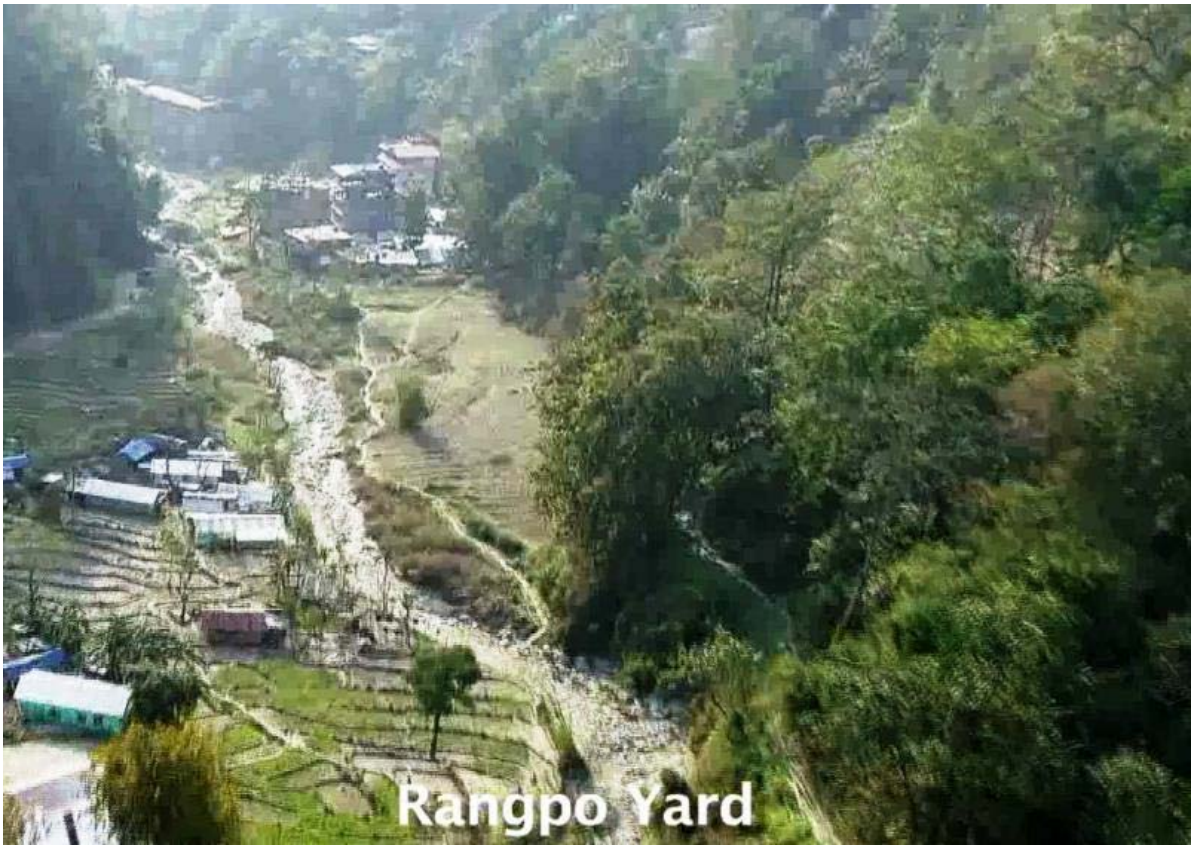
SEVOK-RANGPO RAIL LINE PROJECT

TECHNICAL SPECIFICATIONS

CONSTRUCTION OF RANGPO YARD



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1. SITE INSTALLATIONS AND SERVICES

1.1 SCOPE OF WORK

I) Site installations, site clearance (including removal), services shall be carried out in accordance with the provisions of the Technical Specifications for earthworks. The contractor shall include all the costs for such temporary works into the relevant unit prices unless specifically provided in the conditions, for the whole execution works on construction and for the whole period of construction.

II) The Contractor shall be responsible for providing plant, equipment, materials and labour for the provision of all necessary Temporary Works and services adequate for the execution of the Work under this contract.

III) The Contractor shall design, furnish, install, maintain and operate on the Site Constructional Plants as specified in this Chapter, including camps, workshops: warehouses, storage and assembly areas, all equipment, machinery, vehicles. Scaffolding, water and power supply etc.

IV) Obtaining necessary clearance/ permission that are needed for construction, from various state/ central authorities for the equipment, water, power, sanitary and explosives shall rest with the contractor.

V) Temporary Works and services carried out by the Contractor shall conform to the applicable Indian Standard I Codes / laws, regulations and statutory requirements including compliance to railways codes/manuals/guidelines etc. stipulated for such purpose In-case no National Standard is available, International Standards are to be applied as approved by the Client.

VI) The design, construction, operation and maintenance of the Contractor's Temporary Works and services shall be subject to inspection and approval by the Client.

VII) The rights or customs of adjacent property occupiers for access shall not be infringed by the Contractor.

1.2 SUBMITTALS

I) Within 28 days from the commencement date, the Contractor shall submit to the Client, updated layout plans showing, to an adequate scale, the locations and arrangement of all enabling and temporary Works and facilities. These plans shall be consistent with the requirements of the Project as well as with any subsequent amendments and additions agreed to by the Client and the Contractor and shall include and not be limited to:-

a) Site offices, storages, parking areas, warehouses, materials yard, storage areas.
b) Concrete and material processing plants," including cement storage.
c) Temporary road, including public road diversions and temporary culvert.
d) Communication System.
e) Service vehicles.
f) Camps for Contractor’s Employees.
g) Commercial Establishments.
h) Medical facilities.
i) Power supply and illumination, telephone services (radio and cable).

j) Maintenance of Traffic.
k) Water supply.
l) Sanitation & sewerage, sewage treatment and disposal,
m) Waste & garbage disposal.
n) Security and safety arrangements.
o) Field laboratory along with list of equipment as required under Quality Assurance Programme.
p) Equipment tools and mechanical workshops.
q) Dumping areas, borrow, quarry and stockpile areas with development plans.
r) Explosive magazines.
s) Adequate back up power system.
t) Measures to comply with environmental norms and various conditions.
u) Muck disposal management.
v) Site Signage.
w) Drainage plan during construction.
x) Contractor Quality Plan.
y) Emergency Plan.

II) Within 45 days from the commencement date, the Contractor shall submit to the Client the following:
a) Detailed drawings to a scale ranging from 1:100 to 1:500 showing the camp layout, buildings, roads, recreation areas, all utilities etc. and drawings to a scale of 1: 50 to 1:100 showing typical building construction details.
b) Drawings and Specification for the establishment of primary first aid stations dispensary and ambulances.
c) Detailed design for industrial and potable water supply to the camps and working area as well as sewerage system, sewerage treatment and disposal with an estimate of number of people to be supplied with water. All the system shall comply with the environmental and pollution control norms as applicable.
d) Detailed layout drawings for electrical installations and distribution systems on the site, showing voltages, outlets and routing of power lines. The system should include necessary power back up arrangements for uninterrupted construction work.
e) Detailed design and drawings including manufacturer's drawings for concrete and materials processing plants, including details of equipment for transportation and placement of concrete in accordance with the requirements of the pertinent Chapters of these Specifications.
f) Details of the excavation, drilling and grouting equipment in accordance with the requirements set out in the relevant Chapter of these Specifications.
g) Details of Field laboratory to be set up at site by the contractor.
h) Details of muck disposal and protection measures for compliance with Environmental Management Plan of the work specifications.
i) The designs shall be consistent with the requirements of the Project as well as with any subsequent amendments and additions agreed to by the Client and the Contractor. (The Client reserves the right to require any additional information deemed necessary to be included in the submitted documents.)

1.3 DETAILS OF INSTALLATIONS AND SERVICES

The installations and services to be provided by the Contractor for the execution of Works under this Contract Shall include, but not limited to, the following:

1.3.1 *Camps for Contractor's Employees*

I) The Contractor shall design, construct, provide furnishings, maintain and operate construction camps at the suitable locations. The construction camps shall provide for the housing, feeding and recreation of the Contractor's employees and those of his subcontractors. Kitchens with provision of LPG facility for cooking (Fire wood not to be used), dining rooms, outdoor and indoor recreation facilities, family dwellings, dormitories, sanitary facilities, medical service, places of worship, roadways, drainage, fire control, commercial centres and all utility services (potable water, power, lighting, heating ventilating, sewerage treatment and disposal, cleaning and sanitation, garbage collection and disposal, etc.) shall be provided. The camps shall be large enough to accommodate the anticipated peak work force. The construction labour camp should be as per BOCWA / BOCWR. The contractor has to provide bio-toilets (separate for male and female) at Camp site as well as at all the construction sites. The user ratio shall not be more than that specified in point (iv) below.

II) Camp area shall be provided by employer subject to availability of land after accommodating all plants, materials, employer's office etc. at site. No camp construction shall commence until the Contractor's drawings and Specifications have been approved by the Client.

III) All camp building shall be of sound construction and connected to all utility services.

IV) Fixtures in the sanitary facilities shall be based on the following user ratios

a) 1 toilet for not more than 6 users

b) 1 tap for not more than 6 users

c) 1 washbasin for not more than 6 users.

V) The sewerage from the labour camps, work sites is to be properly treated before discharge by providing septic tanks, soak pits etc. or any other treatment as per norms recommended by the concerned authority.

VI) Canteen facilities shall be provided by the Contractor in properly equipped canteen buildings for all his and his subcontractor's employees.

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

1.3.2 *Site Offices, Stores, Warehouses, Materials Yards*

I). The Contractor shall provide and equip, for his own and his subcontractors' use, main and secondary offices, warehouses, materials stock areas, fuel storage areas and explosive magazines, all of which shall be maintained in good condition until the completion of Works.

II). The buildings, shops and warehouses expected to be constructed and equipped by the Contractor for use in the execution of the Works under this Contract, in addition to the

facilities explicitly specified elsewhere in these Specifications shall be, but not limited to, the following:

a). Mechanical repair shop
b). Electrical repair shop
c). Metalwork fabrication and carpentry shop
d). Main warehouse and parts store
e). Bulk cement silo/cement store
f). Spare parts store.

III). No dangerous goods, explosives, chemicals, fuels or similar items shall be brought onto the Site unless the Contractor has advised the Client of the intention to do so and has complied with all statutory requirements for its safe storage and security.

IV). The Contractor shall minimize the use of the Site for the storage of fuels, explosives and other dangerous goods as may be required for the construction of the works and shall not use the site or allow access for any purpose not connected to the Contract.

V). Dangerous Goods are only to be stored in nominated and approved storage areas and facilities which must comply with the Indian regulations governing such facilities.

VI). The contractor has to make appropriate provision for material storage sheds and tarpaulin sheets for loose construction material.

VII). The contractor has to make appropriate provision for dustbins and corresponding disposal of waste at labour campsite and at each work site.

1.3.3 Concrete and Materials Processing Plants.

I). The Contractor shall install and erect all necessary material processing plants of sufficient capacity to meet the planned peak requirements during construction. The plants shall be subject to approval by the Client 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.

II). The plants required to be assembled/erected by the Contractor shall be but not limited to the following:

a). Concrete plant (batching and mixing)
b). Concrete cooling plant (refrigeration and ice plant), if required.

III) Concrete & material processing plants shall meet all environment guidelines, conditions imposed for construction of project by MOEF/ Government bodies/ State pollution control boards and other statutory bodies at no extra cost to The Employer.

1.3.4 Temporary Roads.

I). The contractor shall construct temporary roads / hauls roads & culverts. Contractor shall develop detailed drawings for the above and accordingly construct the same after approval of Client.

1.3.5 Communication System

I). Outside / Site Communication

II). The Contractor shall install his communication system in the project area for national/ international voice and data communication. These facilities can be availed from the existing network of tele-communication or the contractor shall make arrangement for providing these facilities through existing telecom operators.

1.3.6 Service Vehicles

I). The Contractor shall furnish, operate and maintain sufficient service vehicles for use by his own staff and employees in the management, supervision and performance of the Work.

1.3.7 Commercial Establishments

I). Market and shopping complexes are available at nearby towns of the project site, which caters to the local population of the area. The Contractor may establish, with the prior permission of the authorities of Government commercial place(s) in his camps for use by his employees.

1.3.8 Medical Facilities

I). Indoor medical facilities are available near Ramban.

II). In addition to above, the Contractor shall construct, equip and maintain on the Site, the following medical facilities:

a). One clinic with ambulance and driver at his main camp.

b). One first aid station at each work site.

III). The contractor shall comply with laws and health standards in force in the project area. In the event of an epidemic breaking out, the Contractor shall carry out and comply with all or arrangements or regulations, which may be issued by Government or local authorities.

IV). These facilities shall be fully equipped and staffed to meet requirements of the maximum anticipated workload and labour force, taking into consideration the nature of the Works, its occupational hazards, location and accessibility. These establishments shall be available and fully operational within 45 days after the date of issue the Letter of Acceptance.

V). Medical services in the clinics shall be under the direction of qualified doctor on a 24 hours basis throughout duration of the construction and shall be available free of charge persons engaged in the Works and their families or dependents on the Site. ¬

VI). Treatment facilities and care of seriously ill or injured persons shall be on an emergency basis until their transfer to an established hospital.

VII). All the labors to be engaged for construction work shall be thoroughly examined by health personnel and adequately treated before issuing them work permit by contractor.

1.3.9 Power Supply and Illumination

I). General.

a). Contractor has to make his arrangements at his own cost for entire construction power including any standby power requirements. Equipments/ transmission lines required for

distribution and utilization of energy at Construction site for Power, light etc. shall be installed by the contractor on their own.

b). Power to be used by Contractor for their Labour and Staff Colony shall be arranged by contractor on their own and at their own cost.

c). Contractor shall arrange DG sets of adequate capacity at his cost to meet back up and emergency power supply requirement including lighting.

d). Contractor shall indicate in his proposal of the phase wise requirement of Construction power (HT) at above-mentioned locations.

II). Power supply and Illumination provided by the Contractor

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

b). The Contractor shall ensure adequate illumination for all his operations on the Site and at the Camps, including illumination of the streets for round the clock working. The contractor shall maintain equipment and arrange device to measure light intensities for illumination as follows:

	Area of Operation.	Luminous Intensity
a	Excavation and dumping areas and outdoor access ways	100 Lux
b	General construction areas, concrete placement, excavation and waste areas, access ways, active storage areas, loading platforms, refuelling, and field maintenance areas.	150 Lux
c	Indoors: warehouses, corridors, hallways, and exit ways.	100 Lux
d	General construction plant and shops, e.g. batching plants, mechanical and carpentry shops, active storerooms, barracks or living quarters, mess halls and indoor toilets	150 Lux
e	First aid stations, infirmaries and offices	350 Lux

III). Earthing of Wet work Areas, Control of Electric Discharges

a). All equipment and appliances, which are exposed to lightning, shall be earthed electrically, and the Contractor's specialized personnel shall periodically check the effectiveness or such earthing.

b). Personnel standing in water shall operate no equipment electrically powered by more than 24 Volts.

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

1.3.10 Maintenance of Traffic

I). The Contractor shall be responsible for the safety along the roads related to the Site. Where the work is carried out on the Site of, or close to an existing road, the Contractor shall maintain the vehicular and pedestrian traffic safe at all times. If his operations can cause traffic hazards, he shall repair or fence or take such other measures for ensuring safety that are satisfactory to the Client.

II). The Contractor shall submit his activity, schedule and the locations of his work along the existing public roads to the authorities concerned and obtain all necessary approval prior to the commencement of the respective work.

III). At the road crossings or in heavy traffic locations, the Contractor shall carry out the Work within the working hours as directed by the Client, and after the completion of the work he shall immediately make the necessary backfill and pavement at the crossings.

IV). The Contractor shall provide temporary passes and badges to give an access to the existing village houses, etc., to the satisfaction of the Client and the authorities concerned whenever he disturbs such existing way during the execution of works.

1.3.11 Water Supply

I). The Contractor shall design, Install, operate and maintain two separate water supply systems on the Sites

a). Industrial Water: For general construction use, treated to the extent necessary to meet specified requirements of Works.

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

II). Water shall be, supplied by the Contractor from any suitable sources. The water being supplied shall be free of contamination and unaffected by the Site construction Work.

III). The Contractor shall furnish, install, operate and maintain all pumps, pipelines, 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. 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.

IV). The Contractor shall provide adequate water treatment facilities so as to ensure that the treated water is supplied for drinking purposes to all the camps and construction places.

V). Ample number of drinking points of potable water shall be provided by the Contractor for the use of personnel in all working areas.

1.3.12 Sanitation and Sewerage

I). Toilets shall be provided and maintained by the Contractor for the use of all personnel at all work locations, which are remote from the fixed sanitary facilities. The Contractor shall arrange for all chemical toilets to be attended to daily for proper sanitary disposal.

II). All offices, workshops, laboratory and other occupied work buildings shall be provided with toilets connected to property constructed and regularly maintained septic tanks approved by the Client.

III). The camp sites 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.

IV). Testing of water shall be done to meet the standards for sanitation purpose.

1.3.13 Dumping Areas, with Development Plans

I). The contractor shall make necessary arrangements for the management of muck disposal so that it meets all the environment guidelines / conditions imposed for the construction of project by MOEF / Govt. bodies / State Pollution control board and/or other statutory bodies.

1.3.14 Waste and Garbage Disposal

I). The Contractor shall daily collect waste material and garbage from camps, offices and workshops and transport it to an area approved by the Client, where it shall be incinerated and buried or disposed off as standard guidelines.

II). 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 Client for waste disposal. No waste of any kind shall be deposited in any watercourses.

III). Waste and Garbage disposal system shall meet all environment guidelines and conditions imposed for construction of project by MOEF/ Govt. bodies at no extra cost to The Employer.

IV). The contractor has to make appropriate provision for Oil / Grease interceptor at refuelling stations and at fuel storage locations.

1.3.15 Setting Up of Field Laboratory

I). The Contractor shall establish a field laboratory for ensuring quality control measures for the Works, as detailed under Quality Assurance Programme described elsewhere in the tender documents.

II). Prior to setting up of laboratory, Contractor shall submit detailed building plan with exhaustive equipment-list clearly showing the different area for equipment with sizes of the equipment and circulating area, and CV’s of qualified personnel identified for laboratory work to the Client for approval. The laboratory shall be headed by an experienced graduate civil engineer. All the equipment shall be confirming to either the relevant IS or international standards.

III). Upon receipt of Client's approval, the Contractor shall construct, maintain and operate an integrated laboratory which provides sufficient rooms and equipment to test aggregates, concrete samples, plain shotcrete, soil and rock samples, geogrids adherence test, soil nails/rock bolts capacity tests, nuclear gauge tests to control the density of the compacted layers for earthworks, etc. The laboratory shall be established as early as possible as but not later than two months (60 days) from the date of issue of Letter of Acceptance.

IV). The Contractor shall collect the samples, carry out the relevant tests, prepare the complete reports and submit them to the Client.

V). All tests will be made according to approved standards, and the testing equipment shall comply with the same standards. All relevant standards shall be made available in the laboratory by the Contractor.

VI). The laboratory shall be provided with light, ventilation, water supply, tank for curing, toilet, office for operators and responsible for laboratory, archive etc. and be spacious enough in order to store indoor the test samples

1.3.16 Land Requirement

I). Employer has acquired the required land for permanent components of the project work, approach roads to various project components and muck dumping sites, which shall be handed over to the contractor on as is where is basis. The contractor shall organize the installation site in a way that his temporary buildings, plants, equipment etc will not hinder the final/permanent works. The land shall be used primarily for execution of work of the project and muck disposal. If contractor requires to use land required for development of station areas/ muck dumping, the contractor will sequence his activities to avoid re-shifting of plants and machinery once installed. The contractor will seek approval of the Client for setting up of site facilities on land acquired for the project. Nothing additional will be paid for re-shifting of any plants and machinery to the contractor. Extra land if needed by the contractor for setting up of any of his facilities, such cost of land will be borne by the contractor.

II). Contractor shall submit his scheme of land utilization including muck disposal and subsequently construct the same after obtaining due approval of the Client.

III). Muck generated in the works may be used by contractor for constructing his facilities / filling works etc. free of cost. The royalty payment and/or any cess leviable by the statutory authority shall however be payable by the contractor by such usage. Unusable muck shall be placed in muck disposal area.

IV). Any Government duties, cess etc. levied by the statutory authority for land use outside railway land shall be borne by the contractor at no extra cost to the Employer.

V). Before demobilization, the contractor shall remove all his temporary facilities which were installed for execution of the work and restore the land to its original state for all such land used as in (i) above.

VI). Unless it is unfeasible, the contractor shall segregate the topsoil and store it separately, so as to dump it back in the permanent works at the appropriate locations.

1.3.17 Fencing and Site Security

I). The Contractor's offices, workshops and storage compounds, campsites and all construction areas, where exclusion of unauthorized personnel is necessary for safety and security, shall be adequately fenced, gated and guarded. A central guardhouse shall be established at each main entrance to the Site.

II). The Contractor shall employ adequate force of properly trained security guards at the worksite and at the construction camps on 24 hours 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.

III). All employees engaged in the execution and maintenance of the Works shall wear identification badges when at the worksite.

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

V). The contractor has to make appropriate provision for LED Lights on top of the barricading.

1.3.18 Site Signage

I). Prior to the commencement of work at the Site, the Contractor, at the direction of the Client, shall supply and erect reflector site sign at all work sites for the information of the public at all entrances to the Site, containing the following information, clearly visible and legible (In English and Hindi language) to passers-by intended for the information of those affected by the Contract Works, for the guidance of those making deliveries and for general public safety:

a). Name of Project;
b). Name of Employer;
c). Name of Contractor;
d). Restrictions on access and appropriate safety warnings.

II). The Contractor shall also maintain such signs throughout the contract period with up to date information and free from disfigurement.

III). The Contractor shall also supply, erect and maintain appropriate reflector site signage and safety warning signs as are appropriate for the nature of the work being undertaken. No other signage or advertising materials shall be permitted on the Site, except with the specific consent of the Client.

1.3.19 Mobilization

I). Contractor shall furnish all the labour, materials, equipment and shall perform all work required for mobilization to the Project Site.

II). Mobilization shall include, but not be limited to moving personnel, plant, and equipment to the Site; arranging for necessary Site utilities; establishing camps, shops, offices and administrative facilities; and obtaining all required permits, licenses, and other regulatory authorizations required for the construction of the Project.

1.3.20 Demobilization / Final Clean Up

I). Upon the Completion of Works, or when any plant has completed its functions, the Contractor shall dismantle and demobilize all temporary facilities and remove all refuse, debris objectionable material to areas approved by Client, and fill, grade and dress all excavated areas in a clean and proper condition acceptable to the Client. All such areas as far as possible shall conform to the natural appearance of the landscape. No extra payment shall be made on this account.

II). Contractor shall furnish all the labour, materials, equipment and shall perform all work required for demobilization from the Project Site.

III). Demobilization shall include, but shall not be limited to: removing all plant, equipment, and temporary facilities from the Site; disconnecting temporary utilities; relocating personnel from the Site; cleaning-up and restoring all areas occupied by the Contractor; closing out permits, licenses, and other regulatory authorizations; and disposal of all waste materials and excess construction materials which are not the property of the Employer.

IV). No demobilization or removal of temporary facilities and equipment shall be made without the prior approval of the Client.

1.3.21 Inspection by Client

I). The Client shall 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.

1.4 PAYMENT FOR SITE INSTALLATION AND PAYMENT

I, The Contractor's initial mobilization costs such as purchase and transport of Constructional Plant and materials to the Site, planning, designing, installing, operating, maintaining and removal of all Temporary Works, Site installations, Services and facilities, making submittals to the Client, recruiting and transferring staff, obtaining rights of way, providing and maintaining temporary site roads, providing power at working area, offices, worker's colony, generating standby power for construction purposes, clearing and, grading areas for temporary facilities, and any other costs involved in preparation to carry out the Permanent Works or items mentioned under this sub-chapter, shall not be paid separately (Except where mentioned specifically), but shall be deemed to be included in the rates quoted by the contractor for all the items of works. Charges if leviable for use of water or any other charges imposed by state/local authority for any of the site installation and services to be developed by contractor, the same shall be borne by contractor.

II. Payment for monitoring of following environmental attributes during construction shall be paid separately as per relevant items of the BOQ.

2. SURVEYING

2.1 SCOPE OF WORK

I). The employer has already established certain benchmarks and alignment references. These benchmarks and alignment markers are required to be validated by the contractor. Any error found in these benchmarks and alignment markers shall be rectified by the contractor with the approval of the Client. The contractor is also required to maintain these benchmarks provided by the employer throughout the period of construction. The survey to be done by the contractor shall be done by establishing the control points along the proposed railway alignment through the use of DGPS. All these control points will then be connected to the nearest GTS Benchmark using the Total Station.

II). These services cover in general transfer of control points to working area, the establishment of axis, centerlines, alignments of project structures and features, the setting out for construction thereof; the accompanying control surveys for correct locations, dimensions and elevations as well as the necessary surveys for measurement to permit quantity calculations for billing.

