

**Technical Specifications / Special
conditions for Railway Project.**

EAST COAST RAILWAY CONSTRUCTION ORGANISATION
ADDITIONAL SPECIAL CONDITIONS OF CONTRACT

(TECHNICAL CONDITIONS)

Sl.No.	Description
1.	Concrete Works (Section – A).
2.	Supply of Cement & Reinforcement Steel (Section – B).
3.	Earthwork & Blanketing-GE: 0004 (Section – C).
4.	Ballast less Track (Section – D).
5.	Performance Requirement Of Fastening System (Section – E).
6.	Ballast less track installation (Section – F).
7.	Transportation Of Rails (Section – G).
8.	Explanatory Notes and Tunnel Lightings (Section – H).
9.	Technical Conditions For Tunnel Works (Section – I).
10.	Primary Tunnel Support (Section – J).
11.	Dewatering Of Underground Construction Sites (Section – K).
12.	Concreting in Underground and Open Works (Section – L).
13.	Taxes and duties, royalties etc. (Section – M).
14.	Safety Rules (Section – N).

Technical Specification/Conditions
CONCRETE WORKS

All Concrete work under the contract is to be executed as per relevant IS specifications, IRS standard specifications and as contained in Indian Railways Unified Standard Specifications.

Design Mix Concrete:

Cement Concrete/Reinforced cement concrete for different elements of the proposed work shall be design mix concrete. Compressive strength of concrete indicated in different item of the concrete works is characteristic compressive strength of concrete at the end of 28 days.

The concrete mix design shall be done as per IS-456 and IS-10262-2009 (corrected up to date) code of practice for design mix.

The mix shall be designed to produce the grade of concrete having the required workability, durability and characteristic strength not less than stipulated values. Concrete mix will be designed for Target mean compressive strength = characteristic compressive strength at end of 28 days + (1.65 x standard deviation). Standard deviation depends upon grade of concrete. Refer Table-1 of 10262-2009 for suggested values of standard deviation depending on grade of concrete reproduced as under.

S.No.	Grade of Concrete	Assumed Standard Deviation N/mm ²
(i)	M-10	3.5
(ii)	M-15	
(iii)	M-20	4.0
(iv)	M-25	
(v)	M-30	5.0
(vi)	M-35	
(vii)	M-40	
(viii)	M-45	
(ix)	M-50	
(x)	M-55	

NOTE:-The above values correspond to the site control having proper storage of cement ,weigh batching of all materials, controlled addition of water ,regular checking of all materials, aggregate grading and moisture content and periodical checking of workability and strength ,where there is deviation from the above values given in the above table shall be increased by 1 N/mm²

Concrete for all the works to be executed under this contract, shall be machine mix only. Hand mixing shall not be permitted.

All materials to be used in the work by the tenderer/contractor shall be subject to the prior approval of the Authority Engineer of the work. Before using in the work, tenderer/contractor shall submit sample of materials and arrange for the supplies, only if the same are approved.

Immediately after receiving formal acceptance letter, the tender/contractor should submit the materials such as aggregate, sand, cement, with details of name of the quarry for aggregate, cement brand, grade of cement etc to the approved laboratory to design the concrete mix for M-20 or richer mix. Tests such as specific gravity of cement, sand, metal and testing of cement for physical properties, sieve analysis for fine and coarse aggregate, abrasion, impact and crushing strength etc are to be done by the laboratory to design the concrete mix. Concrete mix design should be done as per IS-10262-2009 with further stipulations indicated in previous paras.

Any time, if there is change in the aggregate, change in Grade of Cement, type of cement and also if the age of the cement increases considerably, the tests for the design mix concrete shall be repeated before the aggregates or cement are used in the work.

Ref: GM/Vig/BBS's Ir. No.GM/V/Engg/ System Improvement/2474, dt.02.04.2015.

Cement

Only ordinary Portland cement 53 Grade shall be used for design mix concrete and shall be conforming to IS-12269-2013 & IS-1489-1991 respectively. Cement testing shall be done for physical properties as and when instructed by Authority Engineer or his representative.

