appropriate Unit Price entered in the Schedule of Prices.

18.8.2 Exclusions

The following shall not be paid extra and is deemed to be included in the unit price of various instrumentation items

a) Sensor networking Bus Multiplexer Systems.

b) All accessories including various types of cables, splicing kit and switch boxes, from installed instrument to Read out Unit/DAS

c) Complete services of installation and monitoring like posting of one representative of the instrumentation manufacturer for the entire duration of contract including one year defect liability period.

END OF SECTION B.18

SECTION B.20
ELECTRICAL AND MECHANICAL WORKS
List of Contents

SECTION B.20

ELECTRICAL AND MECHANICAL WORKS

20.1 SCOPE OF WORKS

20.1.1 General

This section of the specifications covers the provision by the Contractor of all labour, plants and material and performance of all works necessary for the design, manufacture, shop-testing, transport and delivery, erection, testing, commissioning and handing over to Employer of items of electrical and mechanical equipment which are to be installed by the Contractor at the ~~Barrage~~Dam, ~~Desilting basin, Head regulator,~~ Intake, Gate operation chamber of SFT etc. Included is the drainage water pumping system complete with piping, valves, fittings, auto starting and stopping features and other accessories. This equipment, certain of which will be complementary to that being supplied by other contractor, is listed below.

20.1.2 External and Internal Lighting

1) External lighting equipment and fittings will be provided for the following areas:
   a) The approaches to and top of the ~~barrage~~dam and downstream face.
   b) The head regulator areas and the area of the control building.
   c) The road from the ~~barrage~~dam, control building, SFT outlet, Gate operation chamber (SFT) and adit to HRT.
2) Internal lighting equipment and fittings will be provided for the following buildings and underground areas:
   a) ~~Barrage~~Dam control room, DG room & Gate operation chamber (SFT)
   b) Access adits to HRT etc.

20.1.3 Other Items of Electrical and Mechanical Equipment

1) Grounding equipment for ~~Barrage~~Dam, Spillway & Head Regulator, Power Intake.
2) Drainage water pumping equipment for the ~~barrage~~dam area.

20.2 LIGHTING EQUIPMENT

20.2.1 Special Design and Layout Conditions

1) The supply for the illumination system for all areas described above shall be taken from main lighting board (provided by others) situated in ~~barrage~~dam control room. The outgoing feeders from this main A.C. lighting board shall be taken on trays/conduits.
2) The cables for illumination and for convenient power outlets would be partly in the cable trenches, conduits and cable trays.

20.2.2 Basic Dimensioning and Ratings

1) All apparatus and materials supplied and all works carried out under this contract shall comply in all respect with the requirements of the regulations and acts in force in India.

2) Service voltages shall be as indicated in the following table:

Normal lighting system	Three-phase, five wire, 415/240 V, 50 Hz
A.C. socket outlets	Single-phase, three pin, 240 V, 50 Hz
Power socket outlets	Three-phase, five pin, 415/240 V, 50 Hz

3) Minimum specified illumination levels in general and office areas shall be as follows:

Storage rooms	100	Lux
General	150	Lux
Staircases	100	Lux
Traffic routes for people in building	100	Lux
Galleries	100	Lux
Offices	300	Lux
Control room	400	Lux
Approach roads of ~~barrage~~dam and other areas	100	Lux.
Access tunnels and gate chamber	100	Lux.

20.2.3 Performance Criteria and Guarantee

1) The illumination system along with all accessories shall be capable of performing all intended duties and it is the responsibility of the contractor to supply the equipment as per guaranteed technical particulars.

2) All apparatus and material supplied shall comply with the relevant Electricity Act / Rules in force in India.

20.2.4 Design and Construction

20.2.4.1 Illumination Scheme and Fittings

1) It is proposed to use HPSV lamp fittings for the ~~barrage~~dam area, spillway and approach Roads.

2) The control room shall have fluorescent decorative fittings in design to enable installation.

3) Illumination of control room area shall be done by means of fluorescent type tube.

4) Illumination for adits shall be done by incandescent lamp.

5) Emergency lighting shall be provided in the control room.

6) Convenient power outlets shall be provided at different places in control room, and shall consist of triple pole neutral and protective earth.