III). Such surveys shall be based on and/or referred to existing basic grid of datum points, triangulation points and benchmarks extended adjacent to the Work in the project area. This grid shall be the sole basis of reference for all survey work and measurement.

IV). High precision direction measurement of the alignment shall be done at every approx. one km of excavation or as decided by the Client by use of surveying gyroscopes i.e Gyromat or similar, at the cost of the contractor.

V). Responsibility of carrying out the work to correct line and level shall, however, continue to devolve on the contractor notwithstanding the fact that approval for any benchmark and/or alignment marker may inadvertently have been accorded by the Client. Consequently, any expenditure incurred by the contractor for rectification of the permanent and/or temporary works constructed to wrong line/level shall not be payable by the Employer.

2.2 SUBMITTAL

I). Within 28 days from the commencement date, the Contractor shall submit to the Client for his approval a proposal of the sequence of the survey works to be performed, the biodata of the key personnel & in-charge of survey works, the list of survey equipment and instruments the Contractor will have available at the site, and a brief outline on methodologies of survey works to be applied for the various types of survey.

II). At least 7 days prior to the commencement of any survey work, the Contractor shall inform the Client of his intention to perform the survey work. The Contractor shall indicate the purpose of the survey, the area to be surveyed, the structure or facilities involved, the methods to be applied and the survey period.

2.3 MATERIAL AND INSTRUMENTS

I). The Contractor shall provide, maintain and operate suitable and appropriate equipment, instruments, materials and auxiliary equipment, commensurate with various tasks and precision requirements of the survey works.

II). Type and accuracy of the survey equipment to be used by the Contractor shall correspond to the nature of the construction, erection works and the construction technique.

III). All equipment, instruments, materials and auxiliary equipment shall be in perfect operating condition. Prior to the start of survey activities, equipment, instruments, etc., shall be checked as to their proper functioning and accuracy.

IV). During the construction period, the survey instruments shall be checked and adjusted / calibrated at regular time intervals.

V). Instruments and equipment which have suffered from use, damage or accidents to the extent that they are unfit for further use at the site, shall be removed from the site and replaced immediately.

VI). The contractor should ensure availability of sufficient quantity and quality of survey instruments including provision of professional staff, to avoid any delay in the construction.

2.4 EXECUTION

2.4.1 General

I). For the execution of the survey work the Contractor shall employ and provide experienced professionals and auxiliary staff. All survey and measurement work shall be recorded and filed thoroughly.

II). The Contractor shall provide, maintain, adjust when necessary and operate the required survey and auxiliary equipment for the performance of the Work.

III). All survey and measurement activities shall be recorded in maps and field books as directed/approved by the Client. Where required, the production of drawings and maps shall be deemed to be part of the work.

IV). The Client shall have the right to check work performance, accuracy stations, etc., and all survey results, measurements and calculations as well as conformity with plans and drawings.

V). The Contractor shall keep and maintain professional records of all field surveys and measurements, the related computations and calculations, manuscripts, plans, drawings and maps, and shall make them available to the Client whenever requested.

VI). If in the opinion of the Client, deficiencies and/or inaccuracies in field and office work have been found, such work shall be repeated and made good to the satisfaction of the Client at the Contractor's expense. The Contractor shall be solely responsible for accuracy of Survey maps and drawings prepared out of the surveys.

2.4.2 Preparatory Works

I). Prior to starting survey works, the Contractor shall inform his surveyors of the general construction procedure, survey requirements and time limits. The surveyors shall make adequate terrain investigations with respect to sightings, vegetation to be removed, placement of datum points, reference monuments and benchmarks, taking into consideration future construction work which may affect the survey. Based on these investigations, a survey plan shall be developed comprising existing basic data, the survey grid to be developed, the equipments required for the particular survey task. Staff and time requirements arrangement in a way to warrant smooth progress of construction works. The plan shall be submitted to the Client for approval.

II). All survey work shall be done within greatest care and precision.

2.4.3 Verification of Survey Grid

I). The contractor shall verify the basic survey grid.

II). All coordinates and elevations as shown on the Drawings are based on the basic survey grid. If after having executed the verification, the basic survey grid reveals inconsistencies, which may affect the location, alignment and elevation or structures of the works, the Client shall be forthwith informed of these inconsistencies by the Contractor.

III). The Contractor shall record all calculations, control surveys, setting out and check surveying in a suitable permanent form for verification, which shall be available to the Client on request at all times.

2.4.4 Augmentation of Basic Survey Grid

I). Existing datum points and benchmark located very near to the permanent structures may be endangered by construction activities. The Contractor shall therefore in due time establish additional datum points at safe locations and elevations to augment or extend the basic grid.

II). The new datum points shall be of permanent nature and shall be constructed as, directed by the Client.

III). The Contractor shall also establish reference monuments for center lines and line control of structures, which need frequent and extended control surveys.

IV). New datum points, reference monuments and benchmarks shall be protected and maintained in the same way as the original grid points.

2.4.5 Survey of Ground Profiles

I). Original Ground Profiles.

The Contractor shall inform the Client in writing, at least 14 days before commencing such work, of his intentions to perform any work which will result in a change to the topography of the existing site for the permanent works and or for temporary works. Thereupon, before commencing any work, the contractor shall survey the original topography with the approval of the Client over the entire area to be occupied or disturbed. Such survey may again be required after removal, of vegetation, topsoil or other overburden. The Contractor and the Client shall record the information so obtained. The contractor shall then provide the Client with a reproducible copy of each drawing to serve as a permanent record of the purpose of determining the quantities of excavation or earth works carried out in the construction of the permanent structures, Such records will also be required to ascertain the extent to which Temporary works shall be removed or temporary excavations shall be refilled upon completion of the works.

II). The Contractor shall also survey all excavated and final surfaces for the purpose of recording as constructed details, and for the measurement of quantities. Such survey shall be required at the following two stages:

a). On completions of excavation and prior to placing concrete or other work.

b). On completion of works.

2.4.6 Setting Out Works

I). The contractor shall perform all setting out and check surveying of the Works in accordance with methods approved by the Client. The methods and programme of checking shall be such as to ensure the construction of every part of the Work to the correct line and level. The Client may at any time ask the contractor to submit proof that his own setting out has been satisfactorily checked.

II). The number of points required for setting out as well as the spacing between these points shall be determined by the Contractor in accordance with the type of work. The Client may require that some or all of the given points and datum levels be clearly marked during construction in such a way that the marks can be retained after completion of construction.

2.4.7 Setting Out Checks

I). The Contractor is expected to liaise with the Client to program the check survey to be carried out during non-production periods or in parallel to construction activities such that the minimum delay or inconvenience is caused to production works, wherever and whenever possible. The Contractor shall afford the Client, every cooperation and assistance in this regard including but not being limited to the provision of survey equipment, drainage, lighting and the removal of Contractor's equipment and other obstructions such that they do not interfere with the setting out checks.

2.4.8 Accuracies and tolerances

I). Accuracies

Accuracy of survey works shall be within the following tolerances:

Triangulation	
Average Allowable error of closure shall not exceed	5 Seconds
Maximum Allowable error of closure shall not exceed	10 Seconds
Traversing	
Allowable error of closure	10 mm per Kilometer
Allowable error of distance	
Levelling	
Allowable error for each 1 km measured forward and backward	10 mm
Allowable error of closure	10 √S mm

(Where S is the total distance of levelling expressed in km)

II). Tolerances

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

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

c). Where the tolerances overlap, the severer tolerance shall apply.

2.4.9 Subsidiary Monuments and Benchmarks

I). The Contractor shall erect and establish all necessary additional survey monuments, fix points, benchmarks etc. required for setting out of the work and construction control including determination of coordinates and elevations.

2.4.10 Handing over of Basic Survey Data

I). General Requirements

a). Prior to the commencement of the survey works, the Client shall hand over to the contractor all information and data of the verified basic survey gird and benchmarks to which the contractor’s survey work shall refer. Upon handing over, the Contractor shall review this

information and data and shall verify the existence of the datum points and benchmarks by field checks. Furthermore, the contractor shall take responsibility for maintenance and protection of these basic datum points and benchmarks.

b). Should field checks reveal that points and benchmarks have been damaged, displaced or destroyed, the contractor shall inform the Client of this facts, and the Client shall give instructions regarding the re-establishment of such datum points and benchmarks.

c). Should it become necessary that basic datum point and benchmarks be removed because of foreseeable construction works, the contractor shall inform the Client of the need thereof and obtain approval and instruction for the establishment of new basic datum points and benchmarks and/or auxiliary points.

d). If, within 2 months upon handing over, inconsistencies within the basic grid or related datum points and benchmarks are detected by the contractor, he shall inform the Client immediately thereof and produce the evidence. The Client shall subsequently inform and instruct the contractor on remedial measures to be taken. Any survey work, setting out or measurement already taken or performed prior to the detection of such inconsistency shall be rechecked and corrected by the contractor.

e). Additional basic datum points and benchmarks established by the contractor for the convenience of this work shall have at least the same quality and durability as those of the existing points and meets the accuracy requirements.

II). Data and Documentation Available

a). Existing topographical maps based on the surveys, covering the area of the works can be made available to the Contractor upon request to the Client.

b). Topo mapping of areas for temporary facilities like the Contractor's camp, constructional buildings, construction plant, etc., shall be prepared by the Contractor prior to the construction of such facilities. The Contractor shall also perform surveys works for construction roads and Minor Bridges including preparation of maps.

III). Survey Records and Documentation

a). The Contractor shall keep records of all survey activities such as sketches, field books, calculations, etc., for the duration of the entire construction period. The Contractor shall upon request of the Client put at his disposal all records and documentation or provide copies thereof in format agreed by Client. On a monthly basis, the Contractor should submit along with the monthly progress report, a detailed report focused on the performed survey work and relevant results.

2.5 MEASUREMENT AND PAYMENT

I). No item of survey work shall be measured for the purpose of payment. No separate payment shall be made for survey work and related auxiliary services, as the cost thereof is deemed to have been included in the rates quoted for various items of works.

II). The survey work shall include, but not be limited to, the following activities:

a). All survey work, in particular fieldwork, office work, including preparation of survey maps/drawings/sketches, investigations, provision of skilled personnel, provision and

maintenance of survey instruments and accessories, supply of all materials required for survey and associated purposes, provision of suitable labour, protection of survey points etc.

b). Shifting machinery and temporary plant out of the required sightlines.

c). Stopping all machinery, drilling, blasting, driving and other work causing vibrations, dust, gas, etc.

d). Restricting or stopping traffic of persons and vehicles near instruments or in sightlines during instrument observations.

e). Removing all obstructive accumulation of water.

f). Taking all necessary safety precautions.

g). Clearing sightlines by removal of bushes and scrub with the prior approval of the Client.

3 MATERIALS FOR CONSTRUCTION

3.1 SCOPE OF WORK

I). The specification described herein under relate to the Work, which includes all labour, materials, equipment and service required to arrange materials for construction of various works under this Contract.

II). Test reports of materials for the concrete shall be, submitted by the Contractor to the Client at the Trial Mix Stage as set out in Section "Cement Concrete".

III). The specifications of some of the major construction materials are given hereinafter for planning purpose, however the contractor shall abide by all codes/regulations/ specifications as are deemed necessary for the satisfactory completion of work. The use of excavation material for construction purpose (concrete /shotcrete, aggregates, fill etc.) shall be investigated and proposed to the Client for approval.

IV). Minimum buffer stock for one-month quantity as per agreed work's programme of following items shall be maintained at site for Cement, Reinforcement bars, Aggregates for Shotcrete/Concrete, Rockbolts, drainage material and pipes, Geogrids/geotextiles/geostrips as per requirements.

V). However, towards work closure, the contractor may use these quantities with prior approval of Client. Materials which have a defined shelf life will be regularly consumed and recouped with fresh stock at suitable time intervals.

3.2 SUBMITTAL

I). The Contractor shall, specify in his bid and subsequently also, the source (s) from which all construction materials will be obtained. In case the specified sources(s) is not acceptable to the Client, the contactor shall be required to substitute the source by an acceptable source. Additional suppliers and change of suppliers shall be subject to the approval of the Client.

II). At least 28 days prior to procuring, or dispatch of the materials to site, the Contractor shall submit, to the Client, the following:

a). Certified quality test reports from manufacturers in respect of cement, steel, and other materials. This will also be necessary whenever the source is changed or when the sub-standard materials are received on the Site.

b). If the materials are to be arranged from several sources, the estimated quantity to be procured from each source and the proposed Schedule of supply.

III). The layout of the stockpiles and the method of drawing aggregates from them shall be this is to inform that the part of relative documents shall be timely submitted to the Client, at least 28 days prior to the commencement of stockpiling of aggregates.

IV). The details relating to the source, method of delivery and storage of water to be used during construction shall be submitted by the Contractor to the Client for approval, at least 56 days prior to the commencement of the Work.

V). The Client reserves the right to require any additional information deemed necessary to be included in the submitted documents.

3.3 STANDARDS

The specifications, production, sampling, testing and storage of construction materials shall conform to the following latest Indian Standards or where not covered by these Standards, to the equivalent International Standards. The list is for guidance purpose only. The contractor shall abide by all codes/regulations/ specifications as are deemed necessary for the satisfactory completion of work.

I). Aggregates and water

IS 456 Code of practice for Plain & Reinforced concrete.

IS 383 Specification for Coarse & Fine Aggregates from natural source for concrete.

IS 2386 (All parts) Method of test for Aggregate of concrete

IS 516 Method of test for Strength of concrete.

IS 460 Code of Test Sieves

IS 1607 Methods of Test sieving

II) Cement

IS 269 Specification for Portland cement.

IS 1489 Specification for Portland Pozzolana cement.

IS 12269 Specification for 53 grade ordinary Portland cement.

IS 12330 Specification for Sulphate Resisting Portland cement.

IS 455 Specification for Portland slag cement.

III). Steel for Reinforcement

IS 432 (Part-I) Specification for mild steel & Medium tensile Steel bars and hard drawn steel wire for concrete reinforcement.

IS 1566 Specification for Hard drawn steel wire fabric for concrete reinforcement.

IS 1786 Specification for High strength deformed steel bars & wire for concrete reinforcement.

IV). Structural Steel

IS 2062 Steel for General structural purpose.

IS 808 Dimensions for Rolled steel Beam, Channel & Angle Section.

IS 8500 Structural steel- Micro-alloyed (Medium and High Strength Qualities).

IS 800 Code of Practice for General construction in steel.

V). Steel for Pipes

IS 6286 Seamless and welded steel pipes for sub-zone temperature service.

IS 3589 Steel pipes for Water & Sewerage.

IS 1536 Centrifugally cast (spun) iron pressure pipes for water, gas & sewerage.

IS 6631 Specification for steel pipes for hydraulic purpose.

IS 1161 Steel Tubes for structural purpose.

VI). Welding Electrodes

IS 814 Covered electrodes for manual metal arc welding of carbon and carbon manganese steel.

IS 816 Code of Practice for use of metal arc welding for general construction in mild steel.

For all the materials latest IS-Codes shall be followed.

In case or conflict between the above Standards (or specified by Client) and the Specifications given herein, the Specification shall take precedence.

I. STONE

a. All stones used on the Works shall be of sound, hard, durable and tough quality approved by the Client.

b. The stones shall be fine or medium grained; hard, bright in color, breaking with a clean fracture and such as make a ringing sound when struck with a hammer.

c. It shall be free from decay, vesicles, holes, flaws, cracks and other defects and must have, as far as possible, uniform color and texture. Porous stone absorbing water more than 1 (one) % of its dry weight after 24 hours' immersion, shall be rejected. No stones shattered or cracked by blasting operations or having any skin or earthy cover shall be used.

d. In case the stone is not considered to be free from dust, or dirt etc. by the Client. The Contractor shall get the stone screened washed and/or treated as directed by the Client.

e. Samples of stone that the Contractor intends to use shall be submitted for approval of the Client not later than 45 days prior to the date of use.

f. Relevant codes and specifications and tests shall be followed by the contractor.

II. AGGREGATES

a. General

1. All aggregates shall comply with provisions of IS:383 and shall be tested in accordance with IS:2386. Slag and crushed over burnt brick or tile shall not be approved for usage on the project in any form.
2. Use of aggregates (coarse and fine) containing excessive amount of zeolites, secondary minerals and such other components, which cause alkali reactivity of the aggregates and consequent reduction in durability of the concrete is prohibited. The Client may however, allow the use of such material either in part or in full, with suitable remedial measures, keeping in view the extent of reactivity, the location, the nature of exposure and the structure, if the Client considers necessary, he may ask the contractor to carry out mineralogical tests to ascertain the absence of harmful minerals in the stones.
3. The Contractor shall make his own arrangements of aggregate crushing plants etc. for crushing of aggregates from stones extracted from approved quarries or obtained after excavation works of the project. Railway land if available can be used for setting up of aggregate crushing plants etc.
4. The Contractor shall take all permissions, licenses etc in this regard from the concerned Authorities. Till the time permission is obtained, contractor is required to procure material from alternate sources without affecting schedule of works. No claims on account of delays in grant of permission by authorities or delay in installation of the crusher plants will be admissible. The contractor's aggregate crushing plants shall meet all Environment guidelines and conditions imposed by MoEF&CC, Central /State Pollution Control Board and other statutory bodies, at no extra cost to the Employer.
5. The quality of all aggregates used in the works, as also processing such as washing, classifying, screening, rescreening, crushing and blending necessary to meet the required Specifications, shall be subject to the approval of the Client.
6. The aggregates shall be supplied from supplier after obtaining approval of Client. The Contractor shall carry out the required tests and submit the reports to the Client for establishing the acceptability of the quality of material and also for ascertaining the quantity of material in the sources.
7. The aggregates shall be sampled and tested by the contractor in the presence of Client in accordance with the Indian Standards. Gradation, abrasion and water absorption tests on all different types of aggregates procured from approved sources shall be performed at a frequency of 1 test per 200 cum of supply or part thereof.

8. The tests shall be made on samples that are representative of the grading that will be used in concrete and the aggregates shall be processed by the equipment proposed for the works.
9. The Client shall at all times, have access to and association with sampling and testing of aggregates and shall be entitled to discuss with the contractor, the results and proposals for grading of aggregates.
10. Coarse and fine aggregates shall be stocked and batched separately.
11. All in Aggregates is not to be used without prior approval of Client.

b. Coarse Aggregates

1. The term coarse aggregates apply to pieces of natural or crushed rock ranging in sizes from 4.75 mm to 150 mm.
2. The aggregates shall be composed of clean, hard, strong, durable pieces of stone, angular or rounded in shape obtained naturally or by crushing from suitable stones approved by the Client. Coarse aggregates shall not contain more than 15 % elongated or flat particles. An elongated particle is defined as a particle having a maximum length of more than 5 times its maximum width. A flat particle is defined as particle in which its maximum width or length is more than 5 times its maximum thickness.
3. Coarse aggregates delivered to the batching plant shall have uniform and stable moisture content.
4. The coarse aggregates shall be free from objectionable materials such as wood or other deleterious substances, the percentage of which in any size of coarse aggregates shall conform to the relevant Standards except that the coarse aggregates shall contain no more than 0.30 % by weight of deleterious (reactive) iron sulphides. The sum of the percentage of all deleterious substances in any size shall not exceed 3 % by weight. Coarse aggregates having a specific gravity (saturated surface dry basis) less than 2.60 shall be rejected.
5. The aggregates shall be resistant to deleterious substance, chemical or physical change such as cracking, swelling softening, leaching or chemical alterations after its incorporation in concrete.
6. When subject to sodium sulphate soundness test, coarse aggregates shall not suffer more than 12 % loss of weight after five cycles.
7. The aggregates shall be crushed in approved type of stone crushers and different sizes of the coarse aggregate shall be separated into nominal sizes by screening over vibrating screens as under:

i. Designation of size Nominal size range

ii 20 mm aggregate 4.75 mm to 20mm

iii 40 mm aggregate 20 mm to 40mm

iv. 80 mm aggregate 40mm to 80mm

v. 150 mm aggregate 80 mm to 150 mm

8. The grain size distribution of the coarse aggregate for the various maximum sizes of aggregates shall be as set out in the relevant Standards. These may be altered with the approval of the Client from time to time if necessary, on the basis of actual tests carried out regularly in the laboratory so as to get the best possible coarse aggregate grading.

9. Aggregate Impact and abrasion value shall not exceed 30%.

10. The percentage of weight of all the significant under-sizes shall be less than 5 % when tested on the designated test screens having opening 0.5 times the normal minimum size of the material. No oversize (i.e. material that would retain on the designated test screens having opening 1.5 times the normal sizes of the material) shall be permitted.

c. Fine Aggregates (Sand)

1. Sand or fine aggregates shall be used for mortar in stone masonry, in grouting and as fine aggregates in concrete work. It shall be either natural river sand or manufactured sand crushed from rock/stones or mixture of both in specified proportions. The sand shall be composed of hard, clean and gritty pieces of stone and of a quality approved by the Client. It shall be free from injurious amount of clay, soft and flaky particles, vegetable or organic matter, loam, mica and other deleterious substances and shall not contain any salts.
2. Varying amount of moisture in fine aggregates contributes to lack of uniformity in concrete consistency. The fine aggregates shall therefore have uniform and stable moisture contents. Dry sand shall be preferred. Hence sand stockpiles shall be protected from rainfall.
3. The percentage of deleterious substances in the fine aggregates shall conform to relevant Standards except that the fine aggregates shall contain no more than 0.10 % by weight of deleterious (reactive) ferrous sulphides. The total percentage of deleterious substances must not exceed 5 % of the weight in natural uncrushed fine aggregates and must not exceed 2% of the weight in case of crushed fine aggregate.
4. Fine aggregates having a specified gravity of less than 2.60 are liable to be rejected. Fine aggregates when subjected to a soundness test with a solution of sodium sulphate, after 5 cycles of tests, shall not suffer a loss of weight in excess of 10 %.
5. The sand shall be well graded and, when tested by standard sieves, shall conform to the prescribed limits of gradation. The best gradation shall be determined by the Contractor after experiments and tests and shall be followed after approval of the Client.
6. The sand, as delivered to the batching plant shall have a fineness modulus of 2.6 to 3. The grading of fine aggregates shall be so controlled that the fineness modulus of at least 9 out of 10 samples of fine aggregates delivered to the batching plant shall not vary more than 0.20 from the average of 10 samples tested. All classifying, batching or other operations on the fine aggregates shall be done by the Contractor and the cost thereof shall be included in unit rate for the concrete, shotcrete or masonry item as the case may be.
7. The contractor shall provide complete facility at site for determining grading of aggregates by sieve as per IS: 383, IS:460, IS:1607 and IS:2386. The grading of fine aggregates when determined as described in IS:2386 Part-1, shall be within the grading zone I, II, III.

d. Natural Sand

1. Contractor shall seek approval of source from cleint before using natural sand. No sand affected by salty water shall be used. The sand shall be screened and thoroughly washed, preferably in flowing water so as to remove all earthy impurities and very small fine unless otherwise permitted by the Client.
2. Natural sand shall be free from laterite and other softer grains and all sources of sand showing appreciable percentage of these impurities shall be rejected.
3. The presence of mica in the fine aggregate has been found to reduce considerably the compressive strength of concrete. It is advisable, therefore, to investigate the mica content of the fine aggregates and make suitable allowances for possible reduction in strength of concrete or mortar. The decision of the Client whether to use such sand and if so, what allowances to be made, shall be final and binding on the Contractor.
4. The contents of the organic matter shall conform to relevant Standards.

e. Manufactured Sand

1. Whenever natural sand conforming to the required Specifications is not available recourse shall be taken to manufacture sand of desired quality by crushing of stones. The contractor shall comply with the directions of the Client in this behalf. The stone that will be used in crushing for getting tine aggregates shall conform in all respects to the stone / coarse aggregates specified under relevant Paras hereof.
2. In case the natural sand or the manufactured/crushed sand is not considered to be as per Specifications, the same may be rejected outright by the Client or the sand may be allowed after processing, provided the sand conforms to the requirements after such treatment.
3. For improving workability of pump able concrete mixes, the Contractor may consider a combination of natural and manufactured sands. Proposed proportions shall be submitted for approval of the Client.
4. No additional payment shall be made for producing manufactured sand.

III. Storage of Aggregates

a. Storage areas for aggregates have to be covered, protected against any kind of contamination, avoid the possibility of mix among aggregates and protected also against any water inflow. The floor of the storage for aggregates has to be in concrete and has to be drained. Storage areas for different size of aggregates have to be independent to avoid any possibility of mix.

b. During rainy and cold weather periods, the aggregates shall be stored undercover for at least 48 hours before being used and kept sufficiently dry.

c. The stockpiling of the processed aggregate and drawl there from shall be such as to ensure that the variation in the free moisture in the aggregate during anyone shift of working, does not exceed 1 percent.

d. The coarse aggregates shall, be stored as per the procedure of relevant IS: codes.

e. Care shall be taken in screening and stocking of the coarse aggregates so as to avoid intermixture of different gauge materials and inclusion of any foreign materials.

f. The stockpiles shall be built up in horizontal or gently sloping layers.

g. Trucks and bulldozers shall be kept off the stockpiles to prevent breakage and impairing the cleanliness of aggregate.

h. A hard base shall be provided to prevent contamination from underlying materials in storage areas in continuous use.

i. Overlap of different sizes of materials shall be prevented with suitable walls or by ample distance between storage piles.

j. Arrangement shall be made to store natural and manufactured sand in a way that shall protect it from being contaminated with dust, organic matter or other deleterious substances.