The cement contents of various grades of concrete should generally be within the range given as under :-

Grade of concrete	Cement content in Kg. Per cum of concrete
M15	250 to 300
M20	280 to 330
M25	310 to 360
M30	340 to 390
M35	360 to 420
M40	380 to 450
M45 to M55	400 to 450

The cement contents of various grades of concrete beyond above mentioned range, if required due to considerations of durability or otherwise should be critically examined and re-checked by the Authority Engineer before approving any concrete design mix report.

Aggregate:

Coarse and fine aggregate to be used in the work shall confirm to IS-383-1970. Coarse aggregate shall invariably be machine crushed well graded of hard granite/black trap/basalt stone. Lime stone, quarry stone are not acceptable.

40mm stone aggregate shall be used in the Mass concrete works, for mud mat concrete and temporary staging foundation and shall be hard stone confirming to IS-383-1970.

Water:

Only clean potable water free from impurities shall only be permitted for concreting, curing and grouting works.

Reinforcement:

Reinforcement steel to be used in the work shall be produced from recognised manufacturers i.e. SAIL/TISCO/RINL/any other approved sources only, Bars shall be high strength deformed bars of Fe 500 D grade TMT/Rebars (RINL) confirming to IS: 1786. Testing of reinforcement steel shall be done for physical properties as and when instructed by representative of Authority Engineer.

Binding wire:

Binding wire (Galvanised) to be used in the work should be of standard quality. The diameter shall be 16 SWG.

Shuttering:

Contractor should arrange good steel shuttering/ply good shuttering without containing any depressions. Shuttering plates should not contain depressions more than 5 mm. Sufficient number of stiffeners are to be provided to prevent bulging between end runners. The line, level and surface of the finished work should be absolutely neat and pleasing. No touching of concrete will be allowed after shuttering is struck.

Joints between the concrete lifts should be chipped off neatly and the joint should be rubbed with carborundum stones (rough, medium and smooth) after applying cement mortar 1:3

The rods left in concrete for the purpose of shuttering should be cut 2.5 cm deep from the face of structure by gas cutting and the tie rod hole should filled with epoxy at contractor's cost.

20 x 5 mm wide rubber flats should be placed between the shutters for proper joining to arrest leakage of cement water during concreting and compaction. Before laying the concrete, all the gaps of shutters are to be packed with jute/cotton waste and should be applied with grease and cement slurry to arrest leakage of cement water through joints and other holes.

Cover Blocks:

Cover blocks of specified thickness to match the required grade of concrete should be cast in advance for ensuring specified cover to all RCC works for which separate payment will not be made, as the rates of all RCC works are inclusive of this element.

Admixture/Plasticizers:

Admixtures/Plasticizers/ super plasticizers to be mixed with concrete for the purpose of workability, reduction in the cement content, acquiring early strength, etc shall be procured as per IS-9103 latest version and payment will be made as per the schedule item.

Proportioning, Mixing, Transporting & placing of concrete

Batching and mixing of the concrete shall be done by weigh batching and mixing plant, located at an approved distance duly considering the properties of the mixes and the transporting arrangements available with the Contractor. The Authority Engineer shall approve the plant.

Proportioning of various materials shall be done on the batching plant by weight, each type of material being weighed separately. The cement from the bulk stock shall be weighed separately.

The capacity of batching and mixing plant shall be at least 25 percent higher than the capacity for transportation and laying of concrete.

All drums that have been out of use for more than 30 minutes shall be thoroughly cleaned before any fresh concrete is mixed in them.

For transportation of concrete Chutes, hoists and winches, transit mixer and agitators and concrete pumps shall be used as approved by Authority Engineer. Concrete shall be so transported and placed that no contamination, segregation or loss of its constituent materials takes place.

No concrete shall be placed in any part of the structure until the approval of the Authority Engineer has been obtained.