7) The tenderer shall examine carefully the requirements to be met by the lighting system and shall quote in accordance with the requirements. He may quote separately for any alternatives and additions, which may enhance the utility and efficiency of the system as a whole.

8) The system shall comply with all the requirements of surface and concealed wiring standards.

20.2.4.2 Distribution Board

1) The boards shall be of wall mounted type and shall be located 1.5 m above the floor. They shall be made of sheet steel not less than 3 mm thick.

2) Boards shall be waterproof and shall be provided with glands or adapters to receive a screwed conduit.

20.2.4.3 Switchboards

The boards with the required number of piano type switches and socket sets shall be made of metal on all sides, except on the front, bakelite sheet of 3 mm thickness shall be fixed with brass screws.

20.2.4.4 Cables

1) The cables shall be at least 600 V / 1000 V, grade copper single core conductor, unarmoured PVC insulated.

2) The insulating material of cable shall not deteriorate with age or due to the voltage stresses etc. Each cable coil shall be accompanied by the manufacturer's test giving the results of the insulation test.

3) The wiring shall be done in looping back system. No joints shall be made at intermediate points in the given of the cables.

20.2.4.5 Colour System for Wiring and Electrical Fittings

A.C. Three phase red, yellow and blue neutral, green-yellow earth.

D.C. Two wire system, positive red, negative black.

20.2.4.6 Wiring

1) It is proposed to carry out surface wiring for illumination circuits as well as for power outlets. In some areas concealed wiring shall be done based on the site requirements.

2) The cables shall be connected to terminals only by lugs.

20.2.4.7 Lighting Accessories

1) Each socket outlet for lighting and power shall be controlled by a switch which shall be on the live side on the line. The socket outlets shall be pin type, 3rd pin being connected to the earth.

2) All lighting outlets (5 amps & 15 amps) shall be located at the switch board located 1.5 m above the floor.

3) The power socket outlets should be either 16 A and/or 32 A.

20.2.4.8 Conduits

1) The conduits shall be manufactured in accordance with the latest standards and shall be supplied in random length of 4 m to 6 m.

20.2.4.9 Conduits Joints

1) Conduit joints shall be made by means of screwed couplers and screwed accessories.

20.2.4.10 Bends

1) All necessary bends in the system shall be done by bending of conduits or by inserting suitable solid or inspection type normal boards, elbows or similar fittings whichever is more suitable.

20.2.4.11 Fixing of Conduits

1) Conduits pipe shall be screwed to suitable plugs with anchor fasteners.

20.2.4.12 Erection & Earthing of Conduits

1) The entire system of conduits, after erection, shall be tested for mechanical and electrical continuity throughout and permanently connected to earth by means of earthing clamp.

20.2.4.13 Inspection Box

1) Suitable inspection boxes shall be provided to permit inspection and to facilitate removal of wires if necessary.

20.2.4.14 Cables and Trenches

1) Cables in trenches shall be laid such that the cables laid in it do not touch each other. If necessary cables may be fixed with clamps on the walls of the trenches.

20.2.4.15 Earthing

1) The continuous earth shall be run for all the 3 pin sockets.
2) The neutral will be earthed at distribution transformer, the three phase four wires distribution system shall be connected to the station earthing system at two or more places.

20.2.5 Quality Control and Assurance

1) The contractor has to supply the equipment for the illumination system of best quality. The contractor has to maintain quality control during manufacturing of equipment as per the approved Employer quality assurance plans.

20.2.6 Calculation Requirements

1) The contractor is required to submit the calculations for the following to the owner for approval during detailed Engineering:
   a) Calculations for the illumination levels of the different areas with respect to installation plan.
   b) Cable and conduit sizing.
   c) Type of luminaries.

20.2.7 Shop Tests

1) The equipment for the illumination system shall be type and routine tested as per relevant IEC standards & India Standards. The contractor is required to submit all type test certificates and routine test reports to the owner.

20.2.8 Installation and Commissioning

1) The contractor shall furnish all labour, supervision, tools, supplies, bracing, spiders, shims and supports and all other provisions or materials necessary to assemble, erect, install, test and commission the equipment in a thorough workman like manner following the best modern practices. The equipment and all its components shall be placed with great care and accuracy and shall be aligned correctly to provide an installation consistent with the close tolerances used in the erection of modern equipment. The proper elevations and centrelines to which equipment is to be set shall be established by the contractor. The works to be carried out under this contract shall comply with the relevant requirements given in Electricity Act / Rules in force in India.