IV. WATER

a. It may not be practical to arrange water from river at all locations. Contractor shall be responsible to arrange water from river, natural streams, etc. as convenient to him. Necessary permissions from the local authorities if required shall be obtained by the contractor at no extra cost to the employer.

b. Adequate water storage facilities shall be provided by the Contractor at the batching and mixing plant and other Work Sites so that various operations of works do not suffer due to temporary breakdown in the main supply system.

c. The Contractor shall supply test reports of water samples from the intended sources to the Client for approval.

d. The Contractor shall establish the suitability of water to be used for construction purposes and submit for approval of Client

e. Water for washing of aggregates, mixing mortar, concrete or grout shall be clean and free from earth, vegetable or organic matter, injurious amount of oils, acids, sugar, salt and alkaline substances in solution or in suspension and shall conform to relevant Standards. The maximum allowable contents of sulphates (S04) shall be 250 parts per million (ppm) and those of chlorides (Cl) shall be 200 mg per litre for plain concrete works and 100 mg per litre for reinforced concrete works. Turbidity shall be within 2000 ppm (or 0.2 % by weight) and preferably as low as possible.

f. Water used for curing shall be clean and free from contamination and from excess amounts of acids or alkalis or other matter combining chemically with and thus, disfiguring the concrete surface. Water shall not contain organic matter causing stink.

g. Average 28 days compressive strength of at least three 15 cm concrete cubes prepared with water proposed to be used shall not be less than 90 % of the average of strength of three similar concrete cubes prepared with distilled water. The cubes shall be prepared, cured and tested in accordance with the requirements set out in section of "Cement Concrete".

V. CEMENT

a. General

1. The Contractor shall procure the cement of the specified quality from Ultratech, Ambuja, ACC, Birla Gold. Other brand cements will not be used without approval of the Client. For this purpose, Client shall approve at least two sources/plants out to those intimated by the Contractor so that there is a standby for taking care of any eventualities.

2. Cement to be used for various works shall be of different types such as Ordinary Portland Cement or Portland Pozzolana (fly ash based) Cement as approved by the Client and shall conform to the relevant Standards at the time of its use.

3. OPC 53/ 53S grade shall be used for shotcrete/grouting/underground concrete works and Portland Pozzolana Cement for other concreting and masonry works or as per direction of Client.

4. The Contractor shall deliver with each lot of supply of cement a certificate from the manufactures/suppliers by which the cement is guaranteed to comply with the requirement of the specifications. Client shall have the right to check or get the cement tested at any stage of its manufacture or delivery and these test reports shall supersede the test report given in the manufacturer's certificate.

5. The contractor shall perform alkali aggregate reactivity test including accelerated mortar bed test to verify and negate the possibility of alkali silica and alkali carbonate reactive tendency and the cement to be used shall not have alkali contents exceeding 0.6% by weight of cement.

6. The cement shall be sampled and tested by the Contractor in the presence of Client for strength and physical properties and chemical analysis will be carried out as set out in relevant Standards.

7. The Cement samples for testing at the source/plant shall be obtained by the Contractor as the bins are being filled. Tests for false set shall be made on samples taken at the latest time prior to shipment.

b. Transportation

1. Cement shall be transported to site in bulk/bags in bulk containers / trucks approved by the Client.

2. All bulk containers / carriers shall be clean and dry prior to filling / loading with cement and equipped with weatherproof closures on all openings.

c. Storage

1. Sufficient storage facilities shall be provided at the batching plant to enable each new shipment of cement to be stored separately from the cement stored from earlier shipments. ¬

2. Cement shall be stored above ground adequately protected against rain sun and moisture. Bulk storage bins and silos shall be emptied complete and cleaned of all cement accumulation after every 3 months.

3. Arrangement shall be made such that stock 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 shipment before such cement is incorporated in the works.

4. Cement shall be used in the order in which it is received at Site. Cement of different brands, if received on Site, shall not be combined in the same mix and structure. Such cement shall be used in different structures as approved by the Client.

5. Handling and storage facilities shall be such that no cement is stored before use for more than 90 days. Should any cement be unavoidably kept in storage longer than 90 days, it shall be tested and if found failing the specifications required to be met, shall be rejected for use on the Project.

VI. STEEL FOR REINFORCEMENT

a. General

1. High strength deformed steel bars and wires for reinforcing bar used in the works shall be deformed TMT Fe-500D conforming to IS:1786 manufactured by primary steel producers such as SAIL/TATA/JINDAL or equivalent as approved by Engineer-in-Charge .

2. Manufactures test certificate shall be supplied for each lot.

3. Steel shall be free from loose mill scale, rust, oil, grease, dirt, paint or other deleterious matter, when examined immediately before concrete is being placed.

4. Upto 10mm dia, one sample per 30 MT and beyond 10mm dia one sample per 70 MT or part thereof shall be tested for various physical and mechanical tests tests as per IS:226, IS:1608, IS:1559 and IS:1387.

5. Wire for tying reinforcement steel shall be black annealed iron wire or acceptable equivalent, with a suitable diameter and shall have an ultimate strength of 5.68 tonne/cm2 and yield strength of not less than 8.8 tonne/cm2.

6. After material passing done by engineer, the reinforcement rods shall then be treated in accordance with IS: 9077.

7. No extra payment for re-bar treatment shall be made and is deemed to be included in the quoted rates.

b. Transportation and Storage

1. Transportation shall be undertaken in such a manner that no damage is done to the steel.

2. Reinforcement steel shall be stored off the ground in separate groups according to size and length. Reinforcement steel, which has been cut and bent according to the schedules

provided by the contractor, shall be marked with bar number, as shown in the schedule, by using weather proof tag or by placing in marked bins and shall be stored in such a manner as to be readily accessible when required and to facilitate inspection.

VII. STRUCTURAL STEEL

a. General

1. Structural steel used in the works shall conform to IS:2062 manufactured by primary steel producers such as SAIL/TISCO/JINDAL/RINL/IISCO only. Other brand steel shall not be used without prior approval of the Client.

2. All structural steel shall be of new/unused stock, clean and straight, free from excessive rust or scale and without any sharp kinks, bends or other objectionable defects.

3. All structural steel including steel plates and steel to be used for Supports as also for bolts, nuts and washers etc. shall conform to relevant Standards. Manufactures test certificate shall be supplied for each lot.

4. The material used in splices shall conform to the Specifications of the material being spliced.

b. Transportation and Storage

1. Structural steel shall be transported, handled and stored in such a manner that no damage is done to the materials or the structure.

2. All timber to be used for support accessories shall be stored in separate secure locations.

3.4 SAMPLING, TESTING & QUALITY ASSURANCE

I. For sampling, testing and Quality Assurance, Programme will be submitted by the contractor for approval of Client.

3.5 MEASUREMENT AND PAYMENT

I. No separate Measurement & Payment shall be made for supplying, including transportation and storage of material until and unless specifically included in the technical specification/BOQ. The cost of the materials and testing (including the royalties, if any) used in works shall be deemed to be included in the quoted rate for the relevant items of works.

4. DEWATERING OF SURFACE CONSTRUCTION SITES

4.1 GENERAL

I. The Contractor shall perform all works necessary to drain the surface construction sites of rain, flood water, ground water and service water. The Work shall include, but not be limited to the following:

a. Design and construction of drainage, ditches, pits, dikes/bunds and pump sumps.

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.

II. Dewatering of surface construction Sites located near and above a river/stream shall be done up to the existing water level in the river / stream by gravity as directed by the Client. 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 water level of the stream, dewatering shall be done by pumping water collected in the sumps and discharging the same into course of the river/stream downstream of the construction Site.

4.2 REQUIREMENTS AND DESIGN

I. The Contractor shall design and install complete facilities at the surface construction Sites.

II. The surface water dewatering systems shall be designed to accommodate, without undue disruption to the work, any rainfall event and considering the extent of the Sites to be dewatered and the dewatering arrangements proposed.

III. Claims for extension of time due to delays caused by unfavourable weather conditions will not be considered.

IV. The contractor shall provide adequate pumping capacity, including standby units, to handle all water entering 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.

V. Power for operating the dewatering system shall be arranged by the contractor from existing poling points. The contractor shall also make his own arrangement for enough standby power at his own cost to carry out the works during any interruption of power.

VI. The Contractor shall ensure that all drainage water is disposed off without causing interference to his own or other Contractors' operations elsewhere on the Site and that no drainage water runs into adjacent Works.

VII. 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.

VIII. All the components of the dewatering systems shall be installed and operated in accordance with the approved method and the construction time schedule, or approved modification thereof.

IX. The approval by the Client of the dewatering system shall not relieve the Contractor from being fully responsible for the design, construction, operation, maintenance, safety and removal of the facilities provided for the dewatering system and he shall be liable for any

damage or delays caused by its failure. The Contractor shall indemnify the Client against claims arising out of any such, failure made by a third party.

4.3 MATERIALS AND EXECUTION

I. 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 be regularly cleaned out of all accumulated silt and other matter so that water may always flow freely.

II. Where excavation is to be made below the ground water table, the Contractor shall lower the water table sufficiently below any working surface by means of properly screened wells and/or ditches 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. The water shall be collected and removed by pumping, if no outflow by gravity is possible.

III. 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 ground water table, and for such additional time as may be necessary to preclude damages to structure foundation.

IV. In trenches and foundations, the dewatering shall always enable to carry out the excavation Work in dry, and in a manner that will prevent loss of fines from the foundation.

V. Upon completion of dewatering, temporary pipes and pump sumps beneath permanent structures shall be closed off and filled with grout, mortar or concrete as required by the Client.

4.4 MEASUREMENT AND PAYMENT

I. Payment for all dewatering activities for surface construction sites shall be included in the rate of excavation itself. No additional payment shall be payable on this account including pumping required from sump, pits, wells etc. as the case may be.

5. EXPLOSIVE AND BLASTING

5.1 SCOPE OF WORK

The Specifications described herein under relate to supply transportation, handling, storage and use of explosives. All operations shall be carried out by the Contractor as per Indian Explosive Act, statutory requirements and regulations as applicable in India.

Contractor may obtain license from statutory authority for procuring, transporting, storing and using explosives. The same may also be arranged through existing approved suppliers/license holders in the project area. The Contractor may also have his own magazine for the storage of explosive etc. In either case, no claim of Contractor will be admissible on account of any delay in obtaining any mandatory permissions or in arranging the same for progress of the work.

The contractor will be required to draw the explosives, transport to the site and keep it safely as per safety guidelines of Indian Explosive Act. He shall acquaint himself with all applicable latest laws and regulations concerning storing handling, safety and use of explosives. The Client may issue modifications, if required and the Contractor shall comply with the same without these being made a cause for claim whatsoever, against the Client.

Explosives may be required for the Project if the contractor chooses to proceed with blasting and not by excavation with mechanical means. The rock mass excavation is considered limited on site and if blasting is required will be mainly to remove big boulders or the rock slope excavation at the south side of the upper slope. In any case and wherever used, blasting should be performed in a controlled way with limited vibrations so as not to cause instabilities to the permanent and temporary slopes on site.

Word "Explosives" would also mean the accessories related I similar substances for the purpose of safety unless otherwise specified.

5.2 SUBMITTALS

I. At least 30 days after the receipt of the LoA, the Contractor shall submit to the Client for approval, the details relating to transportation, storage and use of materials such as explosives, detonators, Detonating I safety fuse coils, Blasting Cables, Exploders, Loading Poles and tamping materials etc.

II. The Client reserves the right to require any additional information deemed necessary to be included in the submitted documents.

5.3 STANDARDS

I. Transportation, handling, storage and use of explosives shall be carried out under Indian explosive regulation, 1984 in a safe and efficient manner and shall also conform to the following Indian Standards or where not covered by these Standards, to equivalent International Standards.

Indian Explosive Act 1883 and Explosives regulations 1984 (Amended 2005)

IS 6609 Methods of test for commercial blasting explosives and accessories.

IS 10081 Terms relating to commercial explosives, Pyrotechnics and blasting practices.

IS 15447(Part-I) Commercial blasting explosives specification- Nitroglycerin based.

IS 4863 Glossary of mining terms (drilling and blasting)

IS 7526 Detonating fumes.

IS 7632 Detonators.

II. In case of conflict between the above standards and the Specifications given herein the specifications shall take precedence.

5.4 SUPERVISION

I. Before taking up blasting operation, contractor/Explosive manufacturer shall submit blasting pattern, minimum safe charge, vibration control / monitoring etc. Such study report shall have to be got updated improved periodically during the excavation period.

II. Design and excavation by blasting shall be permitted only under the supervision of competent and trained workmen who are fully experienced in the work and who have received adequate instructions. The Contractor shall make sure that his blasting crew is fully conversant with the rules and regulations concerning storing handling and use of explosives.

III. Blasting specifications should include detailed description of state-of-the-art detonators, explosives and blasting patterns as well as blasting expert services including training of actual site personnel to be provided on site at the start of the project.

5.5 TRANSPORTATION AND HANDLING

I. Explosive shall not be transported to the Site of operation except in suitable cases or containers, which are so made as to prevent any spillage of explosives during conveyance. No explosive shall be removed from such cases or containers except when it is to be used forthwith for the purpose of the work.

II. Suitable Explosive Vans, duly approved by the Client, shall be used for transportation of explosives and detonators. The following rules shall be observed for use of Explosive Van:

a. Vehicles shall have springs under the body. Tyre pressures shall be as per Indian Explosives Regulations.

b. Detonators and igniters shall not be carried in the same vehicle with explosives.

c. Beside the driver, only one helper shall be accommodated in the Explosive Van. The vehicle carrying the explosives shall not be used to transport workmen or other materials to workshops although there may be enough space for men or materials.

d. Driver shall not leave the vehicle unattended while transporting explosives.

e. All vehicles transporting explosives shall be marked or placarded on both sides and with the word "EXPLOSIVES” in bold letters.

f. All explosive boxes shall bear explosive's Batch details, Mfg. Date and specifications etc. clearly on them

g. A motor vehicle carrying explosive shall not be refueled except in emergencies and that too only when motor is stopped, and other precautions taken to prevent accidents. Such vehicles shall invariably have at least two fire extinguishers placed at convenient points.

h. Use of Mobile phones shall be restricted while carrying detonators or while refueling takes place.

i. Explosives Vehicle should have the seat belt for driver and the use shall be mandatory for the driver.

j. Vehicles transporting explosives shall never be taken into a garage, repair shop parked in congested areas, or in a public garage or similar building.

k. Explosives shall not be transported on a public highway during hours of darkness except in extreme emergency and that too only with the written approval of the Client.

l. Explosives shall not be transported in any form of trailer, nor shall any trailer be attached to a motor truck or vehicle hauling explosives.

m. No transfer of explosives from one vehicle to another shall be made on any highway except in case of emergency.

n. Persons employed in the transport or handling of explosives shall not carry with them or in the vehicles, matches, loaded firearms, petrol or any flame-producing devices.

o. All explosives shall be adequately protected against theft.

p. Smoking shall be prohibited during handling, transportation and use of explosives. The places of Explosives storage shall be clearly marked as "No Smoking".

q. The speed of the vehicle shall not exceed 25 km per hour on rough roads and 40 km per hour elsewhere.

r. The interior of the body of the vehicle shall not have any exposed metal parts except those of copper, brass and other non-Sparking metals and shall be preferably lined with wood.

III. Motor vehicles used for transporting shall be carefully inspected daily to ensure that:

a. No petrol driven vehicle shall be used.

b. Filled and serviceable extinguished are in position.

c. The electric wiring is well insulated and firmly secured.

d. Chassis, engine and body are clean and free from surplus oil and grease.

e. Fuel tank and feed lines are not leaking.

f. Lights, brakes and steering mechanism are in good working order

g. Vehicle is in proper condition in all respects for the safe transportation of explosives.

h. Two nos of red flags shall be present at the left and right top front ends of the vehicle

i. Condition of Van doors and locking arrangement shall be checked to ensure that rainwater or moisture doesn't damage the explosives case

IV. Boxes or explosives shall not be handled roughly or allowed to fall.

V. Containers of explosives shall be opened only by means of non-sparking tools or instruments.

VI. After the loading of a blast is completed, all excess explosives and detonators shall be removed to a safe location or returned at once to the storage magazine, observing the same rules as when being conveyed to the blasting areas.

VII. Containers for detonators shall always be used for storing detonators only.

VIII. Explosives and detonators shall be carried in separate containers and by separate persons to the loading face. Only non-electric detonators shall be used.

IX. The drivers of the vehicle carrying explosives shall be trained in use of fire extinguishers on his vehicle.

X. If any fire occurs on a vehicle carrying explosives the driver shall take all practicable steps to ensure that all other traffic is stopped at least 300 m from the vehicle and that all persons in the vicinity are warned of the danger.

XI. Loadings, unloading and handling of explosives shall, be supervised by qualified personnel. At the time of loading or unloading of explosives no electric switch shall be operated.

XII. Explosives shall not be placed where these may be exposed to flame, excessive heat sparks or impact or hazards of similar nature.

XIII. The covers of the explosives cases or packages shall be replaced every time after taking out part of the contents as long as any explosives are left in them.

XIV. Explosives shall not be carried in any way other than as specified in The Explosives Act & The Explosives Rules.

XV. Contractor shall ensure no misuse or mishandling of explosives such as carrying the explosives material in the pockets or folds of clothing etc. by any person.

XVI. Primers shall not be made up in advance. Priming shall be carried out only when charging of the face starts except emergency for which written approval from client shall be required.

XVII. Nothing shall be inserted in the open end of a blasting cap except fuses.

XVIII. No person shall strike, tamper with, or attempt to remove or investigate the contents of a blasting cap or an electric blasting cap or attempt to pullout the crimped safety fuse out of a blasting cap.

XIX. No attempt shall be made to soften I harden explosives by any specific treatment such as heating over a fire or by rolling the explosive on the ground.

XX. The blasting powder, explosives, detonators, fuses, etc. shall be in good condition and not damaged due to damp moisture or any other cause. They shall be inspected before use and damaged articles shall be discarded totally and removed immediately.

XXI. No attempt shall be made to reclaim or use fuses, blasting caps, electric blasting caps or any other explosives, which have been water, soaked, even if these have been dried out. The manufacturers shall be consulted for this.

XXII. The Contractor shall make all necessary arrangements for the security of the explosives during transportation. However, the client, upon a request by the Contractor, may arrange protection by the Govt. security forces for large quantities of explosives, and the corresponding cost shall be borne by the Contractor.

5.6 STORAGE

I. The Contractor may either obtain necessary licenses and consents and provide secure storage facilities for all explosives and equipment in accordance with Indian explosive act and requirements of local administration and client or may arrange explosives from nay existing explosive supplier in the region. In either case, the contractor shall take approval of Client and keep him initiated of the source of explosives. No claims on account of any delays will be admissible in this regard.

II. If the Contractor has arranged the required licenses and decided to establish his own magazine for the storage of explosive etc. then: -

a. The contractor will be required to draw the explosives, transport to the site and keep it safety as per safety guidelines of Indian Explosive Act and the Explosive Rules. The magazine shall always , be kept scrupulously clean.

b. All the explosives like dynamite shall be stored in a dry clean, well ventilated and fireproof building' constructed in accordance with Indian Explosives Act, on an isolated Site. The area around the magazine for 8 m shall be kept clear of all vegetation and combustible matter.

c. There shall be a barbed wire fencing and security lights around the magazine and security guards shall be posted around for 24 hours to prevent loss or theft of explosives.

d. Explosives, detonators and fuse coils shall be stored separately.

e. The Contractor shall maintain a record of storage and withdrawal of all explosives. This record shall be made available to the client on request. The client shall be promptly notified of any loss or theft of explosives.

f. Explosives shall be stored and used chronologically to ensure that the ones received earlier are used first. There shall be enough space between the stacks.

g. A “preparation area" shall be identified close to the charging face prior to every blast for preparatory work by experienced men as required for the work. All safety measures shall be ensured in the "preparation area".

h. Unauthorized persons shall not be allowed at any time to enter the magazine.

i. The person-in-Charge of the magazine shall, always, ensure that the magazine is securely locked.

j. Explosives shall be handled and used only by the Contractor’s duly authorized personnel. The names and qualifications of such personnel shall be submitted to the client in writing in advance of any possible use of explosives.

k. The magazine on no account is to be opened during or on the approach of a thunderstorm and no person shall remain in the vicinity of the magazine during such storm. Enough lightning conductors shall be provided on top of the magazine.

l. Magazine shoes, without nails, shall always be kept in the magazine, and a wood tub or cement trough, about 30 cms high and 45 cms in diameter filled with water shall be fixed near the doors of the magazine.

m. Persons entering the magazine shall put on the magazine shoes provided for the purpose and be careful not to allow the magazine shoes to touch the ground outside the clean floor.

n. Persons with bare feet shall before entering the magazine, dip their feet in water, and then step direct from the tub over the barrier (if there is one) on to the clean floor.

o. A brush or broom shall be kept in the lobby of the magazine for cleaning the magazine on each occasion it is opened for the receipt, delivery or inspection of explosives.

p. No matches shall be allowed in a magazine.

q. No person having articles of steel or iron on him shall be allowed to enter a magazine.

r. Oily cotton rags, cotton waste and articles liable to spontaneous ignition, shall not be taken into a magazine.

s. No tools or implements other than those of copper, brass, gun metal or wood shall be allowed inside the magazine. Tools shall only be used with great gentleness and care.

t. Boxes of explosives shall not be thrown down or dragged along the floor and shall be stacked on wooden trestles. Where there are white ants, the legs of the trestles shall rest in shallow, copper, lead or brass bowls, containing water.

u. Package containing explosives shall not be allowed to remain in the sun.

v. Empty boxes shall not be stored in the magazine nor let any packing material lie loose.

w. Blasting caps and electric blasting caps shall never be stored in the same box, magazine or building with other explosives.

x. The following shall be hung in the lobby of the magazine:

I. A copy of these rules;

II. Display of Magazine License No and the capacity

III. A statement showing the stock in the magazine and

IV. Certificate showing the last date of testing of the conductor

y. Adequate firefighting equipment shall be provided in the magazine.

z. Signboards reading "DANGER HIGH EXPLOSIVES" "PROTECTED AREA" "NO SMOKING etc. shall be conspicuously displayed in front of the magazine.

5.7 DISPOSAL OF DETERIORATED EXPLOSIVES

I. All deteriorated explosives shall be disposed off in an approved manner as per Explosive Regulation- 1984, The quantity of deteriorated explosives to be disposed off, shall be intimated to the client prior to its disposal.

5.8 DRILLING

I. Preferably parallel cut drilling pattern shall be adopted.

II All holes shall be of greater diameter than the diameter of the cartridges of explosives used.

III. Under no circumstances shall any holes be charged until completion of all drilling operations at the face.

IV. A drill or pole shall not be inserted in sockets of old holes even its examination fails to disclose explosives.

V. Drilling shall not be resumed after-blasts had been fired until a thorough examination has been made to make sure that there are no misfires and sockets with explosives which the drills may strike.

VI. Drilling shall not be started until all remaining sockets of old holes are examined for unexploded charges.

VII. Drilling crew shall be provided with approved respirators in siliceous dusty atmosphere arising out of drilling operations.

VIII. Blast design should cater to the changes in geology and/or geotechnical parameters and shall be decided face wise on ground

5.9 LOADING AND CHARGING

I. The holes shall be cleared of all debris before a cartridge is inserted.

II. In loading the holes, tamping, if required shall be done with a wooden mallet having no exposed metal parts.

III. Primed cartridges shall be first inserted and shall be seated by even steady pressure only.

IV. All loaded holes or charges shall be checked and located before firing.

V. When holes are sprung ample time shall be left between spring shots for the hole to cool, and between the last springing shot and the loading of the main charge.

VI. When practicable, no more cartridges shall be primed those are required for a round of blasting.

VII. Detonators shall be inserted at the end of the primary cartridge facing the end of the drill hole, which is prepared specially for the purpose.

VIII. Holes in cartridges for inserting the detonator shall be made with a sharpened wooden stick.

IX. When blasting on the surface the entire area to be blasted must be covered with blasting mats, in locations where surface structures are to be protected, from damage by flying rock fragments.

X. Detonating cord shall be cut from supply reel before attaching to explosive or tamping in hole. Use of the short pieces of fuse shall be prohibited for detonation purposes.