COMPACTION AND CURING

Concrete should mechanically compacted by using different varieties of vibrators available to suit to situation of work. Adequate nos. of Shutter vibrators, needle vibrators, surface vibrators (plate vibrators) etc. shall be arranged by the contractor for vibrating the concrete mechanically.

All cement works shall be cured for 21 days by the contractor at his own cost.

If curing is not being done to satisfy the standard, the Authority Engineer may get it done at the contractors cost without any notice to him, as the curing cannot wait for such notice, time etc. The Authority Engineer decision shall be final and binding, as to whether satisfactory curing is being done or not.

Contractor should arrange for painting of date of casting of different elements on the structure with paint for monitoring the curing. Cost of the above should be borne by the contractor at his own cost.

Frequency of Sampling of Concrete:

Minimum frequency of sampling for testing of concrete work should be as per IS-456 Clause 15.2.2.

Testing of Concrete:

The testing of aggregates and the concrete as required to be done in accordance with specification, For this purpose the contractor shall set up a testing laboratory at his works at the location to be decided by the Authority Engineer. He/They shall also make adequate arrangements for curing of test cubes, so prepared as per the direction of the Authority Engineer . The contractor shall prepare the same at his own cost both for (1) preliminary test and (2) the works tests. All such tests shall be carried out by contractor and the record of same jointly signed by the contractor or his/their representative and Engineer or his representative shall be maintained by the contractor as per the direction of the Authority Engineer.

The contractor shall also provide and deliver for tests, at such places other than his premises as the Authority Engineer may specify such materials or cubes as he may require.

The Authority Engineer, at his discretion may decide to perform some of the tests on aggregate of concrete at his own laboratory or any other agency he may consider necessary. In all such

cases, the contractor shall provide and deliver for tests for such materials or concrete cubes duly cured, at the premises as may be specified by the Authority Engineer.

ACCEPTANCE CRITERIA FOR CONCRETE.

Concrete test results shall satisfy Acceptance criteria for various grade of concrete as per IS 456-2000, as also mentioned in Annexure 4.2 of Indian Railway Unified Standard Specifications-2021.

FIELD LABORATORY:

The Details of field laboratory to carry out tests by the contractor has mentioned in the Annexure-II of Chapter-9 of this document.

16. RECORD

After the work is completed in all respects the contractor shall make available for Railways for record, tracing drawings on transparent polythene film of all completed works with all details like general arrangements drawings, reinforcement details, structural details etc. are to be made and supplied along with six ammonia copies for record.

(Section – B).

Technical Specification/Conditions
Supply of Cement & Reinforcement Steel

1.0 Cement and Reinforcement steel for the entire work shall be supplied by the Contractor under relevant Schedule of this tender conforming to IS specifications and Indian Railways Unified Standard Specifications

1.1 Cement

1.1.1 Cement to be used in this work shall be conforming to IS 12269 for 53 Grade Ordinary Portland Cement

1.1.2 Cement produced by reputed manufacturer approved by the Authority Engineer shall be supplied by the Contractor and used for construction.

1.1.3 Decision of Authority Engineer regarding reputed firms shall be final and binding on the contractor.

1.1.4 Cement within 3 (Three) months from the date of manufacture shall only be used in the work covered under various schedules of the agreement.

1.1.5 Cost of the cement procured by the contractor should be paid only after consumption towards the different item of works of schedules.

1.2 Steel

1.2.1 Steel produced by following manufacturers only shall be supplied by the Contractor and used for construction.

SAIL

TISCO

RINL

d. and any other approved Vendors works/plant Registered with RDSO as Primary Steel Producers having Integrated Steel Plant (ISP) and using iron ore as the basic raw material and having in-house iron rolling facilities, followed by production of steel through the process of DRI –EAF, BF-BOF and Corex-BOF only, as per Ministry of Steel's guidelines for supply of TMT Reinforcement steel bars. On the date of purchase firm should have been in approved list of RDSO.1.2.2 Reinforcement steel bars used for work shall be High strength deformed bars of Grade Fe 500 D TMT/Rebars (RINL) conforming to specification IS: 1786.