20.2.9 Field Tests

1) After installation, the illumination system shall be field tested for operational tests and mega value of insulation as per relevant IEC & India Standards. The contractor shall prepare and hand over to the owner details of all test results in a report on a mutually agreed format.

20.2.10 Spare Parts

The contractor shall furnish the following spare parts:

1) Five (5) Multiple plug power sockets suitable for 32/16 / 15/5 A.
2) Two (2) High pressure sodium vapour high bay lighting fittings complete with all accessories
3) Ten (10) Fluorescent fittings complete with all accessories of each type used.
4) Ten (10) DC lamp fittings complete with accessories of each type used.
5) 5%, but at least two pieces of all switches, contactors, terminal blocks, screws
6) 5%, but at least 50 meters of all conduits, cables, wires.

20.3 GROUNDING SYSTEMS

20.3.1 General

1) Embedded earthing system shall be provided for the ~~barrage~~dam, spillway, head regulator & power intake.
2) The earth electrode system as well as other earthing networks shall be designed and constructed for the operating voltages, the short circuit capacities and the corresponding short circuit and earth fault currents.

20.3.2 Special Design and Layout Conditions

1) The Contractor shall design and construct the grounding system for protection of persons and material to allow a safe service and maintenance work on the installations.
2) The earthing system shall be constructed to comply with the requirements of the applicable standards and connected equipment. The grounding system shall be designed to avoid dangerous touch or step voltage.
3) More specifically and independent of the regulation and standards, the earthing system shall provide:
   a) Adequate protection of personnel against dangerous voltages, currents and arcs.
   b) The fault currents shall flow through the earthing system.
   c) Limiting the induced capacity transformed voltages on low voltage, weak current and electronic cables, circuits, panels and other equipment.

20.3.3 Basic Dimensioning and Ratings

1) The earthing conductors shall be dimensioned for carrying earth fault current in any section of the plant for at least one second without any harm to the conductors. The equivalent resistance of the whole earth electrode and main earth collector shall be $\leq 0.5\ \Omega$. Earth conductor in ground shall be welded one to each other.

20.3.4 Performance Criteria and Guarantee

The complete grounding system covered under this contract shall be capable of performing all intended duties and the equipment shall be as per guaranteed technical particulars and final grounding mat resistance.

20.3.5 Design and Construction

20.3.5.1 Embedded Earthing System

1) The embedded earthing system for the ~~Barrage~~Dam, ~~Head regulator, Desilting basin,~~ and intake etc. shall consist of a interconnected earthing grid formed by MS electrode, rods and copper conductors of suitable size. The copper conductors shall have contact with the reinforcement bars of the concrete structure.

2) Prior and during the concreting stage the sub contractor if any shall provide all material and all information in sufficient details to enable the Civil Contractor to install the earthing conductors, connect them to the reinforcement bars and to form the adequate grid and to install the necessary connection pieces required for the connection of the above ground earthing system to the embedded earthing system.

3) The number and location of these interconnecting points shall be determined by the contractor.

4) All connections of the embedded earthing conductors shall be thermo-welded.

5) The conductors buried in the soil or laid in cable trenches or similar, shall be tinned copper cables.

20.3.5.2 Above Ground / Above Floor Main Earthing System

1) The earthing system shall consist of individual loops with connections to the different equipment to be earthed and with connections to the embedded earthing grid. At certain locations earthing measuring points shall be installed.

2) The connection straps from the embedded net to the main protective earthing buses shall be provided with disconnect terminal lugs for measuring, always visible for inspection.

20.3.5.3 Conductors and Connections

1) The Contractor shall supply the all embedded conductor system and the connection rods, and design suitable connection facilities for connection of individual conductors to the system.

20.3.6 Quality Control and Assurance

1) The supplier has to supply all the equipment of best quality. The supplier has to maintain control and quality assurance during the manufacturing, installing, testing and commissioning of grounding system as per the approved NHPC quality assurance plan.

20.3.7 Calculations

The Contractor shall submit design calculations of the whole grounding system, including the embedded grounding system for approval of the Engineer. Additionally to the applicable rules and standards, "Guide for Safety in AC Substation Grounding" ANSI/IEEE Std 80-1986.