XI. Naked flames and lamps shall be kept away at the time of the loading of holes.

XII. Before starting the charging/loading of holes all electrical lines must be disconnected.

XIII. Contractor shall arrange visits of Explosive manufacturer's technical team to design and execute the blast, train the blasting crew and supervise the blasting crew as per the direction of the client.

5.10 TYPE OF EXPLOSIVES & ACCESSORIES

I. Explosives

a. For enhancing safety of operations, saving in time and better control of blast quality, bulk type explosives shall be preferable. However, packaged explosives may also be used.

b. Explosives shall meet following criterion: -

SN	Parameter	Packages Explosive	Bulk Explosive
1.	Density of explosive	1.15±0.05 g/cc	0.6-1.1 g/cc
2.	Relative weight strength	110 -120 %	90 -110 %
3.	Relative bulk strength	155 -165 %	110 -160 %
4.	Velocity of Detonation	4000±500 m/s	3000 – 6000 m/s

These parameters shall be met before seeking client's approval Additionally, client may collect random samples during any charging cycle, in case of any suspicion.

c. Explosive as approved by competent statutory authorities shall only be used. These explosives shall be of safe to handle and use, exhibit excellent water resistance and liberate low volumes of noxious gases.

d. Manual Mixing of chemicals to form any explosives shall not take place and such explosives shall not be used.

e. Any Explosives having shelf life less than 6 months shall not be used.

f. Explosives being used shall be capable of performing in low temperatures.

II. Detonators

a. Priming of the explosives shall be done only with Non - Electric detonators with shock tube containing fine spray of around 13-16 mg/m HMX/AL powder

b. The detonators shall be truly Non-electric in nature.

c. The shock lube shall be of the nature that the color of the tube gets changed post blast and can be located easily for misfires etc.

d. Identification tag and J - hook shall be placed at the end of the tube for identification and easy connectivity respectively.

e. Ultrasonic seal shall be provided at the end of the tube to make it waterproof.

f. Shelf life of the detonators shall be one year.

g. Non - Electric detonators shall be safe against stray currents, static Electricity, Radio-frequency Energies and accidental initiation by impact, shock, friction and time as per the standards fixed by the appropriate authority.

h. The delay range of detonators should comprise of a minimum 0 - 15 delays firing completely in not less than 8000 ms for long period detonators.

i. Short delay series shall contain a nominal delay interval of 25 milli second (ms).

j. Electric detonators shall not be used except for the initiation of Detonating Fuse.

III. Detonating Fuse / Safety Fuse

a. Detonating Fuse shall be used for connecting Non-Electric detonators.

b. Nominal Weight of PETN shall be 10 gm/m in detonating fuses (DF).

c. Detonating Fuses shall be able to get initiated by No.6 electric detonators.

d. Water resistance shall be excellent.

e. Detonating fuse shall be used only to initiate the plain detonators.

5.11 WIRING

I. All detonators in a single blast shall be of the manufacture.

II. Each electric blasting cap used for initiation of shot shall be tested with an approved galvanometer (circuit Tester) to determine whether it will carry the current. All testing shall be done away from the heading face. Testing of a single detonator at any time shall be avoided.

III. After testing the leg wires of electric blasting caps, they shall be short circuited by twisting the 'bare ends together and shall remain so twisted until ready to be connected into the circuit prior to connection to the firing line.

IV. Unless, the power supply is heavy it is recommended that all electric blasting caps shall be wired in series and the firing line shall not be smaller than No; 14B and S-gauge copper wire.

V. The number of electric blasting caps used in a circuit shall not exceed, the tested capacity of the blasting machine.

VI. The circuit including all caps shall be tested with a circuit tester or galvanometer, operating accurately before being connected to the firing line.

VII. In surface blasting the cartridges shall not be primed nor a hole during the approach of a thunderstorm or while it is in progress. If a charge has been primed or holes loaded, every person shall be ordered to a safe distance until the storm is over.

VIII. Blasting circuit wires and/or detonators leg wires shall never touch other wires carrying electric current.

IX. Blasting operation control shall consist of two switches; a safety switch and a firing switch located at least 2 meters apart, the connection between the switches to be made by a “plug-in” jumper, which may be permanently attached to the safety switch. The plug-in jumper Is so made that it cannot be plugged into or connected to the firing switch until the firing switch is unlocked, and the jumper must be disconnected from the firing switch before the firing switch can be locked.

X. Both the safety switch and the firing switch shall be of the locking, double pole, double throw type which, when opened and locked in downward position short circuit and ground the leading wires.

XI. Both the safety switch shall be locked immediately after firing the shot and before any person can return to the area. Keys to the switches shall always remain in the possession of the starter.

5.12 FUSE BLASTING

I. Fuse blasting is not allowed

5.13 FIRING

I. Shots shall, so far as practicable is fired electrically and only apparatus especially designed for the purpose shall be used. Power lines shall not be tapped for the purpose. No shot shall, be fired except by a licentiate blaster authorized by the client.

II. The charge shall be fired successively and not simultaneously.

III. Prior to the firing of a shot all persons in the blasting area shall be warned of the blast through audible warning and ordered to a safe distance from the area.

IV. Competent flagmen; equipped with red flags and whistles shall be posted to stop traffic at access points on each possible route of travel to the vicinity of the blasting area.

V. Blasting shall be done at fixed hours approved by the client and the blasting times shall be displayed on a Notice Board.

VI. Order to fire shall be given only by the Supervisor-in-Charge of the work after giving three warning signals to enable all the workmen to reach safe shelters.

VII. Blast shall not be fired until it is certain that every person has retreated to a safe distance.

VIII. The person-in-Charge of blasting shall be the first one to leave the area to be blasted.

IX. A bugle or an electric buzzer with a distinctive note shall be used to give warning signals. This bugle shall not be used for any other purpose. All the labour shall be made acquainted with the sound of the bugle buzzer and shall be strictly warned to leave their Site of Work immediately for safe shelters at the first warning signal and not to leave the shelters till all clear signal has been given.

X. An all-clear signal shall be given when the blasting is over.

XI. Definite places of shelter, natural or artificially constructed, shall be assigned to the crew. Workers shall be made to go to these shelters rather than trust each other's judgment about a safe place.

XII. In special cases suitable extra precautions shall be taken. The client may, however, permit blasting for underground excavation without restriction of fixed time provided he is satisfied those proper precautions are being taken and that the work of other agencies on the site is not unduly hampered.

XIII. Only Supervisor-in-Charge shall be responsible for the safe custody of the firing apparatus.

XIV. For blasts in series, only detonators of the same brand and same electrical resistance shall be used. All detonators shall be checked before use.

XV. The firing cables shall be with a proper insulating cover to avoid short-circuiting due to encountering water, metallic parts or rock.

XVI. Use of earth, as a return line shall not be permitted.

XVII. The firing cable shall be connected to the source of current only when nobody is in the area of blasting.

XVIII. Mats or rubber tyres tied together will rope shall be used as protection from flying debris to cover the charges where blasting may expose persons or Properly to injury or damage.

XIX. Blasting shall be permitted only after adequate provisions have been made for the protection of persons, the works, and public and private property. The client's approval of any of the Contractor's blasting operations shall not relieve the Contractor of his sale responsibility for the safety of persons and property. Any damage done to the works or property by blasting shall be repaired by the Contractor.

5.14 INSPECTION AFTER BLASTING (MISFIRE DRILL)

I. Immediately after a blast has been fired, the firing line shall be disconnected from the blasting or other source of power.

II. After a blast has been fired, a careful inspection shall be made by the blaster to determine if all charges have been exploded. The blaster shall count the number of the exploding shots in blasting. Misfires in fuse blasting shall not be examined for enough time after its failure to explode. Electric blasting misfires shall not be examined for at least 15 minutes after failure to explode. Other persons shall not be allowed to return to the area of blast until an “All Clear" signal is given.

III. The shot-firer must keep a record of the number of shots fired, their time of firing, type and weights of explosives used per delay and total explosives used in the round and the type and number of detonators used, together with a record of the post-blast situation for each and every location. A copy of the record shall be available to the client at the end of every shift on which shots are fired.

IV. All wires shall be carefully traced, and search made for any unexploded cartridges by the person-in-Charge of the blasting operation.

V. Loose pieces of rock and other debris shall be scaled down from the sides of the face of excavation and the area made safe before proceeding with the work.

5.15 MISFIRES

I. Misfired holes shall be placed in the charge of a competent person.

II. If broken wires, faulty connections, or short circuits are determined as the cause of a misfire, proper repairs shall be made, the firing line reconnected; and the charge fired. This shall be done, however only after a careful inspection "has been made of burdens remaining in such' holes and no hole shall be fired when the burden has been dangerously weakened by other shots.

III. The charge of explosives from a misfired hole shall not be drilled, bored or picked out.

IV. Misfired charges, tamped with solid material shall be detonated by the following method:

a. Float out the stemming by use of a water or air jet from hose until hole has been opened to within 60 cm of charge;

b. Water shall be siphoned off or pumped out;

c. New charge shall be placed and detonated.

d. Whenever this method is not practicable; then a new parallel hole, not nearer than 60 cms, shall be drilled, loaded and detonated. A careful search shall be made of unexploded material in the debris of the second stage.

V. If misfire has been found to be due to defective detonators or dynamite, whole quantity or box from which the defective article was taken must be withdrawn from the works site for return to the manufacturer or destruction as decided by the client.

VI. The Contractor shall report, in writing, to the client, all cases of misfire, causes of the same and steps taken in connection therewith.

5.16 MONITORING OF BLAST

I. General

a. The Contractor shall supply and operate at least four approved Engineering Seismometer (Triaxial) or Seismograph to measure 3-components of ground vibration and air blast overpressure. The equipment shall have enough memory space to store at least 300 events and shall be equipped to measure wide range of ground vibration and air blast overpressure. It also shall be equipped with a microphone attachment, permanent paper trace output with built in strip chart printer, LCD display and PC retrieval attachment for data to be used as and where directed by Client to monitor blasting work.

b. Unless otherwise agreed in writing by the Client trial blasts, initial blasting in general, and initial blasts in new areas and blasts adjacent to complete concrete structures and sensitive areas shall be monitored. For structures in the proximity of blasting the peak particle velocity shall be' measured at the locations immediately adjacent to the structure nearest to the face being stated or another location where it is necessary to limit vibration as instructed by client.

c. The measured vibration results shall be transmitted to the Client together with all the useful information concerning the completed information (cut of the face / slope of the cutting face; particle size distribution of the excavated material etc.; drill marks; vibration wave form in three directions-radial, transverse & vertical; air overpressure waveform; print out of Peak Particle Velocity (PPV) and associated predominant frequency in each direction).

d. Assistance shall be taken from blasting consultants / experts as specified in Quality Manual document.

e. In case the defined thresholds be exceeded, blasting operations shall be stopped in order to finalize the new blasting pattern or the choice of other methods of proceeding with the excavations.

f. In general, the methods, parameters to be measured and equipment for measurement of vibration shall be in accordance with IS 14881 unless otherwise specified.

II. Restriction of Blasting

a. All blasting works shall be completed before pouring the first structural concrete, unless otherwise specifically agreed by the Client in writing. When excavation is carried out using explosives the Contractor shall arrange his excavation and concrete placing programmed so that as far as practicable it shall not be necessary to use explosives close to permanent construction. The Contractor shall be responsible for avoiding damage to adjacent structures from fly rock by erecting barricades and/or the use of blast mats or other means by installing shielding device acceptable to the Client. The maximum allowable limit of noise overpressure in blasting shall not exceed 110 dB (beyond 100m in any direction from blast) In surface blasts: It must be measured close to the structure to be protected from blasting. Ground vibration induced by blasting shall be measured in terms of the Maximum or Peak Particle Velocity (PPV) in mm/s and predominant frequency of the ground vibration.

b. The measurement of peak particle velocity shall be obtained from instruments capable of measuring along three orthogonal axes, one of which shall be aligned parallel to the center line of the excavation and another shall be vertical. The Contractor is to provide supports for the measuring instrument if so, required by the manufacturer's instructions.

c. The measurements of the particle velocities (PPV) shall be the responsibility of the Contractor. Copies of the readings in an agreed form shall be supplied to the client.

d. The following limit on peak particle velocity are given as a guide and may be modified by the Client based on seismograph records and observations during the progress of works.

i. PPV shall not exceed 30mm/sec at 20m distance from the blast hole.

ii. For existing surface structures adjacent to excavation areas, including structures of following types.

Not forming part of the contract,

Belonging to Employer and

Not belonging to Employer,

The frequency and peak particle velocity dependent safety criteria as per Director General of Mines Safety (DGMS) criteria shall be followed for protection of nearby structures in surface blasts.

e. Where circumstances dictate, such as when blasting adjacent to partially cured concrete, the peak particle velocity permitted may be reduced by the Client

f. For specific structures and if requested by the Client the Contractor shall fulfill the following criteria:

i. At a 20 m radius of the blast, the interstitial velocity, for frequencies inferior to 100 Hertz, shall be limited to 4 cm per sec. (40 mm/sec.)

ii. After blasting and scaling of blasted surface, 60% of the half bore holes (barrels) must be visible,

iii. Smooth/control blasting is mandatory, in case of "Smooth blasting the spacing of perimeter holes should not exceed 40 cm c/c and the distance between perimeter row of holes and the buffer row of holes should not exceed 0.7 m.

iv. Bores holes space is 45 cm maximum.

g. If necessary, the Client may require the Contractor to restore at his own expense any building, structure, masonry and equipment damaged by blasting, through direct or indirect effects.

III. Recording blasting operations

a. The Contractor shall keep records of all blasting carried out showing the time and location of each blast, the type and amount of explosive used, together with any other relevant data in an agreed format approved by the Client.

b. During the site works, as mentioned before each blasting pattern shall be submitted to the Client for approval at least 24 hours before the blasting operation is due to begin. This shall be in the form of a presentation sheet setting out all the information concerning:

i. The type(s) of explosives to be used.

ii. The x, y, z coordinates of each firing hole and the firing polygonal,

iii. The diameter, depth, charge and the packing of each hole,

iv. The method of ignition and the type of detonator for each charge,

v. If using a sequential exploder, the connection of the different lines and a plan showing the effective delays of the charges,

c. The total quantity explosives for the firing of the round: always, "CLIENT" can interrupt the explosive operation or request the Contractor to modify to the blasting patterns and the cost on this account shall be borne by the Contractor.

5.17 MEASUREMENT AND PAYMENT

I. No separate measurement & payment shall be made for furnishing safe blast reports & their time to time updating from reputed institution as approved by client, supply of blasting material, its safe storage, drilling of holes, loading of blasting material, all blasting operations including monitoring etc. This is deemed to be included in the quoted rate of

excavation, provision of support system etc., for different classes of rock mass in all open works.

6. GROUTING

6.1 STRATA GROUTING

6.1.1 General

I. Ground treatment includes grouting or other ground improvement proposed by the Contractor to stabilize weak, permeable or potentially unstable ground, where to control the flow of water or for any other purpose.

II. Ground improvement includes penetration grouting with cement, micro fine cement or chemicals. The Contractor may determine other means of ground improvement with the approval of the Client.

III. The need for ground treatment shall be based on:

a. Geotechnical investigations

b. Monitoring results

c. Existence of cavities

d. Any other indications that the ground to be excavated is soft, shattered, fissured or heavily water bearing, making instability or excessive displacement probable

6.1.2 References

The concrete materials, production, methods, testing and admixtures shall conform to Indian Standard or where not covered by these Standards, to the equivalent International Standards.

6.1.3 Submission

I. Mix designs for proposed grout mixtures to be utilized.

II. Full product data for all chemical grout or other proposed grout materials.

6.1.4 Records to be retained

I. Method Statements shall be prepared and the following particular matters shall be included.

a. Plans for grouting work shall include, but shall not be limited to: Work plan: A detailed work plan specifying:

i. Basic type, objectives and principles of ground improvement scheme.

ii. Analyses to support the grout application design.

iii. Location, size and depth of each grout hole.

iv. Target grout volumes at each location.

v. Details of grout type and application method, and proposals to demonstrate suitability of the grout type.

vi. Grout pipe installation procedures.

vii. Injection procedures and sequences.

viii. Data recording and reporting methods.

ix. Field quality control procedures and quality assurance.

x. Schedule of the grouting work and relationship to anticipated excavation or filling work.

xi. Locations and types of instrumentation.

b. Plant and Equipment Detail: Relevant data concerning the plant and equipment which shall include, but not be limited to the following:

i. Layout plans of grout pipes showing the depths of injections, the angles, and other data prior to excavation/filling works.

ii. Complete details and sequence of operations relating to the grout plant, including the manufacturers' catalogues concerning each component of the plant.

iii. Detailed procedure of grouting.

iv. Estimate of the quantity of grout to be used.

II. Grouting Records

a. Keep accurate and up-to-date records of all grouting work. These records shall include grout ingredients and mix proportions, gel time (if applicable), injection date and time, injection rates, volumes, pressures, maps showing locations, details and other relevant data.

b. Display data in an acceptable chart-type graphical format that facilitates rapid visual evaluation of the results of the work.

c. Record and provide particular circumstances, such as geologic and groundwater conditions, groundwater flow, indications of success or failure of ground improvement work; include sketches and photos as required.

III. Samples

a. Samples of materials proposed to be used in ground treatment work.

IV. Certificates

a. Where grouting is used, records of each point of injection with the quantity and type of grout used, the pressure applied, and the depth of the hole.

6.1.5 Quality Assurance

I. Planning for grouting and the actual placement of grout pipes, grout mixing and injection shall be performed by an experienced grouting crew who has completed at least five grouting projects of similar scope and purpose during four years preceding this Contract, and who is experienced in the use of the proposed grouts and grouting methods.

II. Personnel Qualifications: On-the-job supervision of all grouting shall be under the direction of a grouting supervisor with at least three years of recent actual field supervision in the method of grouting proposed.

6.1.6 Material

I. Cement Grout:

a. Cement used in grouting works shall be as specified in ASTM C150 or sulphate resistant cement if required based on the geotechnical investigation.

b. Chemical additives shall be as specified in ASTMC494.

II. Compaction Grout:

a. The fine aggregate shall be uniform well graded natural sand satisfying the following grading criteria:

i. l00 % passing the No. 4 sieve;

ii. The fraction passing the No. 200 sieve shall be between 15-30 percent;

iii. The clay content shall be less than 1%.

iv. The natural fines may be supplemented with aggregate washings, of fly ash. Bentonite shall only be added in the case of the grout mix plugging under the specified pressures.

b. Water: Potable, free of impurities that will affect the grout and shall be as specified in IS 456: 2000.

c. The mix for compaction grouting shall be a mixture of the specified fine aggregate with sufficient water to produce a pumpable grout having a slump range between 15 and 40 mm as specified in ASTM C143. Any mix exceeding 50 mm slump shall not be injected but shall be wasted or recycled and remixed through the holding tank and pump until the specified slump is reached.

III. Protection of Materials:

a. Deliver materials in undamaged, unopened containers bearing the manufacturer's original labels and store and handle in accordance with the recommendations of the manufacturer.

b. All materials shall be non-toxic and non-corrosive and shall be protected from contamination or pollution at all times.

6.1.7 Drilling

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

II. The diameter at the bottom of the grout holes shall not be less than 35 mm. For percussion drill holes the diameter of the drilling bit shall be at least 8 mm larger than the diameter of the couplings used for the drill rods.

III. Only water shall be used for flushing during drilling unless directed otherwise by the Client. All holes shall be thoroughly cleaned immediately after drilling using water and/or air under pressure. After washing, downward holes shall be kept plugged until the commencement of grouting operation.

6.1.8 Water Pressure Tests

I. The Contractor shall propose maximum pressures to be used for grout injection at each location. The pressures specified shall be got approved from the Client.

II. As directed by the Client, water pressure tests shall be carried out in accordance with the above Clause of this Specification.

6.1.9 Mixing of Grout

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

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

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

IV. Water meters shall be provided for accurate measurement of water used for mixing. Pressure gauges, safety valves, by-pass valves etc. shall be provided where required on mixers, agitators, pumps and injection hoses.

6.1.10 Grouting Operation

I. Provisions shall be made to permit accurate control of grouting pressures and volumes as in Clause 6.1.9 (iv).

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

III. Grouting operation shall be performed without major interruptions.

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

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

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

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

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

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

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

6.1.11 Plant and Equipment

I. Design all plant and equipment used in ground treatment works for the procedure with which it is to be used. It shall be maintained in good operating condition at all times.

6.1.12 Execution

I. Where ground treatment by grouting is to be carried out ahead of excavation, drill holes to a distance and to a pattern into the zone to be treated and grout injected under pressure. Where necessary perform secondary grouting by drilling out a previously drilled and grouted hole, flushing with water, and re-injecting with grout.

II. Install gauges adjacent to the point of injection and use to measure the grout injection pressure.

6.1.13 Field Quality Control

I. Take grout samples periodically during pumping times and check for grout quality, gel times and neat strength.

II. Where grouting is carried out to reduce soil or rock permeability, make field permeability tests in boreholes before and after grout injection and calculate permeability changes.

III. Measure grout intake at each hole and record together with average and maximum pressures employed. At the end of each day, compare quantities so recorded with quantities measured at the grout pump in order to identify any irregularities.

IV. Where grouting is carried out to increase soil or rock strength, take core samples of grouted materials to examine for grout intake and for tests for unconfined compressive strength.

V. Perform water acceptance tests of grout holes before grouting in a manner that shall permit the measurement of the volume of the flow of water at various pressures.

6.1.14 Measurement

I. The quantities of strata grouting to be paid shall be the weight of the cement used. It shall be measured by the Client for payment as herein described and accepted with all its additional requirements.

6.1.15 Payment

The accepted quantity measured as provided above shall be paid for at the contract unit prices respectively for the pay items shown in the Bill of Quantities which price and payment shall be full compensation for drilling, washing of the consolidation grouting hole and the inspected holes, the supply, mixing, grouting of the grout, test and quality control inspection, the supply of all labour, supervisors, materials, the Contractor ’s equipment and materials and all work necessary for consolidation grouting.

7. INSTRUMENTATION

7.1 SCOPE OF WORK

I. This section specifies the requirements for the geotechnical measurements in the reprofiled slopes for the purpose of observing and recording deformations, settlements.

II. As part of safety concept 3-dimensional (3-D) deformations of the reprofiled front of the slopes and the natural slope shall be monitored by means of optical methods. The points to be observed are marked by targets or reflectors mounted on standard convergency bolts.

III. Measurement shall be carried out with a free-station high precision Total Station. The flow of data shall be fully automatic. The software shall allow determination of displacements in an absolute coordinate system with an accuracy of =/- 1 mm in minimum.

IV. The work of geotechnical measurements includes the installation of geotechnical instrumentation and devices.

V. Necessary conclusion shall be drawn from the geotechnical measurements, from their magnitude, alterations and tendencies about stability of the primary lining and surrounding rock, performance of the initial support applied and utilization of the support elements.

VI. The location and spacing between geotechnical measurement sections depends geological conditions and as specified in the tender drawing. The location of measurement sections may be changed during excavation according to the local geological conditions and the experience gained during excavation and as required by the Client.

VII. Reading of instruments, interpretation and evaluation of monitoring results as well as geological mapping during excavation will be carried out by the Client.

VIII. The Contractor shall supply, install, calibrate, test, survey and maintain instrumentation on the reprofiled slopes and near-by natural slopes as specified in this Section or as directed by the Client. Minimum instrument stock for 3 months shall be maintained at site as per approved instrumentation program. The Contractor shall supply and install all ancillary measuring equipment, read out units and construct terminal structures, protective surrounds for instruments, excavate pits and trenches, backfilling, drill holes, install pipes and fittings, and cast concrete where required. Contractor shall get approved instrumentation plan prior to installation of any instrument. All the instruments to be installed by the contractor in all the structures shall be procured from very reputed manufacturers who have supplied such instruments at other similar projects also and have good credentials of having satisfactory working of those instruments. The specifications and the source of instruments shall be got approved by the contractor from Client before procuring them.

IX. The extent, type and location of the individual instruments as shown on the Tender Drawings, the number and location of the instruments may be altered by the Client during the construction period, according to the requirements.

X. The Contract Documents give only the numbers, general type, and general arrangement of the instruments to be supplied and installed by the Contractor.

XI. 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 Client prior to installation, unless specifically stated otherwise.

XII. All instruments shall be installed to the lines and elevations shown on the Construction Drawings or as established by the Client as the work progresses during construction.

XIII. 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.

XIV. No instruments or any of their components shall be purchased prior to Client's approval. However, approval by the Client 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.

XV. All instruments shall be guaranteed against defect in installation / manufacturing till completion of Defect Liability Period. The contractor at no cost to “Employer” shall replace all defective instruments during the period of guarantee. However, the buried defective instruments shall not be returned to the contractor.

XVI. 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.

XVII. The measuring devices to be provided shall be manufactured by a reputed manufacturer with proven record and acceptable to the Client.

XVIII. The contractor shall take utmost care in the recording and analysis of the readings and prevent mixing of readings from different instruments.

XIX. 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 Client.

7.2 SUBMITTALS

I. Within 56 days from the commencement date, the contractor shall submit details of the instruments 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 Client 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 successful performance of the instrumentation proposed for installation.

c. Manufacturer's instruction for the installation, testing and operation of the instruments.

d. Schedule of monitoring of instruments.

II. The monitoring instruments must include

a. Piezometer,

b. Targets for measuring deformation using Total Station.

c. Inclinometer

III. During the execution of the works, the contractor shall submit any further details regarding the instrumentation required by the Client. The contractor shall prepare surveys and furnish "AS BUILT" drawings for all the installed instruments.

7.3 SKILLED PERSONNEL

I. The whole of the instrumentation work shall be carried out under the direct supervision of a senior supervisor, approved by the Client, and employed by the contractor who is well experienced in all types of instrumentation and installation work and who understands the purpose and function of all instruments being installed.

II. Installation and calibration of instruments shall be carried out by skilled technicians, well experienced in the installation of instruments and who have a thorough understanding of the purpose and function of the instruments being installed, acceptable to the Client.

7.4 INSTALLATION

I. The Contractor shall install and calibrate all instrumentation conforming to the supplier'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. A representative of instrument's manufacturer shall be present during the entire process of installation. The contractor shall submit a certificate issued by the manufacturer regarding the installation of instruments as per the instrument's manual, to the Client. The contractor shall tag all cables and tubes with identification tags approved by the Client at intervals of 15 m or at such closer intervals as necessary to provide continuous identification.

II. Instrumentation shall be installed and calibrated in the presence of the Client, and when he considers it desirable, instruments shall be installed preferably 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.

III. 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 always during installation keep the insides of casings and tubes free from foreign matter. Cables and tubes shall be protected from mechanical damage.

7.5 CARE OF INSTRUMENTATION

I. No traffic or equipment shall be allowed to pass over any part of any instruments or connections unless suitably protected as recommended by the instrument supplier and approved by the Client. The backfill material shall be carefully compacted in such a way that the density of backfills will become equivalent to the surrounding materials to the satisfaction of the Client.

II. 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.

III. The Contractor shall be fully responsible for the maintenance and repair of all instrumentation during the contract period.

IV. The Contractor shall recalibrate instruments at the frequency / period as specified by manufacturer as approved by Client.

7.6 READING OF THE INSTRUMENTS

I. Calibration of all the instruments shall be done by the contractor and all the facilities for the same shall be arranged by him. An initial set of readings on all instruments installed at any elevation will be taken 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.

II. The contractor, after consultation with Client, 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.

8. INSTRUMENTATION AND MONITORING FOR STRUCTURES

I. 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 Client for the following instruments

a. Topographical markers / survey points

b. Seepage Measuring Devices (Measuring Weir)

c. Automatic Weather Station

d. Cables

e. Cable splicing kit.

f. Junction Boxes

g. Readout units.

h. Tiltmeter

II. The instruments shall be supplied, installed and monitored by the contractor as directed by Client in order to assess the behaviour of the structure and other structures during the Construction of the work.

III. Topographical Markers.

a. The contractor shall supply, install and survey studs, base plates, observation pillars and survey targets along with accessories, as shown on the drawings for precision surveying. Base plates and leveling studs shall be used to measure the vertical movements of the structure top or parapet wall & other concrete structures. Survey targets and observation pillars shall be used for measuring horizontal movement or deflection. Observation pillars shall be installed on the downstream side banks and targets mounted on the structure at various elevations as shown on the drawings.

b. Observation pillar shall be of size 600 mm X 600 mm X 900 mm (projecting 300 mm above ground), RCC of M30 Grade having 4 nos 10 mm longitudinal reinforcement bar with 4 nos 6 mm reinforcement bar stirrups. Observation pillar shall be of size 600 mm X 600 mm X 900 mm (projecting 300 mm above ground), RCC of M30 Grade having 4 nos 10 mm longitudinal reinforcement bar with 4 nos 6 mm reinforcement bar stirrups.

c. Survey studs shall be of stainless steel of 15 mm Ø and 250 mm long and of the shape and size as shown on the drawings.

d. Levelling studs/ base plates shall be installed as soon as possible after placement of concrete at the locations where required. The base plate shall be 100 X 100 X 3 mm stainless steel plates or brass plate with 4 MS spikes (hold fasts) about 5 mm Ø X 70 mm long to hold the plate in concrete. The top surface of the plate shall be a perfect plane.

e. Survey targets shall be made of solid brass or stainless steel of about 35 mm Ø on top and 75 mm long. Its top there will be an engraved cross mark 1 mm thick and 1 mm deep. The contractor may suggest some different type of targets also for approval of the Client.

f. Immediately after installation of any studs / base plates, its position and level shall be precisely surveyed. The level and coordinates shall be computed and submitted in writing to the Client within 24 hours of installation.

IV. Seepage Measuring Devices (Measuring Weir)

a. Measuring Weir shall be installed at appropriate locations as shown in the drawing or as directed by Client to measure the amount of seepage with the help of V-notch steel plate weir.

b. Water level variations shall be accurately sensed by vibrating wire sensors. These gauges shall measure the buoyancy (Uplift Pressure) force acting on buoys within protecting cylinders at various depth of submergence. It shall consist of attached data logger to record time data of flow. It shall be capable of providing alarm signals also at predetermined excessive flow rate.

c. Seepage measuring device shall consist of liquid level indicator (float), vibrating wire transmitter and an indicator. Liquid level indicator shall consist of a V-notch weir and a sensing element. The sensing element shall consist of a pair of cylinders, each having a vibrating wire type transducer as specified earlier. The scope of supply shall include liquid level float, vibrating wire transducer protection box, datalogger, and all other accessories. The measuring range of the weir shall be upto 30 litre / sec.

V. Automatic Weather Station

a. Contractor shall supply and install weather station (automatic type) and take observations during construction period and hand over to the Employer at the end of the construction period.

b. The Automatic Weather Station (AWS) must permit to record automatically and continuously the following meteorological data:

1. Wind speed

2. Air temperature

3. Rainfall

4. Relative humidity

c. The Sensors of the AWS shall meet the following requirements:

1. Wind speed Sensor

Range	:	0.5 to 100 m/s
Resolution	:	0.5 m/s

2. Air temperature Sensor

Range	:	-100 C to +600 C
Resolution	:	0.10 C

3. Rainfall Sensor

Maximum Range	:	10 mm /min
Resolution	:	0.02 mm

4. Relative humidity Sensor

Range	:	5% to 99%
Resolution	:	0.1%

d. The sampling interval shall be adjustable from 1 to 3 hours.

e. All the sensors must be operated with solar cells with provision for power module.

f. The data storing unit of the AWS shall have the facility to store all data for a period of at least 6 month and shall permit instant display/USB transfer of data.

g. The Contractor shall supply and install a complete AWS including all instrument shelters within one month from the date of commencement.

VI. Cables

a. Cables connected to instruments shall be laid as per the detailed cable routes submitted by the contractor and approved by the Client.

b. Cables shall be generally be of following types.

1. 12 core cable: it shall have 7 / 0.25 mm ATC PE insulated, with six twisted pair (12 core), color coded, screened with water blocking aluminum foil or jelly filled, polyester taped,

inner polythene sheeted, 0.3 mm galvanized iron wire braid armored with 50 % coverage, overall polythene sheathed and overall diameter of around 14 mm.

c. Special cables, where required, for various gauges shall be of standard market quality, as approved by the Client.

VII. Cable Splicing Kit

a. It is required for joining two cable ends of four-core cable. It shall be suitable to make a water resistance sealed joint and shall have requisite amount of cable jointing compound like epoxy and silicon grease. The splicer shall be made of stainless steel and shall be able to withstand a pressure of 30 kg / cm2 and a tensile force of 12 KN.

VIII. Junction Box

a. The junction box shall be mounted at appropriate locations as shown on the drawings or as directed by Client. The junction box shall be a device to provide connection between core cables leading from the different instruments and multi-core cables leading to the multiplexer unit. The junction box should have a connector socket for the fly leads from the portable read out unit and a rotary switch to select individual instruments.

b. All switchable junction boxes shall be double ended. This is essential to remove the possibility of one rogue instrument interfering with the performance of the others. The junction box shall have an arrangement for connecting minimum 20 instruments. The wires and terminals within the junction box shall be fitted with entrance hubs to protect them against danger of water penetration.

c. The junction box shall be of drip tight sheet steel and shall be provided with stuffing box for special measuring cables and connecting cables and shall have built in terminals and socket strips. The junction box shall be provided with an arrangement for protection against over voltage. The sheet steel metal construction of the distribution box shall be properly treated and coated with corrosion resistant paint. The junction box shall also be provided with an arrangement for earthing and shall be supplied along with its accessories. The specifications for the junction box given herein indicate broad requirements only.

d. Tiltmeter:

e. Tiltmeters shall be installed at appropriate locations on structures to measure small changes of the inclination.

f. Position of the tilt meter should be determined immediately after installation and parallel to the zero measurement.

8.1 MEASUREMENT AND PAYMENT

I. The payment for supplying and installing all the instrumentation shall be made as per the rates quoted for various items of works in the schedule of item rates. Unless otherwise specified, the scope of instrumentation shall include the following:

a. Supply, installation, calibration, testing, surveying, repairing and maintaining of all instruments, ancillary and read out equipment, including protective steel covers, tubes and tube protections, required to perform the specified measurements.

b. 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.

c. Entire cost of supply and installation, testing, taking measurements and readings and submitting installation protocols and results to the Client.

II. Payment for posting of Instrumentation & Monitoring Engineer (of a reputed instrument manufacturer whose instrument is being procured by the contractor or having suitable experience.) shall be made separately as per rates entered in the schedule. The Instrumentation & Monitoring Engineer shall possess minimum 5 years working experience of field installation, maintenance and taking readings of the instruments. The Instrumentation & Monitoring Engineer shall be mandatory for installation, Regular reading of the instruments / equipment, and interpretation and submission of reports on formats approved by the Client during construction and the handing over of all data up to the time of completion along with and the instruments and readout units, with all accessories, in proper working order as required by the Client. The Contractor shall deploy Instrumentation & Monitoring Engineers according to man month mentioned in BOQ in 2 shift per day.

9. OPEN EXCAVATION

9.1 SCOPE OF WORK

I. The specifications described herein under relate to the work of open excavation for various structures and shall include all labour, tools, plants, Constructional Plant and services, necessary to carry out the excavation of different type of materials, geological mapping of excavated surfaces, dewatering, temporary slope stabilization measures required to facilitate excavation, transportation and stockpiling I disposal of all excavated materials into stockpiles I dumping areas as shown on the drawings or as approved by the Client.

II. Excavation shall be made to the lines, grades and dimensions shown on the drawings or as otherwise directed by the Client, which shall be required to be backfilled with acceptable material and compacted by contractor in a manner acceptable to the Client.

III. The Contractor shall maintain the excavated slopes, drainage and trenches and prepare foundations as shown on the drawings or as required by the Client. The Contractor must ensure slope protection measures for riverbank and non-dumping station areas ensuring environmental mitigation measures as per the approved environmental mitigation plan.

IV. The area of open excavation shall, where, in the opinion of the Client, clearing is necessary, be cleared of all trees, bushes, rubbish and other objectionable matter and the materials so removed, shall be disposed off suitably or as directed by the Client.

V. When additional excavation outside the lines and grades shown on the drawings is required by the Contractor for his own convenience, such additional excavation shall be required to be backfilled with acceptable material and compacted by the Contractor in a manner satisfactory to the Client. The contractor shall submit his plans for such proposed work in writing for Client's acceptance prior to the commencement of the work.

VI. The removal of mud and slush resulting from heavy rains or flooding of the sites, when necessary to ensure the safe and effective performance of the work, shall be performed by the Contractor. For this purpose, Perimetric drains will also be required to be provided at a suitable distance from the edge of the cutting around the slopes to ensure the safe drainage of superficial water, avoiding slope erosion.

VII. At all times during construction, the Contractor shall adopt such excavation procedures that at no time the stability of any slope be impaired. For the excavation in intake area special care shall be exercised and the contractor shall adopt modern controlled blasting techniques.

VIII. The approval given by the Client to the contractor's methods and equipment shall not relieve the Contractor of his full responsibility for a proper and safe execution of excavation, or of liability for injuries to, or death of person(s), or any obligations under this Contract.

IX. The Contractor shall comply with all safety procedures and requirements as stipulated elsewhere in the tender documents.

9.2 SUBMITTALS

I. At least 30 days prior to the commencement of excavation, the Contractor shall submit details of his excavation methods and sequences for all open excavation Works including the schedule of deploying equipment.

II. The description of drilling and blasting procedures, if required, shall include the following:

a. Diameter, spacing, depth, pattern and orientation of blast holes

b. Type, strength, amount and distribution of explosives to be used, per hole.

c. Description and purpose of any special method to be adopted by the Contractor.

d. Sequence of various activities of the excavation work with an indication of corresponding time requirements.

III. At least 30 days prior to dumping or stockpiling of any excavated material, the Contractor shall submit the layout of the spoil and stockpile area. All data pertinent to working methods and provisions for the security, stability and temporary and permanent drainage of the work areas shall be included along with details of volumes, material types, heights and grade provided. To prevent spillage of muck, R. R. masonry/ Gabion retaining walls with adequate arrangement shall be provided in disposal area.

IV. To enable the Client to verify all necessary setting out and elevations carried out by the Contractor, the latter shall notify the Client in writing, giving at least 1 (one) week notice of his intention to start excavation.

V. The Client reserves the right to require any additional information deemed necessary to be included in the submitted documents

9.3 CLASSIFICATION OF EXCAVATION

I. Open excavation shall comprise of the following types of excavation:

II. Soil excluding Rock (Seismic velocity Vp <1000 m/s)

a. Loose excavation shall include all types of soil and such other material, which can be excavated manually by ordinary pick and shovel or barring and wedging or by mechanical equipment such as dozer blade, ripper, power shovel and dragline but without resorting to blasting. It shall also include embedded boulder not bigger than 1-meter size in anyone direction.

III. Rock not requiring blasting

a. This shall include excavation of all rock, which can be excavated by mechanical equipment such as dozer blade, ripper, power shovel and dragline but without resorting to blasting to loosen the same.

b. This shall also include boulders and detached rock blocks of size larger than one meter in any direction. It shall also include the removal of softer materials, lying between layers of rock.

IV. Hard Rock requiring blasting

a. This shall include excavation of all rock, which cannot be excavated without prior blasting to loosen the same.

b. The term rock shall include boulders and detached rock blocks of size larger than one meter in any direction which requires blasting for removal. It shall also include the removal of softer materials, lying between layers of rock.

V. Hard Rock requiring blasting but blasting not permitted

a. This shall include excavation of all hard rock, which cannot be excavated without blasting but due to restriction imposed at site by employer, the same is required to be excavated by

chiselling or rock breaker, vibratory rock rippers, rotary drum cutters. Alternatively, propellants (non-detonating silent explosives for ex. NONEX, ROYAX).

b. The term rock shall include boulders and detached rock blocks of size larger than one meter in any direction which requires blasting for removal. It shall also include the removal of softer materials, lying between layers of rock.

VI. Removal of Slip

a. Unavoidable slips, which may occur in the excavated slopes, shall be removed by loading, hauling, dumping of the material and the surface cleaned.

9.4 REMOVING BLUFFS AND LOOSE ROCK

I. All loose boulders, semi-detached rocks (along with 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 Client, to fall or otherwise endanger the workmen, equipment of 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 Client is likely to become loosened or unstable later on shall also be promptly and satisfactorily removed as directed by the Client.

9.5 EXCAVATION IN OPEN CUTS

I. The side slopes of the excavation shall be as shown on the drawings or as directed by the Client.

II. Any changes in the slopes as shown on the drawings on account of site conditions shall be subject to the approval of the Client.

III. Every precaution shall be taken to prevent slips. In case slips occur, the slipped material shall be removed to the designed / modified slope. Utmost care shall be exercised to cause no harm/structural damage to structures and/or utilities in the vicinity of the excavation area.

IV. In case of loose excavation, where the surface is left as excavated, or is to be covered by pitching, formation of rain cuts and gullies shall be avoided by proper drainages. Any gullies formed shall be made good, by properly packing excavated rock spoil in them. All holes left by removing boulders shall also be filled in with rock spoil.

V. Where plain surfaces are required, such faces of excavation shall be formed in such a manner that would least shatter the rock mass. Only light blasting, ream holes pre-splitting or similar methods shall be allowed in areas adjacent to such faces.

VI. In special locations (only in rock) where specifically indicated or ordered by the Client, the use of explosives shall be discontinued and excavation completed by the drilling, wedging or barring or other suitable method approved by the Client.

VII. Blasting within 30m of concrete or grout or shotcrete will be permitted only after concrete grout is 7 days old and only after the submission by the Contractor and approval by the

Client of a plan showing the relative positions of structures or grouted area and the areas to be blasted, Contractor 's proposed drilling and blasting plan together with an outliner of precautions to be taken.

VIII. All concrete/shotcrete works and other completed works within 30m of blasting shall be protected by limiting the charges / size of blasts so as to ensure that the maximum displacement velocity of particles at nearby structures is not more than 50mm per second. For concrete or grout or shotcrete less than seven days old, this velocity shall not be more than 10 mm. In such cases, trial blasts for assessing the displacement velocity shall be carried out without additional remuneration.

IX. The Contractor shall carry out the excavation of open cut rock slopes utilizing the controlled perimeter blasting technique wherever blasting is required.

X. Excavation shall be carried out in a descending way by benching. The bench height shall not exceed 2 m. A horizontal berm with a minimum width of 4 m shall be provided at least every 10 m of height or as shown on the drawings.

XI. Immediately after excavation and sealing to the satisfaction of Client and prior to the excavation of next bench, the Contractor shall install drainage boreholes with pipes, shotcrete, wire mesh, rock bolts and weep holes if considered necessary, as shown on the drawings or as required by the Client. Water ingress behind the shotcrete lining shall not be allowed.

XII. The wire mesh for shotcrete shall have proper overlap between two successive benches or elsewhere as required. The overlap shall not be less than 300 mm or as shown on drawing or as directed by the Client.

XIII. At slope surfaces where shotcrete but no rock bolts are to be installed, the Contractor shall install soil nails to secure the shotcrete lining. The soil nails shall be at least 1 m long L-shaped steel rebars, diameter 16 mm. At least one soil nail shall be installed every 4 sqm.

XIV. All blasted rock shall be removed from the bench toe before undertaking further work.

XV. All other specifications pertaining to blasting and scaling etc. relevant to open excavation shall be as per stipulations of Section of Explosive and Blasting.

9.6 EXCAVATION FOR FOUNDATIONS OF STRUCTURE

I. While carrying out excavation for the foundations of the structure, if it is considered necessary for a work and if approved by the Client, the sides of the loose excavation shall be shored and strutted to the satisfaction of the Client.

II. After completion of the loose excavation, the rock excavation in foundations of the Structures shall be carried out to the depths as shown on the drawings. At all stages of excavation, precautions shall be taken to preserve the rock beyond the lines of required excavation. The quantity and strength of explosives used in the foundation excavation in rock in various locations shall be such as will neither damage nor crack the rock outside the limits of excavations.

III. As the excavation approaches its final lines and is within 300 mm to 600 mm of the specified foundation levels, the depth of the holes and the strength and quantity of explosives shall be progressively and suitably reduced so as to ensure that the rock profile beyond the lines and levels specified on the drawings shall remain undisturbed. If so, directed by the Client, this excavation shall be carried out by the line drilling.

IV. Final excavated surface shall have no abrupt changes in slope and sharp projection greater than 500 mm. Projections in excess of 500 mm shall be treated where necessary by supplementary excavation as determined by the Client to produce the desired surface of contact between concrete and rock/soil.

V. All excavations done beyond the lines and the dimensions shown on the design drawings shall be back filled with concrete of the same grade and quality as that of the foundation or as directed by the Client.

VI. Acceptance criteria for important foundations: Important structures shall be founded on sound and competent rock and suitable for taking up the load of the super structure without undergoing deformation beyond the acceptable limits as per the directions of Client. After excavation up to fresh rock level, further excavation shall be done up to one meter by wedging and barring to remove all the loose and soft, weathered rock, sheared material etc. All sheared portion shall be excavated to a desired depth and filled with concrete with steel reinforcements as per approved design and drawings. Concreting shall be taken up only after getting written approval of the Client.

VII. Stable slopes shall be provided in open excavations along with berms of specified width as per approved design & drawings.

VIII. All permanent rock slopes shall be stabilized by suitable treatments such as shotcrete with chain link mesh, rock anchors, spot rock bolts, perforated drainage pipes, berms with drains etc., as per approved design and drawings.

IX. Surface Preparation of Foundations

a. After completion of excavation of foundations, trimming for the final removal of all dummy rock or loosened mass, shall be done by chiseling, barring and wedging as directed by the Client.

b. Any weathered or decomposed rock remaining shall be removed. Open fissures joints; crevices and any other doubtful areas shall be cleaned to a suitable depth up to firm rock and backfill with the concrete/mortar of the same grade as that of the main structure and contact grouting as specified.

c. Consolidation grouting of the foundation rock shall be carried out upto the specified depth before the placement of concrete.

d. Contractor shall wash all rock surfaces of the excavations. This washing shall be carried out initially for inspections when required by the Client.

e. Final washing of any section of the work prior to concreting or application of shotcrete shall be carried out only when the blasting for the excavation and removal of projections inside the neat lines has been completed.

f. Final washing prior to concreting shall be done by directing a stream of water at a pressure of about 8 to 10 bars on the rock surfaces from a distance of 1.5 meter through a nozzle of 18 mm diameter so as to remove all loose rock, fragments, dust and debris from the surfaces.

9.7 DISPOSAL OF EXCAVATED MATERIALS

I. The excavated materials suitable for construction shall be stockpiled at locations approved by the Client, if the immediate placement in the final location in Permanent Works is not possible.

II. Excavated materials which are not suitable for construction and those in excess of the requirement for construction shall be disposed off in the waste disposal area. Surfaces of material so disposed off shall be trimmed to regular lines and grades satisfactory to the Client. Disposal of all material shall be such that it will not interfere with natural drainage and is as per the regulations for environmental protection or with Client 's acceptance. The Contractor must ensure muck management as per the approved environmental mitigation plan with proper turfing and plantation at dumping sites. Nothing extra shall be paid for it and the contractor must include the same in his quoted price.

III. The contractor shall ensure that no excavated materials are disposed off in the streams or at locations, where these are liable to be washed away by the floods or may block the water way of streams.

IV. The plan of muck dump yard fill, berms and provision of retaining walls, slope of fill etc. will be as per site requirements and the same shall be got approved by contractor from Client before start of such works.

9.8 DRAINAGE

I. Seepage water from springs or rainwater shall be suitably collected and drained away from work area by gravity, wherever it is possible to do so. Where, however, drainage by gravity is not feasible, pumping could be resorted to all stipulations laid down in Section of "Dewatering, Drainage and Pumping" shall be followed.

II. The surface water dewatering systems shall be designed to accommodate, without undue disruption to the work, any rainfall event. The removal of mud and slush resulting from heavy rains or flooding of the sites, when necessary to ensure the safe and effective performance of the work, shall be performed by the Contractor. For this purpose, Perimetric drains will also be required to be provided at a suitable distance from the edge of the cutting around the slopes to ensure the safe drainage of superficial water, avoiding slope erosion.

III. The reprofiled upper slope and the fill at lower slope shall be covered with protective felt during monsoon to prevent erosion and subsequent failure of the slope.

IV. The long drainage pipes installed in the natural soil for ensuring drained conditions during the 120 years of design life shall be slotted PVC pipes wrapped with geotextiles. The length, diameter and the spacing of the drainage pipes shall be as given in the drawings. The drainage pipes in the reprofiled upper slope shall go up to 10 m in the bed rock.

V. The drainage pipes laid in the fill soil on the lower slope shall be HDPE pipes of 200 mm diameter.

VI. Thickness of the drainage pipes shall be as per Table 1 of IS 4985:2000

VII. Geotextile Type III for wrapping around drainage pipes and as filter media shall be as per MoRTH (Fifth Revision) Clause 700. The nonwoven thermally bonded or needle punched, or any equivalent geotextile shall be used. The geotextile shall be made of polyethylene or Polypropylene or polyester or similar fibres manufactured through machine made process of heat bonding or needle punching techniques. The mean Values of Geotextile shall be referred from Table 700-1 and 700-3 in MoRTH Clause 702.

VIII. Drainage layers in the fill on the lower slope at levels of sub surface drains shall be minimum 600 mm thick, protected from contamination of fines by layers of non-woven geotextiles. The drainage layers shall be with well – graded crushed aggregate (materials of 19.5mm to 9.1mm size as per IS: 383). The desirable gradation of the aggregate used in the drainage layer is indicated in the table below. Besides meeting gradation requirements, it should be ensured that the aggregates are not friable, flaky, elongated and are sound in strength. Relevant tests as per MORTH 2013 specifications may be used to judge the suitability of the material used in the drainage layer.