20.3.8 Work Shop Tests

The material used grounding system shall be routine tested for dimension checking, corrosion protection and material strength as per relevant standards at the work's of supplier in presence of owner. The Supplier is required to submit routine test reports of materials.

20.3.9 Installation and Commissioning

The laying, erection and commissioning of all grounding system shall be carried out by contractor. The concreting shall be done by other contractors. The contractor is required to remain present at concreting for supervision of work. The contractor is required to submit detail drawing for grounding system. All erection and commissioning of the grounding system shall be done by skilled workers in a workmanlike manner.

20.3.10 Field Tests

1) The grounding system shall be site tested to demonstrate operation capability as per the intended requirements.
2) The following tests shall be performed:
3) Visual inspection of exposed system
4) Electrical continuity test
5) Measurement of earthing resistance, as far as reasonable of individual loops.

20.4 DRAINAGE WATER PUMPING SYSTEM

20.4.1 Basic Dimensioning and Ratings

20.4.1.1 Standards

Unless otherwise stated hereafter, rating, characteristics of the equipment concerning to drainage systems shall comply with the provision and requirements of applicable international or Indian standards.

20.4.1.2 Rating and Characteristics of System

Two numbers of pumps shall be provided. The pumps shall be submersible type having discharging capacity of 1500 litres/min each at a discharge head of 50 meters.The pumps shall be suitable for continuous operation, capable of pumping water with heavy silt, directly driven by electric motor rotational speed of which shall not be more than 1450/1500 rpm.

20.4.1.3 Control System

1) The Contractor shall provide and install all the sensory and operating devices necessary to fulfil the functional requirement of the specification for control system.

2) A control and indication panel shall be installed for drainage systems in the control building. Following controls & indications shall be provided:

   a) Manual/Automatic/on-off switch for manual/automatic operation of drainage pumps.

   b) Remote/ local selector switch

   c) Drainage pump selector switch

   d) Start/stop push buttons

   e) Emergency stop push button switch

   f) Lamp test push buttons.

   g) Drainage pump running

   h) Drainage water no flow

   i) Drainage water level " Max"/ "Min"

   j) Pumps inlet choked

   k) Other required indications and control and current/voltage measurement

20.4.1.4 Protection Equipment

The motor for each pumping unit shall be provided with at least the following device:

a) Over load protection

b) Under voltage protection

c) Single phasing protection

20.4.2 Performance Criteria and Guarantee

The drainage systems shall be capable of performing all intended duties and it is the responsibility of the supplier to supply the equipment as per guaranteed technical particulars.

20.4.3 Design and Construction

20.4.3.1 Pumps

1) The drainage water pumps shall be vertical shaft type with submersible motors equipped with water leakage detector.

2) Pump speed shall be 1450 rpm. Pump bearings shall be water lubricated. The suction strainer of drainage water pumps shall be bronze or brass.

3) Flow indicators with four potential free contacts for remote indication for alarm and start levelling shall be provided for water flow for each pump. Shut-off valves and check valves shall be provided to allow disconnection and switching of each pump without emptying pipes.

20.4.3.2 Valves and Piping

All required pipes, flanges, fittings, supports, fasteners, insulation cover and related material shall be supplied as a part of the contract. Valve vents and drains shall be provided as required. Minimum pipe wall thickness shall be as per relevant Indian standard for heavy duty pipes. All drainage water piping shall be insulated against condensation and be provided with vapour proof cover.

20.4.4 Quality Control and Assurance

The supplier has to supply the equipment for drainage systems of best quality. The supplier has to maintain quality control and assurance during the manufacturing of equipment as per the approved NHPC quality assurance plans.

20.4.5 Calculations

The contractor is required to submit the calculation for selecting the pump capacity and working head for each pump for drainage system for approval.

20.4.6 Work Shop Tests

The contractor is required to submit type test certificates and routine test reports of equipment for approval by Engineer before despatch of equipment.

20.4.7 Installation and Commissioning

1) The Contractor shall furnish all labour, supervision, tools, supplies, bracings, spiders, shims and supports and all other provisions or materials necessary to assemble, erect, install and test and commission the equipment in a thorough workmanlike manner following the best modern practices. The equipment and all its components shall be placed with great care and accuracy and shall be aligned correctly to provide an installation consistent with the close tolerances used in the manufacture of modern equipment. The proper elevations and centrelines to which equipment is to be set shall be established by the Contractor.