Sieve Opening, mm Percentage Finer

37.50 90-100

20.00 80-100

12.50 0-20

Alternatively, geo composite conforming to IRC 34:2011 which ensure adequate drainage may be provided. Specifications for Geo-composite should be as recommended in MORTH Specifications- 2013 Tables 700-9 and 700-10.

9.9 BACKFILL

I. The backfill of the lower slope in Rangpo yard is vital for the slope and platform stability and thus, Contractor's quality assurance is will be strictly monitored by the Client.

II. The whole humus layer from the natural surface has to be removed and stored separately to be used afterwards for replantation.

III. Backfill shall consist of materials as approved by the Client and shall be placed in locations as directed by the Client.

IV. Only suitable materials obtained from excavation, if practicable, shall be used for backfilling.

V. Material to be used in backfill shall be free drainage type.

VI. The fill material is to be selected from the upper slope excavation and by quarrying it in the neighbouring areas. Muck material from the excavation of the adjacent tunnels of USBRL line can also be used. The coarser size fraction is to be favoured and the quantity of the fines shall be carefully calibrated for assuring the final target characteristics (= 35° and c = 2 kPa).

VII. The coarser size fraction is to be laid as first layer over the natural scraped surface which will act as a draining high friction layer. And over this initial layer, the fill can proceed up to the target elevation and incline (23º). This operation shall proceed from the bottom of the valley upwards.

VIII. The backfill shall be laid in 300 mm thick layers and compacted as per RDSO guidelines. The compaction of backfill material shall be 95% of maximum dry density obtained from modified Proctor compaction test performed as per IS 2720 (Part-8).

IX. Each layer shall be thoroughly compacted with the help of suitable compaction equipment to reach minimum density of 17.5 kN/m3. Subsequent layers shall be placed only after the finished layer has been tested for required density and accepted by the Client.

X. Compaction needs to be performed over material with optimal moisture content so as to achieve the required results. This implies that interruption of earthworks during rain events are to be expected.

XI. When density measurements reveal any soft grounds, further compaction shall be carried out. In spite of that the specified compaction is not achieved, the material in the soft areas shall be removed and replaced by approved material, compacted using appropriate mechanical means to the density requirements and satisfaction of the Client.

XII. If required or requested the backfill shall be covered with protective felt during monsoon to prevent erosion and subsequent failure of the slope.

XIII. Earthmoving equipment shall not be accepted as compaction equipment nor shall the use of a lighter category of plant to provide any preliminary compaction to assist the use of heavier plant be taken into account.

XIV. The material used for fill shall be free of logs, roots, rubbish or any other ingredient likely to deteriorate or affect the stability of the reprofiled slope.

XV. The fill should not have clay with liquid limit exceeding 50 and plasticity index exceeding 25. Expansive clay exhibiting “free swell index” exceeding 50 percent shall not be used as fill material.

XVI. The backfill at the proximity of nalas and river banks or other water bodies, is to be protected against erosion of the toe structure foundation. These secondary works are to be ascertained

in detail during the topographic positioning of the fill and the relevant foundation excavation.

9.10 MEASUREMENT AND PAYMENTS

9.10.1 General

I. Payment for open excavation shall be made as per Bill of Quantities.

II. The Contractor is assumed to have included the entire cost but not limited to the following:

a. Provision of all labour, equipment and materials required for open excavation in various locations including drilling holes for blasting, developing and Improving controlled blasting methods, performance of blasting, cleaning, washing protection and maintaining excavated surfaces in satisfactory conditions' and additional excavations if any, required by the Contractor for his construction methods.

b. Geological mapping of the excavated area and the temporary stabilization measures adopted for facilitating the open excavation work.

c. Provision for loading, handling and dumping the excavated material on stockpiles, dumping area or point of incorporation into permanent work up to a lead of 200m from exit point of various structures to entry point of disposal area, shaping and trimming of the excavated materials in the dumping area, cleaning of the stockpile area, formation and maintenance of stockpiles, rehandling of suitable materials including segregating; grading, draining and drying of materials suitable for use in embankment construction or as backfill.

d. In case, the dumping of excavated material is required to be made in the areas beyond 200m of initial lead or incase due to any reason beyond contractor’s control, then extra payment shall be made for additional lead as per relevant item of the Bill of Quantities and no other claim what-so-ever shall be admissible to the contractor.

e. Complying with all requirements of statutory laws and regulations relating to the works and any restrictions resulting there from obtaining all necessary permits and licenses for the purchase, use storage and transport of explosives and other materials.

f. Surveying, setting out, checking of excavated profile, layouts and any subsequent rectification works resulting from unable or incorrect surveys, provision of suitable equipment for and delays due to carrying out this work.

g. Furnishing, installation, operation, maintenance and removal of Communication and illumination systems and observing safety precautions.

h. Recording and preparation of reports related to excavation progress and procedures.

i. All work involved with and any partial or short interruptions or inconveniences caused by the check surveys, performance of the rock mechanics tests, installation and monitoring of instruments and geological mapping, for which no separate payment is provided elsewhere in these specifications.

j. Seepage water or rainwater suitably collected and drained away by gravity including provision of catch drains, diversion of nallah etc.

k. Dewatering by pumping in the open excavation area due to any reason whatsoever.

l. The compensation for removal of mud and slush resulting from heavy rains/flooding of the sites if necessary, to ensure the safe and effective performance of the work shall be deemed to be included in the quoted rate of excavation.

m. The payment towards the preparation of disposal area shall 'be deemed to be included in the quoted rates of excavation".

n. Excavation for drainage trenches will neither be measured nor be paid for.

o. All taxes duties including royalties.

p. Clearing of all trees, bushes, rubbish and any other objectionable materials and their removal and disposal.

q. Over excavation beyond the excavation lines shown on the drawings, removal of material or backfilling with acceptable material where and when as required by the Client.

r. Replacement of survey points fixed by the Client, which are damaged by Contractor's negligence, and fixing of additional survey points near working area.

s. Methods adopted for specially controlled excavation at foundation level or near the faces where plain surfaces are required.

t. Formation of berms or ramps sump pits for installation of dewatering pumps at places, which fall beyond the specified excavation lines.

u. Replacement or repair of concrete or other works damaged by bIasting.

v. Over-excavation required for contractor's convenience. The concrete required to fill such excavation shall also be at the contractor's expense.

w. Draining, shaping and trimming of the dumped materials in waste disposal area to the lines and grades as directed or approved by the Client.

x. Provision of catch drain, nallah diversions etc. to avoid flow of water to working area.

9.10.2 Open Excavation

I. Measurement for payment of excavation will be of the in-situ volume defined by the excavation lines as shown on the drawings, and shall be worked out on the basis of solid volume, worked out from the initial, intermediate, and final ground cross sections recorded or as per direction by the Client.

II. Payment will be made at the appropriate Unit Rate per cubic meter as entered in the Schedule of Item Rate.

III. Payment for removal of bluffs and loose rock close to the areas to be excavated shall be deemed to have been included in the quoted rate for item of open excavation for various structures.

IV. Payment for removal of unavoidable slips, which may occur in the excavated slopes, will be deemed to have been included in the quoted rate for the item of open excavation for various structures.

9.10.3 Shoring and Strutting

I. The rates for shoring and strutting shall be included in the rates of excavation itself.

9.10.4 Royalties

I. Soil or rock spoils such as stones, boulder, pebbles, gravels etc. available from excavation, if are found suitable for use in works as per required specifications, can be used free of cost but the legally payable royalty and taxes are to be paid by Contractor to the concerned authorities.

10. ROCK BOLTS/SOIL NAILS AND WIREMESH

10.1 SCOPE OF WORK

I. The specifications described herein under relate to the Work which includes all labour, material, equipment and services required for the supply, installation, testing and monitoring of rockbolts/soil nails. and also the supply and installation of wire mesh and mesh anchors as specified herein or as shown on the drawings.

II. Rockbolts/soil nails etc. shall be furnished complete with all accessories and other materials necessary for their installation, stressing and grouting.

III. If directed or approved by the Client, the Contractor shall supply and install flat steel plates or rolled steel sections to connect together two or more rockbolts/soil nails.

IV. The contractor shall maintain on site or have immediately available at least one month buffer stock as per agreed work programme of any of the support element s i.e. Wiremesh, Self-Drilling bolts, SN bolts or any other specialised bolts required according to the geological conditions and as per drawings. However, towards work closure, the contractor may use these quantities with prior approval of Client.

V. STANDARDS:

The specifications, production, working etc. shall conform to the following latest Indian Standards or where not covered by these Standards, to the equivalent International Standards. The list is for guidance purpose only. The contractor shall abide by all codes/regulations/ specifications as are deemed necessary for the satisfactory completion of work.

a. Indian Standards:

1. IS: 1786 – 1985 (Reaffirmed 2000), Specification for high strength deformed steel bars and wires for concrete reinforcement

b. American Society for Testing and Materials (ASTM):

1. ASTM A36/A36M - Standard Specification for Carbon Structural Steel
2. ASTM C150 - Standard Specification for Portland Cement
3. ASTM C494 - Standard Specification for Chemical Admixtures for Concrete
4. ISRM - Doc.2, Part 1 "Suggested Method for Rock-bolt Testing".

10.2 SUBMITTALS

I. At least 8 (eight) weeks prior to the commencement of excavation works, the contractor shall submit, to the Client, the details of equipment to be used for testing and installation of Rockbolts / Soil Nails / wiremesh etc.

II. The Client reserves the right to require any additional information deemed necessary to be included in the submitted documents.

III. Test reports of tensile strength tests and pull out tests, routine pullout tests (IS:11309) shall be submitted immediately within 3 hours after the test is carried out.

10.3 GENERAL

I. For the sake of convenience, the terms used in the Chapter are defined as follows:

a. Reinforcement Element is a general term of rockbolts, soil nails, wiremesh etc.

b. Rockbolt/soil nails is a stressed (or tensioned) reinforcement element consisting of a rod, grouted anchorage, and plate and a nut for stressing by giving torque to the nut or for retaining tension applied by direct pull. It is synonymous with “active rock anchor”.

c. Individual rock bolting refers to the installation of reinforcement elements in localized area of in stability or weakness as determined during excavation. It is synonymous with spot bolting.

d. Pattern Rock bolting refers to the installation of reinforcement elements in a regular pattern over the excavation surface.

e. The reinforcing bar steel used shall be from sources as indicated in the Section – Material for construction. Corroded steel bars shall not be used.

II. The following types of reinforcing elements are proposed to be used:

a. SN Bolts: cement grouted.

b. Self-Drilling anchors as Rock bolts/Soil Nails.

III. The type, length, diameter, inclination and pattern of the rockbolts/soil nails shall be as shown on the drawings or as approved by the Client. The Contractor shall provide manufacturer's test certificate for all batches of rockbolts/soil nails supplied. At least 5 samples shall have been tested for tensile strength until failure from each individual batch of rock bolts which is marked with the same manufacturer's identification number. All the results of the tensile test shall comply with the specified data of the manufacturer.

IV. Bearing plates shall conform to IS 2062 and be flat or dished steel plates having minimum dimensions suitable to carry take full load for Rock bolt is installed (At least 1 plate of 200x200x12 for 32mm dia bolts and 1 plate of 150x150x10mm for 25mm dia bolts). The washers to be used shall be bevel or hemispherical.

V. All surfaces of the bearing plates, nuts, washers and wedges, and threads on the projecting ends of rockbolts/soil nails shall be protected and lubricated with rust preventive compound.

VI. Corroded bolts or steel or other elements shall not be used.

VII. When rockbolts/soil nails are used in conjunction with wire mesh, the mesh shall be connected firmly to the bolts by means of extra steel plates and nuts.

VIII. Wire mesh shall not be placed between rock/soil and the bearing plate of the rockbolts/soil nails. Additional plates shall be provided for this purpose.

IX. Couplers may be required for the bolts. When coupler is used, the threading in the bar shall not reduce the effective diameter of bar. Coupler itself should be able to transfer at least 125 % of the yield load of the bar. Couplers shall not be permitted for rock bolts/soil nails less than 4m in length.

X. Minimum one PVC centralizer per rock bolt/soil nail shall be provided. In long rock bolts/soil nail, one centralizer at every 6m shall be provided along the length of the bolt.

10.4 TESTING AND MONITORING OF ROCKBOLTS / ANCHORS / SOIL NAILS

I. The contractor shall furnish at least two sets of testing equipment including hydraulic jacks, fixing device, hydraulic pump with pressure gauge / manometer, extensometer and all necessary accessories. The testing equipment shall be capable of stressing the largest diameter bolt to the yield stress of the bolt.

a. Proof Tests

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

2. Specific deviations from the ISRM suggested method shall be approved by the Client.

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

4. For each type of rock bolt/soil nail submitted information shall comprise:

a. type of bolts

b. testing equipment

c. location and installation records

d. Applied testing loads and records of deformation

e. Otherwise the evaluation of test results as specified in ISRM's document

f. Interpretation and suggested action for failed pull-out tests

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

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

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

8. The maximum load to be applied shall be the bolt´s yield load or as otherwise approved by the Client.

b. Grout mortar: Prior to acceptance tests of rock bolts/soil nails, tests with available cements and sands shall be carried out to determine an appropriate mix design to achieve the specified strength and a proper workability in association with the grouting equipment used. Additives will be used to improve workability. The grout mortar shall be tested on cubes 5x5x5 cm. The cubes shall be cured in water. Five numbers of cubes shall be prepared for each compressive strength test. The resultant strength is the average evaluated from the three remaining values after elimination of the highest and the lowest. During construction, cube sample shall be taken weekly at each five bolts drivage from the grouting hose at the nozzle. Preparation and evaluation shall follow the procedure as described above.

c. If any rockbolt/soil nail fails due to improper workmanship or defect in materials or due to any reason whatsoever, the Client may order a test on all adjacent rockbolts/soil nails and all rockbolts/soil nails so failing shall be rejected, replaced and retested.

d. The bolts and anchors shall be checked for their straightness Tolerance with + 1 mm.

e. The pullout trials shall be conducted in conformity with IS: 11309.

f. Further sampling and testing for quality control will be got done as directed by the Client at contractor’s cost.

10.5 DRILLING HOLES & PREPARATION FOR INSTALLATION

I. Holes for rockbolts/soil nail shall be drilled as specified herein and in accordance with the provisions set out in Section of “Drilling and Grouting”

II. The minimum diameter of each hole shall be as specified below or as directed by Client:

a. Rock Bolt/Soil Nail of 25mm dia: Hole dia 45mm with coupler and 38mm without coupler

b. Rock Bolt/Soil Nail of 32mm dia: Hole dia 64mm with coupler and 50mm without coupler

III. The length of drill hole shall be such as to receive the specified rockbolt/soil nail and to provide for its satisfactory anchorage.

IV. After drilling, each hole in compact, 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 tend to swell or are interspersed with clay filled fissure shall be cleaned with compressed air only. The compressed air shall not contain any oil or other material preventing the bond.

V. Prior to installing the rock bolts/soil nails, which will be stressed, the rock/soil surface adjacent to the hole shall be prepared for the bearing plate. Only bevel washers shall be used which shall be placed between the bearing plate and the nut, or dished bearing plate and hemispherical washer used to ensure uniform bearing.

VI. If a rock bolt/soil nail is not installed immediately after drilling the hole, the hole shall be washed and cleaned as stipulated above, immediately prior to installing the rockbolt/soil nail.

VII. Fresh holes, as directed by the Client, shall be drilled by the contractor at his expense to substitute such holes as have been drilled out of place or alignment.

VIII. The rock surface around the drilled holes to receive the bearing plate shall be chipped smooth or be covered with a smooth quickset cement pad.

IX. All bolts within 10 m of a blasting operation shall be retightened to the specified torque within 4 hours after each blast. If it is found that any bolt does not take the required torque without anchorage slip, a new bolt shall be installed in the immediate vicinity of the unsatisfactory bolt.

10.6 INSTALLATION RECORDS

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

10.7 ROCK BOLTS / SOIL NAILS CEMENT GROUTED (SN BOLT)

I. Rockbolts/soil nails shall consist of deformed steel bar of 25 mm or 32 mm Ø (Grade Fe-500D conforming to IS 1786). Each bolt shall have one end threaded with a coarse thread over a length of 200 mm.

II. Anchor bars/anchor bolts shall be thoroughly cleaned before being placed in the drill hole. The hole shall be filled with grout constituting 1:1 cement/sand mix with low water cement ratio, by inserting the grout hose to the full depth of the hole and withdrawing as the grout is pumped in. The nozzle shall be kept buried in the grout as the pipe is withdrawn so that air is displaced as the hole is filled. The bolt is then pushed into the hole. Admixtures for fast setting and low shrinkage may also be required.

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

IV. The nut of the grouted rock bolts shall be tightened not later than 12 hours after installation to achieve a force at the anchor plate of approx. 20 KN. This force shall be applied by a calibrated torque wrench.

10.8 SELF DRILLING ROCK BOLTS / SOIL NAILS

I. This is a high-grade (Yield load more than equal to 230KN) hollow core Seamless steel bar with continuous threaded surface for mechanical coupling. In addition to hollow core Seamless steel bar, other parts of the assembly consists of Hexagonal nut, bearing plate, extension couplings and sacrificial drill bit. Before and during installation, thread ends will be kept cleaned to allow hex nut and coupler threadability. Construction and drilling shall be as per manufacturers guidelines.

II. SDA Bolts shall have outer dia of minimum 32mm and inner diameter less than equal to 18mm. Length of rod to be procured shall be decided in agreement with the Client.

III. Bearing plates shall allow articulation of 5 to 7 degrees in all directions.

IV. Drill bit to be used shall be selected according to installed length of bolt, geology and size of bolt.

V. Couplers and Nuts shall exceed the tensile strength of bars by minimum 20%.

VI. The bolt shall be grouted according to manufacturer’s guideline (to a minimum pressure of 6 bars) with manufacturer’s grout material supplied along with bolt. Alternatively, grout mix (M-35 grade) may be prepared using OPC 53 cement and sand having maximum particle size of less than 0.3mm. Grout mix shall have a water cement ratio less than 0.4 and shall contain PC based super plasticizer (Minimum 2%) and expanding plasticizer (allowing upto 3.5% expansion in neat cement) from reputed manufacturer. Admixtures containing chlorides and alkali shall not be used. Face of the Bolts shall be sealed off with GP2 or Similar rapid setting grout to prevent grout leakage during build-up of pressure.

VII. All accessories of self-drilling bolts shall be suited to the main anchor rod type and shall be procured from original manufacturer of the bolt.

10.9 WIRE MESH AND MESH ANCHORS

I. Welded wire mesh shall be installed in surface as reinforcement for shotcrete, usually in combination with rockbolts/soil nails.

II. Welded wire mesh shall conform to the requirements of IS: 1566. The fabric shall have a minimum square mesh of 150x150x6, made of wires having yield strength not less than 500 Mpa and diameter 6 mm or as directed by client.

III. Where possible, the welded wire mesh shall be placed at the same time as rockbolts/soil nails are installed. It shall not be placed between the rock/soil surfaces and bearing plates of rockbolts/soil nails but shall be placed over the heads of rockbolts/soil nails and fastened to them by separate plates and nuts. Sufficient intermediate mesh anchors, or if directed by the Client, additional rockbolts/soil nails, shall be placed to ensure that the mesh is drawn close to the excavated surface so that when shotcrete is applied subsequently, the mesh neither sags nor vibrates excessively and impairs the effectiveness of the shotcrete.

IV. In case the welded wire mesh is placed at such locations where rockbolts/soil nails have not been provided, wire mesh anchors of a type acceptable to the Client shall be used to secure the edges of wire mesh tight to the rock/soil surface to provide anchorage at overlaps and to provide intermediate support. The wire mesh anchors shall have a minimum length of 450 mm.

V. The use of wooden pegs and pins for fastening the wire mesh to the rock/soil surface will not be permitted.

VI. Welded wire mesh shall be firmly stretched between the rockbolts/soil nails. Care shall be taken to ensure that air pockets are not formed behind the wire mesh, when used as reinforcement for shotcrete. Overlaps in the wire mesh shall not be less than 300mm.

11. SHOTCRETE

11.1 SCOPE OF WORK

I. The specifications described herein under related to the work, which includes all labour, materials, equipment and services required for the shotcrete work (plain and fiber reinforced) to be carried out by the contractor under this Contract.

II. All shotcrete work shall be carried out in accordance with guidelines specified in this section. The shotcrete work shall be performed to the dimensions as shown on the drawings or as otherwise directed by the Client.

III. Compressive strength of shotcrete shall be met by compression testing of cylindrical cores extracted for the slope surfaces. The sample prepared for testing shall have a 100mm length and 100mm diameter (Equivalent of a cube).

IV. The approval given by the Client to the Contractor’s equipment of their operation or of any construction methods shall not relieve the contractor of his full responsibility for the proper and safe execution of Shotcrete work or any obligations under this Contract.

11.2 SUBMITTALS

I. Within 28 days from the commencement date, but before procuring or mobilizing to the site, the equipment, the Contractor shall submit to the Client, updated and detailed plans and descriptions, of the following:

a. Batching and Mixing Equipment

1. Description and details of the equipment, which the Contractor intends to use to determine and control the quantity of shotcrete ingredients and mixing thereof into uniform mixture. This shall also include automatic dosing equipment for various admixtures. All equipments shall be capable of monitoring and recording the dosage during production process.

b. Placing Equipment

1. Full details, of the equipment to be used for placement of shotcrete (Robotic Shotcrete machine) and details of standby equipment.

c. Details of methods and equipment which the Contractor proposes to use to control the temperature of aggregates and water during extreme hot and cold weather conditions.

II. At least 28 days in advance of any shotcrete work being carried out on the site, the contractor shall submit, to the Client the following:

a. Notifications of any admixture and Pozzolana, which the contractor proposes to use, manufacturers thereof and information about the chemical names of the principal ingredients and the effect of under or over dosage.

b. Description and details of methods which the contractor proposes to adopt for Shotcrete.

III. The Client reserves the right to require any additional information deemed necessary to be included in the submitted documents.

11.3 STANDARDS

I. The Shotcrete materials, production, methods of application, testing and admixtures shall conform to the following latest Indian Standard or, where not covered by these standards, to the equivalent International Standards.

II. Indian Standards

a. IS: 456 Code of Practice for Plain & Reinforced concrete.

b. IS: 269 Specification for ordinary Portland cement.

c. IS: 383 Specification for coarse and fine Aggregates from natural source for concrete.

d. IS: 516 Method of test for Strength of concrete.

e. IS: 9012 Recommended practice for Shotcrete.

f. IS: 2645 Specification for Integral cement water proofing compound.

g. IS: 9103 Concrete Admixtures.

h. IS: 269 Specification for ordinary Portland cement.

i. IS: 15388 Silica-Fumes.

j. IS:7861 Code of practice of extreme weather concreting.

k. IS: 1199 Methods of Sampling and Analysis of Concrete.

III. International Standards have been mentioned at relevant locations in the section.

IV. In case of conflict between the above standards and the specifications given herein, the specifications shall take precedence.

11.4 GENERAL

I. Shotcrete shall be applied by either the wet or dry process as appropriate to the circumstances. All aspects of the application of shotcrete shall be subject to the agreement of the Client.

II. The Contractor shall develop a shotcrete mix and a plan for its production and application. Specifications of constituent materials shall comply with those listed in this. Admixtures shall be compatible with each other and the mix.

III. The shotcrete mix design shall, unless otherwise stated, comply with the characteristic strengths specified by the Designer for early-age and long-term loading.

IV. Contractor's shotcrete expert should be on site at all times to check that the materials and workmanship are consistent with the design intent, and to ensure that ground and groundwater conditions are in accordance with design assumptions. The Contractor shall establish a procedure to respond effectively to changes in ground and groundwater conditions from the design assumptions.

V. The Contractor shall establish and maintain the instrumentation and monitoring required by the design. The Contractor shall establish a procedure that will enable prompt and regular review and effective response to the results from the instrumentation and monitoring. The Client shall be included in the monitoring review procedure.

11.5 DEFINITIONS

I. Shotcrete: Shotcrete for the purpose of this work is defined as wet mix of cement concrete (plain) applied from a spray nozzle by mean of compressed air. The Client may, in exceptional cases, allow use of dry mix for plain shotcrete. Shotcrete shall contain approved additives like Accelerator, Superplasticizer, retarder, stabilizer, Pumpability improving additive or curing agents suitable to attain desired properties as mentioned in these specifications and site conditions.

II. Rebound: Rebound is defined as the portion of shotcrete mix or any of its constituents, which bounces away from a surface against which it is being projected.

11.6 MATERIAL FOR SHOTCRETE

I. Material for shotcrete shall comprise cement, aggregates, water and approved admixtures, micro-silica/Silica fume as specified herein.

II. Cement:

a. Cement used shall be ordinary Portland cement of 53/53S grade.

b. For M30 Grade Shotcrete: Minimum OPC 53/53S content will not be less than 385 Kg/cum. Minimum 15 Kg/cum / Micro-silica/ Silica Fume will be added to enhance mix durability and reduce life cycle cost of shotcrete.

c. Preferably cement fineness shall not be less than 275 m2/kg for OPC 53 and 370 m2/kg for OPC 53S.

d. Maximum temperature of the cement in the mixing plant silos should be limited to 70°C and it should not exceed 50°C at the time of mixing. Cement should be preferably purchased in bulk and fresh cement shall be stored in a suitable silo.

III. Aggregates:

a. All fine and coarse aggregates to be used shall be supplied from approved sources, which shall not be changed without permission in writing from the Client. Aggregates shall conform to the requirements of IS:383.

b. The aggregate shall be checked for chemical reactions, such as alkali–aggregate reaction, with latent hydraulic binders and admixtures, especially accelerators.

c. The aggregates size for shotcrete shall not exceed 10 mm. The proportion of aggregate larger than 8mm in size should not exceed 10%. The aggregate shall be well graded, and no fraction shall constitute more than 25 % of the total. The contents of the crushed and non-cubical material under 0.1mm shall not exceed 8 %.

d. Acceptance of source by Client shall not be construed as constituting the acceptance of all aggregates to be taken from that source or grading of aggregates to be in conformance with contract.

e. It is the responsibility of the CONTRACTOR to choose the most suitable grading for the process and materials available from the range given in table below. The grain size distribution of aggregates shall be within ±2% for each sieve size as shown below:

Standard Sieve	Sieve Size [mm]	Passing in %
IS	10.0	100
IS	8.0	90-100
IS	4.0	73-100
IS	2.0	55-90

IS	1.0	37-72
IS	0.50	22-50
IS	0.25	11-26

f. Testing

1. The flexural toughness of steel fiber shotcrete shall be tested according to ASTM C 1018-89. Field suitability tests shall be performed for different quantities of steel Fiber in the shotcrete. During construction, the flexural toughness shall be measured for every 200m3 of steel Fiber shotcrete installed.

2. The actual fiber content of steel fiber shotcrete shall be tested by washing out and weighing the steel fibers from a 10l container of fresh shotcrete. Three tests shall be performed for every 100m3 of steel fiber shotcrete applied.

IV. Air used for spraying shotcrete shall be clean and free of oil.

V. Water used for mixing shall comply with IS-456. Water to cement ratio shall be less than 0.43.

VI. Admixtures: Admixtures conforming to IS:9103 shall be used to develop quick set and high early strength, to ensure good workability, low pumping pressure, adequate slump retention and low rebound as approved by the Client, conforming to the requirements of the relevant standards. The proportion of admixtures shall be kept less than 10-12% of the weight of cement or as determined by testing prior to any shotcrete work.

a. General

1. Technical criteria, approved documentation, test reports and test certificates shall be furnished to the CLIENT for approval.

2. Admixtures shall be stored under the conditions specified and recommended by the manufacturers. The related storage Specifications and recommendations shall be presented to the CLIENT before approval of such admixtures.

3. The manufacturer’s safety instructions shall be observed Admixtures shall be free of chlorides such that the percentage of chlorides shall not exceed 0.1% by weight.

4. The required characteristic values and consistency of delivery to the site shall be agreed in writing with the manufacturer of each admixture before commencement of concrete spraying.

5. Written confirmation of the stability of admixtures with the mix water shall be provided prior to commencement of site trials.

6. The content of SO3 shall not exceed 4.8% by weight of total binder content.

b. Accelerators

1. Accelerators are used to produce a fast set and to get sufficient early strength development. Accelerating admixtures shall be compatible with the cement used.

   The compatibility shall be tested in the laboratory by the Manufacturer and verified by the CONTRACTOR in field suitability tests to achieve the required properties for early and final strength.

2. The accelerator must mix with the concrete in the nozzle and begin the hardening immediately after the concrete hits the rock.

3. Only liquid alkali-free accelerators (pH 2.0 to 8.0 and having alkali content less than 1% by weight Na2O equivalent) shall be used. Additives based on Lingo sulphates (P agents) shall not be used due to retarding and reduced early strength.

4. The accelerators shall be added at the nozzle and only the minimum quantity of accelerator necessary shall be permitted in normal concrete spraying operations. The quantity shall be determined by site trials, subject to maximum dosage of 7% by weight of cementitious materials. Higher dosages of upto 8% accelerator can be considered subject to establishing the effect of the dosage rate on the medium and long-term strength development on the in-situ concrete. At no stage in the strength development should the strength of the accelerated mix drop below 0.7 times the strength of the unaccelerated concrete mix.

5. Testing of accelerators and the base mix with respect to acceleration of setting, early strength and decrease of strength at a later age (28 days), shall take place in due time before commencement of concrete spraying.

6. Laboratory testing of the selected type(s) of accelerator shall be carried out at dosages as recommended by the manufacturer, to establish the variability of the above properties with dosage. Accelerators showing excessive variability with dosage will not be permitted.

7. Accelerators shall be selected so that, at the dosage chosen for use in the Works, the characteristic compressive strength of any shotcrete at an age of 28 days can be achieved. Compliance with this clause shall be demonstrated by site trials.

8. Accelerators delivered to site shall be tested at least once every two months for their reaction with the Portland cement used, with particular reference to the setting behavior and strength decrease after 28 days. The stability of accelerators during storage shall be visually inspected at similar intervals. Storage times and working temperature ranges shall be in accordance with the manufacturer’s recommendations. The manufacturer’s safety instructions shall be observed.

c. Super Plasticizers and retarders

1. Used to reduce the quantity of the mixing water and to improve the pumpability of the concrete. The effects and optimum dosages shall be determined by site trials.

2. The above-mentioned desired properties shall only be attained through superplasticizers.

3. Shall be added at the batching plant to keep the shotcrete mix workable during transportation and to ensure good pumpability to an acceptable low water cement ratio.

4. The influence of the superplasticizers and retarders within the concrete mix shall be checked regularly for setting time, water reduction, and development of strength. These values shall be compared with the results from the pre-commencement trials.

5. Compatibility of superplasticizers and retarders with Portland cements, latent hydraulic binders and accelerators shall be verified by observation and site trials. Traditional retarders shall not be allowed.

6. Hydration control admixtures

7. Hydration control admixtures may be used to control the hydration of the mix as appropriate to expedite construction of the Works. The effects and optimum dosages of hydration control admixtures shall be determined by site trials.

8. Compatibility of hydration control admixtures with Portland cements, latent hydraulic binders and accelerators shall be verified by observation and site trials. Hydration control admixtures shall be used in accordance with the manufacturer's instructions.

VII. Additives: Micro-silica or silica fume

a. Micro-Silica or Silica fume shall conform to ASTM C1240 / IS-15388. Contractor shall submit MTC from original manufacturer. Manufacturer shall furnish evidence of factory production control systems.

b. The performance of the shotcrete mix with optimum dosage of additives shall be determined by field suitability tests. Testing of Silica fume shall be carried out by contractor before or anytime during its usage at discretion of Client.

VIII. Curing agents

a. External curing agents and internal curing admixtures shall be allowed to maximize hydration of the cement by reducing uncontrolled water evaporation.

b. The curing agent selected should not affect the bond of further layers/coatings or be easy to remove. Solvent based curing agents should be avoided

c. External curing agents are sprayed onto the surface of the shotcrete shortly after it has been applied. When set accelerators are used, an external curing agent should be applied within 15 minutes after the end of spraying. When no accelerators are used it should be applied within 30 minutes.

d. Internal curing admixtures are special admixtures added to the mix (see 4.6). Compatibility of curing agents with cements, hydraulic binders, accelerators and other admixtures should be verified in site trials. Particular care must be taken to ensure adequate mixing when used in the dry-mix process.

11.7 MIX DESIGN AND PROPORTIONING

I. The type of shotcrete to be used in a particular location shall be as per drawings and as directed by the Client.

II. The mix proportions of cement, aggregates, and permitted admixtures in each class shall be determined by the Contractor satisfying the requirements given in Table no. 1 below and shall be subject to the approval of the Client. The mixes shall be such as to permit placement without excessive rebound and segregation.

Table-1

28-day Characteristic compressive strength of Cylindrical cores (after applying a factor of 0.85 for In-Situ coring effects)	**Aggregate size/grading**	**Cementations content, (C) kg/M3**	**Water cement ratio**
30 MPa (Average of 4 consecutive non-overlapping tests)	Size grading: Dmax ≤10 mm, Aggregate flattening coefficient ≤20.	Refer para 16.6	≤ 0.43

III. The water content of the mixes shall be limited to prevent sloughing. The water: cement ratio of fresh shotcrete in place shall be less than 0.43.

IV. Slump of mix shall be kept less than 200mm, as high value of slump will affect fiber distribution in the shotcrete.

V. The Mixes shall be such that aggregate gradation and cement content after placing are as those obtained from samples taken from test panels produced from approved trial mixes. All constituents shall be uniformly dispersed throughout the mix.

VI. Proportioning of aggregates and cement shall be only by weigh batching.

VII. Moisture content of the combined aggregate at the time of mixing with cement shall not exceed 6 % (Six percent) by weight of the over dry aggregate.

VIII. Mixed material shall be used within 90 minutes after addition of water to cement. This period may be extended by the use of hydration control admixtures, subject to the approval of the Client.

IX. Approved mix proportions may have to be varied, during execution stage, to obtain required strength of shotcrete, to maintain rebound to the minimum and to meet other requirements of Contract. The Contractor shall notify to the Client of all variations to the mixes.

X. The Contractor shall carry out all field tests before hand and then propose mix design for shotcrete to meet the requirements of the specifications for prior approval of the Client. The quantities of super plasticizers may be adjusted to compensate the slump loss because of fiber. The mix design shall provide the following details for one cubic meter of Shotcrete.

a. Ordinary Portland Cement Kg

b. Microsilica Kg

c. W/C Ratio

d. Aggregate

1. Natural fine aggregate Size Kg

2. Natural coarse aggregate Size Kg

3. Crushed fine aggregate Size Kg

4. Crushed coarse aggregate Size Kg

e. Super Plasticizer Agent Kg

f. Retarder or Stabiiser Kg

g. Internal curing Kg

h. Pumpability iimprover Kg

i. Alkali free Accelerator Kg

j. Fibre (Aspec Ratio/Length) Kg

k. Slump mm

l. Density (Wet) Kg/cum

11.8 EQUIPMENT

I. Details of all equipment to be used shall be made available to the Client prior to commencement of site trials.

II. The equipment selected and approved by the Client will be capable of maintaining the ratio of concrete and accelerator as selected from the trials and approved by the Client. The actual ratio of accelerator to concrete selected shall be identified at the nozzle and take into account the filling efficiency of the equipment and the efficiency of the accelerator dosage equipment to overcome the air and concrete pressure at the nozzle while spraying at typical outputs and air flows. Contractor shall provide shotcrete machine data in digital format after every cycle whenever required by the Client.

III. Equipment shall be thoroughly cleaned at least once per shift. The spray nozzle shall be checked for wear and where necessary replaced.

IV. Transport pipes consisting of hoses and pipes shall be designed to convey the concrete efficiently and without leakage or blockage. The transport pipes shall have uniform diameter appropriate to the mix characteristics determined by site trials and be free of any dents or kinks between the shotcrete machine and the nozzle.

V. Working area for sprayed concreting shall be well illuminated and ventilated. Dust pollution shall be minimized by choice of appropriate equipment and by means of additional ventilation, water sprays, and by maintaining equipment in good order. Protective clothing and dust masks shall be provided for and used by all persons present during spraying.

VI. The equipment shall allow for air and water in any combination to be available for preparation of surfaces and/or cleaning of finished work.

VII. Recipe of mix shall be entered into PLC control prior to spraying.

VIII. A boom mounting or similar device shall be provided for the spray nozzle unless it can be demonstrated to the Client that the use of such equipment is impractical.

IX. In particular, the spray nozzle shall be kept as perpendicular as possible to the surface and care shall be taken to achieve a regular properly compacted coating of the correct thickness.

X. The shotcrete shall emerge from the nozzle in a steady uninterrupted flow. Should the flow become intermittent for any cause, the nozzleman shall direct it away from the work until it again becomes constant.

XI. The thickness and position of the shotcrete shall be defined by screed boards, lattice arches, guide wires, depth pins, lasers or other means.

XII. The site trials shall employ the equipment which will be used in the Works and the constituent materials shall be fully representative of those to be used in the Works. A clean, dry mixer shall be used, and the first batch discarded.

XIII. The equipment proposed for the application of concrete in the Works shall be used for the trial. The trial will establish whether the selected equipment is capable of efficiently mixing concrete, accelerator and air at the nozzle, and be capable of positioning the nozzle at a suitable distance and orientation to the surface geometry of the structure to which the concrete is to be applied.

XIV. During the trials the Contractor will establish the volume of air required to give adequate compaction of the material using the nozzle and conveyance lines selected for the Works. If the delivery equipment or nozzles are to be changed during the course of the works, the volume of air required will need to be verified again. The equipment will be maintained adequately, to ensure that the required volume of air can be maintained while spraying. Air pressure can only be used as a control if the air delivery system is not altered from the original verification trial. No additional taps or restrictions will be permitted to be added into the system without repeating the verification trials.

XV. The static compressed air capacity measured at the shotcrete pump shall be according to the manufacturer’s recommendations and generally as per EFNARC guidelines G 8.3.2 for wet process and G 8.3.3 for dry process.

11.9 QUALITY CONTROL AND TESTING

I. The Contractor shall enable the Client access to the shotcrete Works at all times and shall allow the Client access to inspect the excavated ground surface prior to spraying if requested.

II. The quality control and testing of shotcrete (Plain) shall be carried out by the contractor in the presence of Client. Tests for Field suitability (to determine mix design) and In-situ suitability (to control quality) shall be carried out separately. Field suitability tests shall be carried out on minimum three test panels for initial establishment of suitable range of accelerator/superplasticizer dosage (All types of Shotcrete). The pressure at which the shotcrete shall be applied to the test panels shall be the same as will be used in actual works at the place of application. Mechanical rebound hammers shall not be used to obtain indirect compressive strength of shotcrete.

a. Control of Fresh shotcrete:

1. Water/Cement ratio: Daily by calculation or test method.

2. Aggregate gradation: Weekly by standard sieving.

3. Accelerator/Superplasticizer: Daily through record of quantity added.

4. Slump: For Each batch separately, measured any time during application, at the pump and should conform within 25mm of the target slump range established earlier and approved by the Client.

5. Early (0-24hrs) strength development: Strength results shall conform to Class J2 as per EN-144887-1 unless specified otherwise in the design drawings. In-situ test shall be carried out every 250m2 of shotcrete applied subject to minimum 2 test per month in accordance with EN 14488-2 (Strength up to 1.0 N/mm2 shall be determined by Penetrometer and in the range between 1.0 and 16 N/mm2 shall be determined using the HILTI shot bolt method).

b. Control of hardened shotcrete:

1. In-situ strength shall be carried out on shotcrete applied at the slope face and shall be determined by crushing of cylindrical shotcrete specimens. Samples shall be collected with core drilling equipment from In-situ shotcrete applied on slopes/or from test panels as the case may be, after lapse of 1 day. Cores for strength testing shall be obtained from random locations. The cores will be visually inspected and the dimensions and comments regarding the quality of the cores will be recorded. The cores will be free from lamination. No sets of cores to be tested at any given age shall come from the same panel/In-situ location. Sets of cores to be tested at different age may come from the same panel/In-situ location. For each test at least one spare specimen shall be provided. The cores for determination of strength shall be cured in temperature-controlled water until 3 days before further testing. The specimens shall have a diameter of 100mm and be cut to a height of 100mm. Where the nominal required shotcrete thickness is less than 100 mm, the cores for the compressive strength testing shall be taken from areas where the actual thickness is greater than 100 mm. Alternatively additional shotcrete thickness shall be applied in selected areas agreed by the Client for subsequent coring of test specimens.

2. Further (1-7days) Strength Development: Average strength of 3 cores tested at 3 days and 7 days each shall exceed 12.5MPa and 70% of 28-day strength requirements respectively. The Client may also require the drilling of cores from the test panels perpendicular to the spraying direction.

3. Final strength: 3 cores shall be further tested at 28th day and at completion of 6 month each and the 28-day strength obtained shall exceed 28-day strength requirements mentioned in Table-1 at 11.7.2. Strength results at 6 months shall not be less than 28-day results.

c. Shotcrete thickness: The contractor will be required to undertake confirmatory shotcrete thickness testing of the in-situ shotcrete thickness. The basic test shall consist of 4 nos. drill holes drilled on a 1m² pattern. The average thickness of the 4 holes shall exceed the specified design thickness. If not, the Client shall propose remedial measures and/or further drill testing. All such drill holes shall be subsequently filled back by Non shrink mortar. Nothing extra shall be paid on this account.

d. Bond Strength: Bond strength of shotcrete shall be tested every 1250m2 (in case of Ground strengthening) or min 3 tests (in other cases) of the shotcrete applied in accordance to EN 14488-4. Bond strength between plain shotcrete and fiber reinforced shotcrete shall also be established.

e. Contractor shall keep at site various testing tools like Penetrometer, HILTI shot bolt, Shotcrete core cutter, Test panels etc. along with all spares required as per standards and specification mentioned above. The frequency of testing, test type or the testing method will not be altered without approval of Client. Shotcrete from both the field suitability test panels and the In-situ quality control shall be tested by the Contractor in the presence of Client. Client may ask contractor to undertake further tests for examination purposes.

III. The Contractor shall propose to and agree with the Client trial mixes for the works at least 56 days before their commencement. Excavation shall not be permitted to start until the Field suitability tests have been approved by the Client.

IV. The site trials shall be repeated if the source or quality of any of the materials, mix proportions or placing equipment is to be changed during the course of the Works.

V. Where shotcrete does not comply with the required strength, the Contractor shall execute remedial work which may involve additional shotcrete or replacement in sections where it is safe to do so. The Contractor shall submit to the Client for agreement, a method statement, specification and calculations for remedial work. The Client shall, in the event of repeated failure in Quality Control, require the Contractor to adjust the mix to achieve the required strength.

VI. The Contractor shall keep a record in a form to be agreed with the Client of all tests on shotcrete, which shall be kept on site identifying the tests with the section of work to which they relate.

11.10 PROFICIENCY OF WORKMEN

I. Nozzle men shall have had sufficient previous experience in the application of shotcrete or shall work under the immediate supervision of foreman or instructor having such experience.

II. Each crew shall demonstrate acceptable proficiency in the application of shotcrete to trial areas before being employed on the Works to the agreement of the Client.

III. Subject to the Client's agreement, tests for proficiency may be combined with trial mix tests.

IV. Contractor shall be bound to arrange 2 visits (First visit within a month of start of shotcrete work and second visit after next 6 months) of an expert nozzlemen who has successfully completed EFNARC Nozzleman Certification course in last 5 years at no extra cost to the employer. Each visit shall be arranged for at least 3-4 days giving prior intimation to the Client. The EFNARC certified personnel will check the application of shotcrete and it's quality according to EFNARC guidelines and guide the existing nozzlemen for required improvements to the satisfaction of the Client.

11.11 PLACING OF SHOTCRETE

I. Rock or previously applied shotcrete surfaces to be shotcrete shall be carefully cleaned of all loose material, scale and other contaminations. It may be necessary to use compressed air and a water jet. The surface to receive shotcrete shall be damp but shall not exhibit free water.

II. Where groundwater flow could interfere with the application of shotcrete or cause reduction in the quality of shotcrete the Contractor shall take all action necessary to control groundwater. Such action shall include the channeling of water by means of pipes and chases.

III. The optimum distance between nozzle and surface of application is 1.5 to 2.0 meter. The nozzle shall be positioned at right angles to the surface of application.

IV. For vertical and near-vertical surfaces application shall commence at the bottom and the leading edge of the work shall be maintained at a slope. Downward spraying shall be avoided where possible. The nozzle may be inclined sufficiently to ensure reinforcement is properly embedded.

V. If the design thickness must be applied in more than one layer, then the previous layer must have developed sufficient strength to support the additional layer(s). Wire mesh and other reinforcement shall be embedded in shotcrete as shown on the drawings. Prior to continuation of spraying from a joint or leading-edge position or in any other circumstances where shotcrete has hardened beyond its initial set, loose material shall be removed by jetting with a compressed air lance. Any laitance which has been allowed to take final set shall be removed and cleaned by jetting with air and water.

VI. If more than one layer of reinforcement is used, the second layer shall not be positioned before the first one is embedded and covered with shotcrete. Exemptions are to be approved by the Client.

VII. The temperature of the mix before placing shall not be below 150C and shall not exceed 350C unless special provisions are made. Spraying shall not be undertaken when ambient temperature is below 150C unless special measures can be taken to provide protection against frost until the shotcrete has developed a compressive strength of at least 5 MPa.

VIII. A system of delivery notes shall be maintained to record the date, the time of mixing, mix design number, quantity, delivery point, time of delivery and completion of placing. The delivery notes shall be available to the Client for inspection.

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

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

XI. Measures to establish the thickness of shotcrete shall be set up by the CONTRACTOR and approved by the Client. These may include visual guides installed prior to shotcrete, holes drilled after completion of shotcrete or a full control by laser scanning.

XII. Shotcrete shall be left in its natural finish without further working except as required to trim excess thickness where the shotcrete shall be allowed to stiffen sufficiently before being trimmed with an approved cutting screed.

XIII. If deemed necessary by the Client, curing of the shotcrete shall be performed by water spraying or other appropriate measures subject to the approval of the Client in the first 48 hours after application.

XIV. Major ground water seepages shall be drained off or sealed off by grouting prior to spraying or after application of a first sealing layer.

XV. Nozzle men shall be trained in the correct application of shotcrete.

XVI. Full personal protection equipment to protect the nozzle man from eye and skin contact and inhalation of shotcrete and/or admixtures shall be provided. The admixture manufacturer's precautions and actions for accidental contact shall be provided and adhered to.

XVII. Before a succeeding layer of shotcrete is placed, the preceding layer shall be checked for defects. Areas of work shall be properly compacted and bonded and free from honeycombing, laminations, dry or sandy patches, voids, sagged or slumped material, rebound, excessive cracking and overspray.

XVIII. Where defects occur, the Contractor shall agree with the Client proposals for the removal of the defective material and replacement by material without defect and the area to be replaced shall in any event be not less than 300mmx300mm at such locations.

XIX. Gloves and necessary protective clothing shall be worn to protect against dermatitis.

11.12 MEASUREMENT AND PAYMENT

I. FOR SURFACE WORKS (SLOPES):

a. Measurement for payment for shotcrete shall be made for the theoretical volume in cum of the shotcrete placed as indicated in drawing or as directed by the Client and shall be paid as per relevant item in the Bill of Quantities (BOQ).

b. No payment shall be made for filling of "overbreak" with shotcrete.

12. REINFORCED SOIL WALL

12.1 Reinforced Soil Wall System Provider

The past experiences and credentials with necessary supporting documents as per the requirement of eligibility criteria mentioned in the EQC shall be submitted to the Client well in advance for approval of the specialized agency for reinforced soil wall work

The reinforced soil wall technology shall have a proven adoption in Indian environment. Documentary proof of adoption of the proposed technology shall be provided for period not less than 15 years. The technology Provider shall have independent third-Party certification by accredited certification body like BBA for walls and abutment**.**

The specialized agency shall have in-house design and manufacturing of soil reinforcing element or shall have a tie up with manufacturers & small shall be ISO 9001:2015,ISO 45001:2018 credited by an internationally accredited organization. The specialized agency shall have inhouse computer controlled tensile testing machine for ensuring quality of soil reinforcement. Reinforced soil structure being a specialized technology, shall furnish design, drawings, method statement,QA plan etc through contractor for approval by the Client and make his own arrangements to secure the supplies and services needed.

12.2 Deleted

12.3 DESIGN OF REINFORCED SOIL STRUCTURE

The design shall ensure internal and external stability of the reinforced soil wall, global stability, external and internal stability under seismic loading as per IS 1893: 2002 and Federal Highway Administration (FHWA) design guidelines (FHWA-NHI-00-043) and BS 8006.

12.3.1 Design Loads

The following loads shall also be considered while designing the Reinforced Soil Wall structures apart from all applicable loads for its tendered use: -

I. Buildings Live load surcharge: 6 t/m2

II. Seismic loads as per (IS 1893 (Part 1): 2002) for Zone IV.

III. Wherever railway loading is to be considered, the design will cater for railway axle load of **25** MT as per IRS standard. Specialized system provider's Specifications shall also be incorporated wherever relevant for design and construction.

IV. The design of reinforced soil slopes should be verified by analyzing the system using geotechnical finite element analysis program like PLAXIS 2D or equivalent. The lateral and vertical deformations, forces in different reinforcement layers predicted by the finite element analyses should be verified against the design requirements.

12.3.2 Design Temperature

For designing the RS wall with geostrips as soil reinforcing elements, the creep reduction factor should be based on up to design temperature of 40°C and durability reduction factor should be based on design temperature of 30°C. In the sub-zero climatic conditions, the geostrips should not get deteriorated. Special care shall be taken for storage of geostrips during cold weather and shall not be kept in open during winter and rainfall.