2) Pipe fixtures shall be spaced according to accepted standards and provisions made for thermal expansion and contraction of piping. Before installation all system components shall be checked for cleanliness and after installation the systems shall be effectively flushed out with clean water and filled up for testing.

20.4.8 Field Tests

1) After installation and prior to putting the terminal equipment into operation at least the following tests shall be made:

a) After installation of all equipment the complete systems shall be leakage tested at 15 kg/cm^2. The systems shall maintain the test pressure for 24 hours without showing any sign of pressure loss (constant temperature provided). If the systems are tested in sections same applies for each section.

b) Test to demonstrate operational capabilities of the system as per the intended requirements

2) The Contractor shall prepare written test certificates in a form agreed upon by the Contractor and Engineer of all tests results and hand them over to the Engineer in due time.

20.4.9 Spare Parts

The following spare parts shall be supplied:

1) One valve of each type used
2) Two sets of pump shaft seal of each type
3) Two sets of all rings and seals
4) One flow meter
5) One set of pressure gauge of each type used
6) One set of indicating instrument of each type used
7) One set of indicating lamps along with assembly of all types used
8) Any other spares as recommended by the Manufacturer

20.5 MEASUREMENT AND PAYMENT

20.5.1 Lighting Systems

1) The payment for illumination system shall be made Lump Sum quoted for all areas covering External lighting & Internal lighting:

External lighting

a) The approaches to and top of the ~~barrage~~dam and downstream face.

b) The head regulator areas and the area of the control building.

c) The road from the ~~barrage~~dam, control building, SFT outlet, Gate operation chamber (SFT) and adit to HRT.

Internal lighting

a) ~~Barrage~~Dam control room, DG room & Gate operation chamber (SFT)

b) Access adits to HRT etc.

20.5.2 Grounding Systems

Payment for grounding system for ~~barrage~~dam, ~~head regulator, Desilting basin~~ & intake etc. shall be made on lump sum quoted by the contractor and shall be paid after successful commissioning of grounding system.

20.5.3 Drainage Water Pumping System

The payment for complete drainage water pumping system as described in these specification shall be based on the lump sum price quoted by the contractor and shall be paid after successful commissioning of the system as a whole.

END OF SECTION B.20

SECTION B.21
ROAD WORKS
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SECTION B.21

ROAD WORKS

21.1 SCOPE OF WORK

1. This section covers all labour, material, equipment and services required for the construction of temporary site roads, bailey bridge~~balance access roads,~~ upgradation/widening/strengthening with provision of protection and drain works of already constructed project roads including parking areas and such other areas in the vicinity of structures as shown in drawing or as directed by Engineer –in-Charge.
2. These road will be double lane/intermediate lane/single lane as per requirement or as directed by Engineer-in-Charge. These roads will be handed over to the Contractor as is where is basis. The surfacing will be done by the contractor.
3. The contractor shall be responsible for maintenance and repair of permanent internal/access roads as well as temporary roads of the project.
4. The maintenance will include good riding condition, filling of potholes, Levelling/dressing, maintenance/cleaning of side drains, culverts, protection works/walls.
5. The roads constructed by the contractor shall conform to the latest IRC /CPWD/Sikkim PWD specifications for Road and Bridge works. Reference for technical specification, unit of measurement and mode of payment shall be as per relevant clauses of IRC / CPWD/ Sikkim PWD as specified in BOQ.
6. Construction of project roads and temporary site roads shall include but not limited to the following items
   a) Common excavation
   b) Ordinary/Hard Rock excavation
   c) Backfill with available stones/material
   d) Wet Stone masonry /Dry Stone Masonry Walls
   e) Gabions/Crate Works
   f) Lined Drain
   g) Construction of base and surface courses (bituminous)
7. The contractor shall establish adequate traffic and dust control measures and safety regulations on all roads. Paved/Unpaved roads shall be frequently sprayed with water during dry weather to prevent the formation of dust clouds. Road surface should be well drained and graded to ensure a firm non sliding surface during rains & winter.
8. In case of failure of any road structure without any fault in the part of the contrctor, the same will be rebuilt by the contractor and payment shall be made as per road work rates of BOQ.

21.2 PRINCIPAL ACCESS ROAD TO THE SITE

Teesta (Stage-V) Power station is located in East district of Sikkim and is situated at about 100 km from Siliguri, the nearest rail head. The project is approachable through National Highway no. 31/31A and a BRO road connecting Singtham and Mangan. Singtham-Mangan-Lachen road via Dikchu is vital and all time requirement for access to the dam and power house as well as all the adits. Dam site is approached through a 2 km link road from Singtham-Mangan road at 28 km mark. The power house is located at 2 km from Dipudara near Shirawni on the same road but 7 km from

Singtham on NH-31A. The link road further extends up to adits of Surge shaft, bottom pressure shaft and main HRT. This road further extends to Surge shaft top. The state capital of Sikkim is approachable from the dam site via Tintek or Singtam. 28 km long Dikchu-Tintek-Gangtok road is maintained by Sikkim PWD and has formation width of 4.5 m. The BRO road from dam site to Gangtok via Singtham is 55 km.

Nearest Airport is approx. 110 km away at Bagdogra. Nearest main market that fulfills the need of various items required for construction purpose are Siliguri and Gangtok. A helipad is located at project headquarter site, Balutar. The coordinates of helipad are 27°14'56.5"N (latitude) and 88°27'25"E (longitude).

The principal access roads to the project are of NH standard and are maintained by BRO for all weather condition. Access roads from Singtham mangan road to the project components and residential colony are maintained by the project Authority.

~~Barrage is situated near Sirwani downstream of L D Kazi Bridge (Capacity 70R), South Sikkim. The Barrage is connected with BRO main road (Singtam - Mangan bituminous road) via state highway (Singtam- Namchi bituminous road). The Sirwni-Signtam road gets affected due to slides in the monsoon & may remain closed for few days during this period.~~

~~On the right bank of the river Teesta, there is a road connecting Singtam to Namchi which will get affected near Intake area of the Desilting basin during project construction. Further, there is an under construction road connecting Namchi to Singtam on the right bank, above Adit-I/Intake structure, in this regard due care needs to be taken at site against falling boulders slides etc.~~

~~The principal access road to Power House and Adit-III/Adit-II are double lane black topped on NH-31/NH-10 which is being maintained by BRO/ Sate PWD. The internal /acess roads to Power House take off from NH-10 near Tarkhola and the internal/acess roads to Adit-III/Adit-II take off from NH-10/State Highway near Mamring Bridge. Most of the streches, the internal roads mentioned above are single lane non-metal (Kachha) and are WBM in few stretches.~~

21.3 ACCESS ROADS WITHIN THE PROJECT AREA

The access roads will be handed over to the contractor on "as is where is basis" at the start of mobilization period as decided by Engineer-in-Charge. The contractor thereafter until completion of all works shall be responsible for construction of balance works and all remedial and upgradation/widening/strenghening works with provision of protection work & drain as per requirement as well as maintenance & repair work needed to keep these roads in satisfactory condition at all times for his own use, as well as for use by NHPC, other contractors, sub-contractors & supplier working for the project.

21.3.1 Deleted~~Access roads in Barrage Complex and Adit-III/II/I etc.~~

~~Details of internal/acess road in the area are as under:~~

~~1. L D Kazi Bridge to Barrage complex : (+/-) 0.1 Km~~
~~2. NH-10 road to Steel Bridge at Tarkhola : 0.5 Km~~
~~3. Steel Bridge to Power House MAT : 2.0 Km~~
~~4. Mamring Bridge to Adit-III : 2.5 Km~~
~~5. Adit-III to Adit-II : 2.0 Km~~
~~6. For SFT outlet : 1.5 Km~~

~~Most of the streches, the internal roads mentioned above are single lane non-metal (Kachha) and are WBM in few stretches. These roads need to be widened/strengthened to make it double /intermediate/single lane as per requirement or as per direction of Engineer-in-Charge in accordance to the latest relevant IRC/ CPWD/ Sikkim PWD specifications/Standands with the provision of drains/protection works on the hill as well as valley side..~~

~~21.3.2~~Deleted~~Access Roads to the Quarries / Borrow / Dumping Areas~~

~~Any temporary road to the work sites, quarries, dumping areas, parking areas etc. if required, will be constructed by the contractor at his own cost.~~