12.3.3 Slope Stability Analysis

The slope stability shall specifically be checked for global slip failures using design software prior to commencement of all works. The stability analysis shall cater for minimum factor of safety of 1.3 in static and 1.1 in seismic working load condition. The designs shall be checked by performing 2-dimensional analysis using geotechnical finite element program PLAXIS or equivalent. All estimated deformations and reinforcement forces should be lesser than the allowable quantities.

The proof Checking of Design and drawing of reinforced soil steep slope structure as per BS 8006:2010, FHWA NHI-10-024 (2009) and also by performing finite element analysis using geotechnical engineering program or equivalent Software shall be done by IRCON/proof consultant approved by IRCON.

12.4 TECHNICAL SPECIFICATIONS

12.4.1 Reinforced soil backfill

12.4.1.1 Specifications

The reinforced soil backfill shall be a select granular fill having high frictional resistance, low compressibility and free draining. Coarse-grained soils with limited fines adequately satisfy these requirements. Thus, the select granular fill shall not contain fines (passing 75 micron sieve) more than 10%. Co-efficient of uniformity (Cu) of the backfill shall be greater 2 and the peak angle of internal friction should be greater than or equal to 30^0, however the desired friction angle for the reinforced soil wall is 34^0. The plasticity index shall not exceed 6.

The backfill shall also be free from organic or otherwise deleterious materials so as not to cause corrosion of the soil reinforcement and the facia.

Desirable Gradation for Reinforced Soil Fill shall be as given below

Sieve Size	Percentage Finer (in %)
75mm	100
4.75 mm	85 - 100
425 micron	60 - 90

75 micron	< 10

The select backfill shall be compacted to ensure achieving peak angle of friction not lower than 32° as established from test as per Annexure C, BS 8006. For design, effective cohesion of backfill shall be taken as zero.

The compacted layer should not be more than 200mm thick. The compaction of backfill material shall be 95% of maximum dry density obtained from modified Proctor compaction test performed as per IS 2720 (Part-8).

12.4.1.2 Tests for Reinforced and Retained Fill

To ascertain the suitability of the fill, samples should be drawn from the borrow area by drawing a grid of 25 m c/c to full depth, logging and sampling for ascertaining suitability of the borrow material as per MORTH 2013 Specifications. Following tests shall be carried out as per Indian Standards.

1. Sieve Analysis - IS: 2720 Part - 2 tests per 3000 cu.m. of soil
2. Atterberg Limit Tests- IS: 2720 Part- 5-2 tests per 3000 cu.m. of soil
3. Compaction Tests - IS: 2720 relevant part corresponding to modified as well as Standard Proctor test - 2 tests per 3000 cu.m. of soil
4. Direct Shear Tests - IS: 2720 Part 13 & 39 and IS 13326 Part 1 to ascertain the peak angle of shearing resistance. The tests should be done at 95 percent of Modified Proctor Density at -2 percent of OMC at a frequency of 1 per 3000 cu.m. of fill

   During construction the quality control should be exercised by conducting one set of density test of 3000 sq.m. of compacted area considering the importance of compaction in reinforced soil walls. (Clause 903.2.2 of MORTH 201 3) One set shall consist of 6 tests.

   At the end of each day's operation, the contractor shall shape the last level of backfill as to permit runoff of rainwater away from the structure face.

12.4.2 Reinforcing elements

12.4.2.1 Material Specification

Reinforcing materials made of geosynthetics as per **IS 17372:2020** shall be used for reinforcing the select fill. Geosynthetics in the form of high tenacity high modulus polyester tendons encased within polyethylene sheathing (tensile strength varying from 25KN to 125 KN) shall be used as reinforcing element. High Adherence Geostrips shall be used in top 3 m of RS Structure to generate superior frictional resistance. In addition, galvanized steel strips are also permitted to be used as reinforcing element. The selection of suitable reinforcing element shall be approved by the Client.

The long-term design strength shall be derived as per guidelines given in ISO TR 20432 for design life of 120 years and should be designed to sustain temperature from sub-zero to 40ºC considering following factors.

Tallow = TUTS / RF

RF = RFCR x RFID x RFW x RFCH x FS

Tallow = Allowable tensile strength

TUTS = Ultimate tensile strength (95 % confidence limit)

RF = Reduction factor

RFCR = Reduction factor for creep

RFID = Reduction factor for the effect of installation damage

RFW = Reduction factor for weathering

RFCH = Reduction factor environmental degradation (chemical and biological) at the service temperature

FS = Reduction factor related to the mass of information available and to the production quality

Use of default reduction factors mentioned in codes like FHWA or MoRTH shall not be permitted. The adoption of reduction factors should be strictly based on reliable test data and performance data available with the manufacturer from accredited independent agency or the manufacturer should provide a valid third party accredited certification from BBA (British Board of Agreement) certifying the Reduction Factor (RF) value for their geostrip for temperature range of 0°C - 40°C and design life of 120 years. Manufacturer should have creep test data from independent accredited laboratory for period over 10 years at temperature range of 0°C - 40°C.

12.4.2.1.1 Geosynthetic

The material factors as per the specified design life of reinforced soil wall structure and design temperature for the project, shall be used to determine the long term strength of the geosynthetic reinforcement for design of reinforced soil wall structure. The design life shall be 120 years. The agency should provide independently certified partial material factors to be considered in the design of RS Wall for the geosynthetic reinforcement for design temperature and design life of reinforced soil wall structure.

All quantity control strength of geosynthetics must represent minimum average roll values (MARV) corresponding to 95% confidence limit. Testing of geosynthetic for tensile strength shall be performed in accordance with ISO 10319 for every 20000 linear m of geostrips and test data for each lot of material shall accompany shipments.

The geostrip shall be made from high molecular weight and high tenacity polyester (PET) yarns. The reinforcing elements to be used for the project shall be manufactured at ISO 9001 –2015 and ISO 45001 : 2018 certified production facility only and the system provider should also be ISO 9001:2001 certified. The polyester used for manufacturing geostrips should satisfy the following requirements:

Minimum molecular weight no. > 25000

Maximum carboxyl end group no. (CEG) < 30

Geostrips shall be provided with a protective LLDPE coating to maximize the resistance to hydrolysis and enhance durability and increase survivability during construction and in service.

12.4.2.1.2 Connection

The connection between the reinforcing element and facia shall be as per BS: 8006-2010, suitable for seismic zone IV & V. It is once again reiterated that the connection strength and layout once used in design calculations, shall not be changed during execution, unless approved by the Client. The method statement for construction of fascia shall be approved by the Client. Designers and construction personnel should note that, several failures have occurred due to improper connections and deviation from the connections proposed in the approved designs.

In addition, the method of construction shall have quality assurance plan and tolerances as specified by Clause 3106.6 of MORTH 2013 Specifications.

The RS Wall system may be accepted by the Client if it has certification for material (mainly reinforcement) and connection strength, from accredited laboratories referred in IRC:113-2013 and Table 3, IRC: SP:102.

12.4.2.2 Handling and storage of reinforcing elements

1. Reinforcing elements shall not be subjected to rough handling, shock loading or dropping from a height.

2. Reinforcing elements shall be stored in such a manner to eliminate the possibility of any damage and shall be clearly labelled to identify items with different dimensions and properties.

3. Nylon, rope or padded slings shall be used for lifting galvanized reinforcing elements; bundles of reinforcement shall be lifted with a strong back or with multiple supports to prevent abrasion or excessive bending.

4. Polymeric reinforcing elements shall be properly stored and protected from precipitation, extended ultraviolet radiation, direct sunlight, chemicals that are strong acids or strong bases, flames including welding sparks, temperature in excess of 50°C, and any other environmental condition that may damage the physical property values.

12.4.2.3 Tests for reinforcements

Tests should include Tensile tests, (Stress strain graph), creep test results, tests to determine resistance to mechanical and environmental damage, raw material used and other properties characterizing the reinforcement e.g. Aperture size, wt./sq.m. etc.

The tests performed to evaluate the in-situ/life time performance like resistance to installation damage, environmental damage, creep, type of raw material, carboxyl end group and molecular weight, should also be provided by the supplier. Creep test results for 0°, 20°, 30° and 40°C should be provided. The testing should also include tests to evaluate block to block and block to

reinforcement testing as specified by ASTM tests. The supplier should also clearly indicate the methodology of identifying the reinforcement vis-a-vis its strength in the field.

12.4.3 Facia units

The facia units, which help maintain a near vertical face of the reinforced soil structure, avoid erosion of the fill and provide aesthetic appearance to the reinforced soil, shall be the following:

a) Galvanized welded mesh panel of minimum 8 mm dia. steel bars with coir non-woven geotextile. Minimum diameter of the bars used for the facing shall be 8mm. The galvanization shall not be less than 610 grams/ sqm on the surface of the steel bars .

   The type and shape of the facia units to be finally adopted shall be subject to approval by the Client.

   The RS Wall system may be accepted by the Client if it has certification for material (mainly reinforcement) and connection strength, from accredited laboratories referred in IRC:113-2013 and Table 3, IRC:SP:102.

12.4.3.1 Wire Material

Tensile strength: The wire used for the manufacture of Mesh shall have a tensile strength minimum 350 N/mm2 in accordance with IS 280. Wire tolerances (Table 1) shall be in accordance with IS 16014:2018 (Class T1).

Elongation: Elongation shall not be less than 10%, in accordance with IS 16014:2018 and MoRTH(Fifth Revision) Clause 3100. Test must be carried out on a sample at least 20 cm long.

Metallic Coating: The wire shall have minimum quantities of Zn alloy shown at Table 1 in accordance with IS 4826:1979. The adhesion of the metallic coating to the wire shall be such that, when the wire is wrapped ten turns around a mandrel having four times the diameter of the wire, it does not flake or crack when rubbing it with the bare fingers in accordance with IS 4826:1979.

The coating shall ensure safety against deterioration for design life of 120 years.

12.4.3.2 Fill material in face of construction

For slope angle > 70 Deg. with horizontal, dressed boulders of Size 125mm to 200mm shall be used in facia.

12.4.4 Soil Nail/Self Drilling Anchors

12.4.4.1 Material specification

Soil nails or self-drilling anchors must be designed for mechanically connecting the soil reinforcement to form composite or hybrid structure in case of non-availability of adequate space behind facia for providing reinforcement. The grout shall be made of OPC grade 53 with suitable admixtures. The soil nail/SDA, nuts, bearing plates and couplers shall be galvanised and epoxy coated (combi coat corrosion protection).

Load transfer mechanism between the soil reinforcing geostrip and soil nail shall be direct and mechanical, comprising of either loops or hooks with rotational flexibility in both horizontal and vertical planes for 100% load transfer from the geostrip to the soil nail.

Drilling shall be carried out by suitable equipment. The soil nail/SDA shall be made of yield strength of min. 670 N/mm2. The soil nail/SDA rod shall be continuously threaded. For convenience of installation, appropriate arrangement (coupler) shall be made to connect two smaller lengths of soil nail/SDA to achieve the required length.

Length of Soil Nails or SDA Anchor shall be validated on the basis of actual pull out strength obtained at site.

12.4.4.2 Installation guideline

1) The soil nail/SDA is driven in the required position with help of sacrificial drill bit at the bottom of the anchor bar which facilitates in drilling the hole. The diameter, length and spacing of soil nail/SDA shall be as specified. Additional/reduced length or spacing of anchoring/nailing shall be carried out as per site condition and as directed by the Client.

2) The grout is pumped through the hollow bar during the drilling process. Grouting shall be done by using OPC grade 53 along with addition of suitable admixture. Mixing shall be done along with potable water so as to form the cementitious paste.

3) The base plates of size 200mm x200mm x 8 mm shall be placed at slope surface for tightening the nuts.

4) The fascia (if applicable) shall be installed in front and connected to the steel rods with base plate and nuts.

Further specifications on soil nails and rock bolts refer to Chapter 9.

12.4.5 Drainage Layer

12.4.5.1 Material Specification

The drainage provision shall be strictly followed as per the approved working drawing. The retained fill shall have a suitably designed drainage bay and associated drainage system to allow for free drainage of the reinforced fill. The minimum drainage gallery width just behind the facing units shall be 600mm with well – graded crushed aggregate (materials of 19.5mm to 9.1mm size as per IS: 383). The desirable gradation of the aggregate used in the drainage layer is indicated in the table below. Besides meeting gradation requirements, it should be ensured that the aggregates are not friable, flaky, elongated and are sound in strength. Relevant tests as per MORTH 2013 specifications may be used to judge the suitability of the material used in the drainage layer.

Sieve Opening, mm	Percentage Finer
37.50	90-100
20.00	80-100

12.50 0-20

Alternatively, geo composite conforming to IRC 34:2011 which ensure adequate drainage may be provided. Specifications for Geo-composite should be as recommended in MORTH Specifications2013 Tables 700-9 and 700-10.

The main collection drain pipe just behind the precast facing, if used, shall be a minimum of 150 mm in diameter. The secondary collection drainage pipes should be sloped a minimum of two percent to provide gravity flow into the main collection drainpipe. Drainage laterals shall be spaced at a maximum 15 meters spacing along the wall face. The drainage collection pipe shall be a perforated or slotted, PVC or corrugated HDPE pipe. The drainage pipes shall be wrapped with geotextile.

12.4.6 Geotextile Type III as filter media behind RS Wall and around perforated pipes

Geotextile Type III shall be as per MoRTH (Fifth Revision) Clause 700.

The nonwoven needle punched, or any equivalent geotextile shall be used. The geotextile shall be made of 100% Polypropylene manufactured through machine made process of needle punching techniques. The mean Values of Geotextile shall be as shown in table below, referred from Table 700-1 and 700-3 in MoRTH Clause 702.

PROPERTIES:	Mean Values	Test Method
Mechanical:		
Tensile Strength	7 kN/m	ASTM 4595
Elongation at maximum load	> 50 %	ASTM 4595
Grab Tensile Strength	500 N	ASTM D4632
Grab Elongation	>55 %	ASTM D4632
Trapezoidal Tear Strength	180 N	ASTM D4533
CBR Puncture Strength	1200 N	ASTM D6241
Mullen Burst Strength	950 N	ASTM D3786
Hydraulic:		
Apparent Opening Size, AOS90	120 micron	ASTM D4751
Permittivity	0.5 Sec-1	ASTM D 4491
Physical:		
Mass per Unit Area	150 g/sq.m	ASTM D5261

12.4.7 Geosynthetic Clay Liner (GCL)

The berms,if any, in the Reinforced Soil Wall, slope shall be covered with one layer of Geosynthetic Clay Liner and 100 mm thick Plain Cement Concrete (PCC) of M-15 grade to mitigate ingress of any water into the subsequent tier of Reinforced Soil Wall/ slope. Provision for drainage on the berms shall also be provided.

The specification of GCL shall be as under:

SPECIFICATION FOR GEOSYNTHETIC CLAY LINER			
MATERIAL PROPERTY	**TEST METHOD**	**TEST FREQUENCY (ft^2/m^2)**	**REQUIRED VALUES**
Bentonite Swell Index[1]	ASTM D 5890	1 per 50 tonnes	24 mL/2g min
Bentonite Fluid Loss[1]	**ASTM D 5891**	**1 per 50 tonnes**	**18 mL max**
Bentonite Mass/Area[2]	ASTM D 5993	40,000ft^2 (4,000m^3)	0.75 lb/ft^2(3.6kg/m^2)min
GCL Tensile Strength[3]	**ASTM D 6768**	**200,000ft^2(20,000m^2)**	**30lb/in(53N/cm)MARV**
GCL Peel Strength[3]	ASTM D 6496	40,000ft^2 (4,000m^2)	1 lb/in (1.75 N/cm) min
GCL Index Flux[4]	**ASTM D 5887**	**Weekly**	**1x 10^8 m^3/m^2/sec max**
GCL Hydraullic Conductivity[4]	ASTM D 5887	Weekly	5x10^9 cm/sec max
GCL Hydrated Internal Shear Strength[3]	**ASTM D 5321** **ASTM D 6243**	**Periodic**	**150 psf (7.2kPa) typical**

12.5 CONSTRUCTION REQUIREMENTS

The construction of Reinforced Soil Structures shall be carried out in accordance with the specifications and in conformity with the lines, grades, design and dimensions shown on the approved drawings.

12.5.1 Excavation

The plan area of the of Reinforced Soil Structures shall be excavated in accordance with the requirements of General and Special Specifications and in reasonably close conformity to the limits and to the lines and grades during construction stages as shown on the approved drawings. The contractor shall take precautions to minimise over- excavation. Excavation support, if required shall be designed by the Contractor.

12.5.2 Foundation preparation

The foundation for Reinforced Soil Structures shall be graded level for width equal to or exceeding the length of reinforcing geosynthetics. Prior to wall construction, the foundation shall be compacted with a smooth wheeled roller. The depth of foundation below the finished ground level shall not be less than as specified in BS 8006.2010 or 1 m whichever is greater.

12.5.3 Ground improvement

Where foundation soil is found to be unsuitable, either removal and replacement technique or ground improvement is required to be carried out, as required by the Client. The need for ground improvement, design and ground improvement methodology shall be verified and approved by the Client prior to construction.

Suitable ground improvement technique shall be identified based on the results of subsoil exploration. Foundation preparatory works and foundation treatment/ improvement shall be treated as integral part of the reinforced soil structure and accordingly Contractor shall arrange for detailed sub-soil investigation works and employ his resources to design and construct the foundation/ ground improvement treatment, wherever necessary to satisfy the requirements of reinforced soil structure. The design check and validation for foundation treatment/ ground improvement and the methodology shall be verified and approved by the Client prior to construction.

12.5.4 Levelling concrete

A levelling concrete pad shall be provided under the reinforced soil structures. Concrete shall have a minimum grade M-15. Maximum size of aggregates shall be 20 mm and the pad shall be cured for at least 48 hours before placement of fascia elements

12.5.5 Erection

Reinforcing elements shall be installed at the proper elevation and orientation as shown in approved drawings or as directed by the Client. The reinforcement strips shall be placed normal to the face of the wall unless otherwise shown on the drawings.

12.5.5.1 Facia Elements

Prior to installing the assembled facia units, the foundation on which these units are to be placed shall be cut or filled and graded to the lines and grades shown on the construction drawings. Surface irregularities, loose material, and vegetation shall be removed during the preparation of the foundation.

The units are carried to their final position and connected with the adjoining empty units along the vertical and top edges of their contact surfaces. Whenever a structure requires more than one layer of units, the upper layer shall be connected to the top of the lower layer along the front and back edges of the contacts.

12.5.5.2 Reinforced soil backfill placement

The reinforcing elements shall be laid free from all kinks, damage and displacement during deposition, spreading, leveling and compaction of the fill. The programme of filling shall be such that no construction plant runs directly on the reinforcement. It shall be ensured that the exposure of soil reinforcement to ultraviolet rays is minimal and should be covered with fill within one day of placement.

During construction, the retained material beyond the reinforcement at the rear of the structure shall be maintained at the same level as reinforced fill. The entire works related to compaction should be carried out generally in a direction parallel to the facing. Fill placement methods near the facing shall ensure that no voids exist below the reinforcing elements.

At the end of each day's operations, the contractor shall shape the last level of backfill as to permit run-off rainwater away from the wall face.

12.5.5.3 Drainage material placement

Drainage material shall be placed to finished thickness and widths shown on the construction plans or as modified by the Client. During placement and compaction of drainage material, care must be taken to ensure that there is no contamination with undesirable materials. Vertical layers of drainage material shall be brought up at the same level as the adjoining fill material.

Drainage collection pipes shall be installed to maintain gravity flow of water outside of the reinforced soil zone. The drainage collection pipe should discharge into a storm sewer, manhole or along a slope at an elevation lower than the lowest point of the pipe within the aggregate drain.

More efficient drainage system, if possible, may be suggested by the proprietary Supplier/ Contractor for the review and approval of Client.

12.6 INSPECTION

Client and/or the representative shall verify the materials supplied and quality of work to ensure that all the requirements of the specifications are satisfactorily met with. This includes all submittals and proper installation of the system.

The reinforced soil structure system supplier shall provide one qualified and experienced representative at site on full time basis during the entire working phase to ensure that the quality of the works performed by the Contractor is in accordance with the specifications and to assist the Contractor regarding proper wall installation.

The Contractor's field construction supervisor shall have demonstrated experience and should be qualified to direct all work at the site. All expenses relating to this presence on site shall be deemed to have been included in the rate and no extra claim on this account shall be admissible.

12.7 QUALITY CONTROL AND TESTING OF MATERIALS

a. The system provider should provide the following test certificates: -

i. Manufactures test certificate for tensile strength, yield strength, elongation and galvanization of the reinforcement materials are to be supplied. The different geosynthetic reinforcement-soil interaction parameters under pull-out are to be supported by suitable experimental results. The various reduction factors for creep, construction induced damage, chemical and biological degradation of polymeric reinforcement elements, should be supported by manufacturers certification/accredited laboratories.

ii. Thirds party test report from any NABCB (National Accreditation Board for Certification Bodies) or NBAL accredited laboratories or agencies mentioned in Annexure 2 of IRC 113-2013 or reputed academic institutes like IITs or NITs are to be supplied. The steel and the galvanization shall be independently checked by any NBAL accredited laboratories or a global testing authority like TUV, Bureau Veritas (BV) or Societe Generale de Surveillance (SGS).

Any other Testing if required shall also be done if stated elsewhere in this specification on all materials required for reinforced soil structure construction. The tests shall be done from a reputed independent agency or at the manufacturer's facility under the presence of the Client or his representative as and when required. All tests and testing certificates shall be submitted to the Client at least 7 working days prior to use of any material. Tests on materials before and during construction shall not be limited to the following types.

12.7.1 Reinforcing elements & Facia elements:

Tensile strength certificate from the supplier for each lot.

Testing at manufacturer's facility witnessed by Client's representative to verify the test results.

Determination of interaction coefficients by shear box test, maximum once in a project, if the values used in design are not as per the codes of practices or as specified by certified body, otherwise at owners' costs.

The following particulars of the proposed geosynthetic reinforcing elements and connections shall be submitted to the Client:

- Literature on the proposed reinforcing element and connection.
- Copies of valid quality assurance certificate such as ISO 9001 or equivalent certifying the quality system for the manufacturing of the reinforcing elements.
- A certificate showing the manufacturer's name, the date and place of manufacture and showing that the reinforcing element complies with the requirements stated in the contract and including the results of tests specified in the contract or as specified by the Client.

Samples of the reinforcing elements and connections shall be submitted to the Client at the same time as particulars of the material are submitted.

Galvanization for wire mesh/facia panels - The steel shall be manufactured from virgin ore which has very few impurities and steel shall be silicon kilned. Aluminium kilned steel which has low silicon content shall not be allowed for manufacturing which can lead to poor adhesion of Zinc to the steel.

12.7.2 Fill material

At source approval, the borrow area shall be divided into grid of 25m c/c (or closer if variability is high) as per Clause. No. 903.2 of MORT&H specifications and trial pit shall be taken to full depth in each grid. These trial pits should be logged and plotted for proper identification of suitable source of fill material. Following tests on representative samples shall be carried out:

- o Grain size analysis - 2 tests per 3000 cu.m of fill.
- o Plasticity test – 2 tests per 3000 cu.m of fill
- o Shear test for □Peak as per Appendix C of BS 8006 – one test for every 3000 cu.m of fill material.
- o Modified Procter test as per IS:2720 (Part-8) – 2 tests per 3000 cu.m of fill material.
- o Electrochemical properties of soil if steel reinforcing elements are used – 1 test per 3000 cu.m of fill material.
- During construction:
- o Grain size analysis for every 3000 cu.m of fill
- o Shear test for ϕ_{Peak} as per Appendix C of BS:8006 for every 10,000 cu.m of fill if the grain size analysis matches with the tests that were carried out during source approval or else one test per 3000 cu.m of fill material.
- o Modified Procter test as per IS:2720 (Part-8) – 2 tests per 10,000 cu.m of fill material if the grain size analysis matches with the tests that were carried out during source approval or else two test per 3000 cu.m of fill material.
- o Electrochemical properties of soil if steel reinforcing elements are used – 1 test per 10000 cu.m of fill matieral.
- o Density of each compacted layer (>95% of MDD) at frequency as per clause 903.2.2 – one set of 10 tests in every 500 sq.m.
- The following particulars of the proposed fill material shall be submitted to the Client for approval:
- o Statement identifying each source of supply and showing that sufficient suitable material is available for the works.

- For material from borrow areas, a plan showing the location and extent of each proposed borrow area, and the location, depth and test results for each sample obtained.

- Certificates from a laboratory approved by the Client which show that each material proposed for use complies with the requirements of the Contract and has been tested in accordance with the appropriate test methods given in this Specification.

On receipt of the above particulars, the Client may require the Contractor to carry out additional sampling and testing to demonstrate that the properties of the proposed sources of fill will meet the requirements of the Contract.