21.3.3 Repair and Maintenance Work on Internal/ Access Roads

The maintenance of access roads of project to be carried out by the contractor shall include but not limited to the following work.

a) Immediate repair of all irregularities produced by traffic, water, snow/rainfall such as pot holes or other damages to roadway surface.
b) Repair of any road related structures damaged by traffic or weather
c) Periodic shaping and grading of roadway wherever necessary to allow good surface drainage and to maintain it in optimal condition for traffic at all times.
d) Clearing of slides onto the roadway and lateral slpoes
e) Keeping the drainage structures and culverts etc free of debris or any other material that may reduce their flow capacity.
f) Disposal of materials removed by the above mentioned operation to approved spoil areas
g) Any land damaged because of widening/disposal of muck shall be made good by the contractor at his own cost. The contractor shall be solely responsible for any disputes arising on account of this.
h) Provide the necessary traffic signs and signals.
i) Effective dust control by regular sweeping/cleaning and water sprinkling etc. All roads having with or without WBM work only needs to be sprinkled with water several times a day to avoid dust pollution throughout the dry period of the year.
j) Repair and maintenance of WBM and Bituminous carpeting ordered by the Engineer-in-Charge.

21.3.4 Bailey Bridge 40R

a. For the design of bailey bridge, refer IRC specifications for Roads and Bridge Works (fourth revision)

b. Work shall consist of design, soil investigation, supply and installation of single lane bailey bridge (40R) with clear carriageway width of 4.25 m at site including diversion and dewatering, abutment caps, dirt wall incl. fabrication & launching of

superstructure providing and fixing bridge bearings complete in all respect conforming to Indian standard.

c. Bailey bridge shall be removed and kept at safe place from the river as directed by Engineer-in-charge after completion of the work and before start of the monsoon season.

21.4 TEMPORARY SITE ROADS

1. The contractor shall select, design, construct and maintain all necessary temporary roads, parking areas and other access facilities within the site required for construction of Permanent and Temporary Works, including all borrow and quarry areas.
2. The roads shall be wide enough to allow heavy weight traffic in both directions. To prevent excessive erosion, longitudinal slope more than 10 % shall not be used, expect when specifically approved by the Engineer-in-Charge.
3. Except where rock is encountered, the back slope of cut banks shall be stable and compatible with existing topography, and shall be flattened and rounded as far as practicable into natural ground surface.
4. The contractor shall install suitable devices and drainage structures in sufficient nos. to prevent accumulation of excessive water and erosion of the road surface, drainage ditches, and excavated area.
5. The Engineer-in-charge as well as other contractors and sub contractors working on the project shall be permitted access, free of charge, to all site roads throughout the duration of the contract.
6. Upon completion of the works, these roads shall be handed over to NHPC. Those site roads which NHPC does not choose to keep; the surfaces shall be scarified and left in a condition which will facilitate natural vegetation
7. Effective dust control by regular sweeping/cleaning and water sprinkling etc. All roads having with or without WBM work only needs to be sprinkled with water several times a day to avoid dust pollution throughout the dry period of the year.

21.5 LINED DRAINS

21.5.1 Scope of Work

This work shall consist of constructing Lined Drain in accordance with the requirements of these Specifications and to the lines, grades, dimensions and other particulars shown on the drawings or as directed by the Engineer-in- Charge. Schedule of work shall be so arranged that the drains are completed in proper sequence with road works to ensure that no excavation of the completed road works are necessary subsequently or any damage is caused to these works due to lack of drainage.

21.5.2 Execution Methodology

1. Lined Drains shall be excavated to the specified lines, grades, levels and dimensions as shown in the drawing or as directed by Engineer in charge. The excavated material shall be removed from the area adjoining the drains and if found suitable, utilized in backfill/subgrade construction. All unsuitable material shall be disposed of as directed.

2. The excavated bed and sides of the drains shall be dressed to bring these in close conformity with the specified dimensions, levels and slopes. Where so indicated, drains shall, be lined or turfed with suitable materials in accordance with details shown on the drawings or as directed by Engineer-in-Charge.
3. All works on drain construction shall be planned and executed in proper sequence with other works as approved by the Engineer-in-Charge, with a view to ensuring adequate drainage for the area and minimizing erosion /sedimentation.
4. Materials and construction of each item of Lined Drain shall conform to relevant specifications of the corresponding items.

21.6 SURFACE EXCAVATION

Surface Excavation for road works shall be carried out as per Technical Specifications mentioned in the Section B-2 " Surface Excavation".

21.7 DESIGN CRITERIA

1. For the design criteria of roads and bridges refer Latest IRC/CPWD/SSOR specifications for Road and Bridge works
2. The finished dimensions of the lined drain shall be 500 mm deep, 600 mm wide at the top and 400 mm wide at the bottom . The bottom and the side walls of the lined drain shall be 200 mm thick concrete line by Cement Concrete 1:2:4 with 40 mm and down agreegate.

21.8 MEASUREMENT & PAYMENT

21.8.1 Terms of payment for road, Protection & Lined Drain works etc.

1. For measurement and payment refer to respective/relevant clauses of Latest IRC / CPWD/SSOR-2012 as specified in the BOQ.
2. Measurement for payment and payment for the item " Surface Excavation" (i.e. Common &Rock excation) mentioned in BOQ for Road Works shall be made in accordance with Section-B.2 of specification.
3. Measurement for payment for the works of " Repair and Maintenance work on internal/Access Roads" will be km-months which will be calculated as the number of months for which the road is under use multiplied by the length of road in Kilometers. Payment will be made at the Unit Prices per Km-month entered in the Bill of Quantities, which shall include all costs of labour, equipment, and materials required for repair and maintenance except for the repair and maintenance of the WBM/Bituminious carpeting ordered by the Engineer-in-charge which shall be paid separately.
4. For measurement and payment of the repair and maintenace of WBM & Bituminous carpeting work ordered by the Engineer-in-charge refer respective/relevant clauses of latest IRC/CPWD/SSOR-2012 as specified in the BOQ.
5. Payment for repair and maintenance of Roads with various items of WBM and Bituminous Carpeting ordered by the Engineer-in-Charge, due to damages of WBM/Bituminous Carpeting, during the contract period will be made on completion of WBM (all layers) and/or carpeting works as per actual execution at site subject to a yearly maximum limit of 25% of BOQ provision for repair in WBM and carpeting work of above items or 5% of the original executed quantity

of such items of work, during construction on a stretch of road, whichever is lesser. The payment of the WBM & Carpeting items will be made only after completion of WBM and/or carpeting work. No measurement of repair or payment of the quantity will be made within six month of completion of WBM and/or carpeting work of any stretch of road.

6. Measurement for Lined Drain shall be per running meter length of the drain.
7. Payment for the construction of Lined Drain shall be done at the unit rate entered in the Bill of Quantities.
8. The Unit rates for Lined Drain shall be payment in full for all items such as excavation, dressing the sides and bottom; providing lining, concrete and plastering; providing, laying and compacting backfill and bed of granular material, including full compensation for all materials, labour, tools, equipment and other incidentals to complete the work as shown on drawings or directed by Engineer-in-Charge with all leads and lifts except for removal of unsuitable material for which the lead shall be 1000 m. Provision of inlets, gratings, sumps, outlet pipes, bedding, disbursers, shuttering, stone soling below lined drains etc where ever required shall be incidental to construction drain

21.8.2 Terms of payments for bridge works

The payment of bridge works shall be made on lump sum per unit quantity as stipulated in the Bill of Quantities and as mentioned in the scope of works including supply, erection testing and commissioning. Rate shall include the removal of the bailey bridge and shall kept at safe place from the river as directed by Engineer-in-charge after completion of the work and before start of the monsoon season.

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21.9 EXCLUSIONS

No extra payment will be made for the following:

1. Extra work caused by the contractor's negligence in setting out the structures and slopes.
2. Rectification, removal and replacement of the materials which during the placement or afterwards have been contaminated with foreign matters, mixed with unsuitable materials or lost due to erosion.
3. Extra work or material required to repair damages to the temporary or final surfaces caused by the erosion or travel of the construction equipment.
4. Stockpiling, re-handing, reloading, & transport of materials which cannot be directly placed in the final locations after being excavated.
5. Damage & repair to concrete structures caused by contractor's operations.
6. Additional passes of the compacting equipment ordered, by the Engineer-in-charge if he determines that a higher degree of compaction is required.
7. Construction and maintenance of temporary site roads, Roads to quarry/borrow/dumping areas etc.

END OF SECTION B.21