1.2.2 Reinforcement steel bars used for work shall be High strength deformed bars of Grade Fe 500 D TMT/Rebars (RINL) conforming to specification IS: 1786.

1.2.3 In addition to the above, as per Railway Board's Letter No. 2018/06/CE-III/BR/Stainless Steel dtd. 02.05.2018 Stainless Steel Reinforcement bars (Grade G(410L)- Ferritic conforming to IS 16651:2017) to be used for the following structures:

(i) Bridges in coastal area (up to 30 km from coast): Railway bridges, FOB, ROB/RUB, Rail Flyover/Metro, Mono Rail crossings.

(ii) Tunnels in coastal areas.

(iii) C & W and Loco inspection pits, catwalks, washing aprons & water tanks at all places.

(iv) Any other structure located in extremely adverse environmental conditions or where frequent inspection is not possible even if it is away from coastal area after due justification & with the personal approval of PCE/CAO(C).

1.3 General

1.3.1 The contractor has to arrange the manufactures test certificate for the steel and cement procured at the site along with the other documents such as invoices etc.

1.3.2 The Contractor shall arrange testing of cement and steel as directed by Railway representative. All the charges for testing of all materials shall be borne by the contractor. Steel shall be tested for tensile strength, elongation, bend test etc. Testing of these materials shall be done at approved laboratories/recognized laboratories as is being done by other Government Organizations such as CPWD.

1.3.3 Railway reserves the right to inspect contractor's godowns and documents pertaining to this work.

1.3.4 The contractor shall use these materials in the work as per specifications contained in this document approved drawings and shall not use less quantities than what is stipulated in the relevant specifications/approved drawings.

1.3.5 No allowance wastage on any of the materials supplied by the contractor including Cement and Steel is payable by the Railway.

1.3.6 Contractor will make his own arrangements for storing cement, steel and other materials.

1.3.7 Standard weights as per relevant IS code to be followed.

Special conditions and technical specifications

Earthwork & blanketing-GE:0004

1. General:

1.1 Specifications and conditions for earthwork are as contained in the Guide lines for Earthwork in Railway Projects" issued by Geo-Technical wing of RDSO in September 2020 known here under, as RDSO's Guidelines for Earthwork – RDSO/2020/GE: IRS-0004, September -2020, with Indian Railways Unified Standard Specifications.

1.2 While executing the earth work, Contractor(s) shall ensure that the Safety of Communication and power lines, Telegraph/electric poles, underground power cables, OFC cables etc is not endangered. Telephone poles/electrical poles and underground cables coming in the alignment will be shifted by the Railway. For any other reasons, if the same are not shifted, contractor should take precautionary measures to safe guard the above without damaging them during the execution of formation work.

1.2.1 For any other reasons, Electrical /Telephone posts/ Telephone wires and Signal and other cables are damaged by the contractor, cost for rectification and other charges as indicated by respective Telephone/Electrical departments has to be borne by the tenderer(s)/contractor(s).

1.2.2 If the earthwork equipment is not approachable within the vicinity of the telephone or electrical posts due to inadequate clearance of Telephone/Electrical wires for movement of rollers, dozers, tippers, water tankers etc., such locations should be attempted manually and compacted by using plate Vibrators/Earth Rammers (Vibrator without needle fitted on steel shutter) to the specified height of formation as indicated by the Authority Engineer. No extra payment will be made to execute the earthwork in formation at the above said location if arise. While quoting the rates, tenderer should keep in mind the above aspect.

1.3 Earth obtained from cut spoils in cuttings and from underground excavation shall be utilized first in making banks and earth obtained from outside Railway land should be operated subsequently for making bank formation after utilization of cut spoils if found suitable.

1.3.1 The tenderer(s)/contractor(s) have to utilize first the Railway rock / boulders obtained from cutting formation / bridge foundations within the section limits after converting the same to the required sizes at his cost suitable for boulder back filling, RR masonry, pitching, and flooring etc.. The cost of rock / boulders shall be recovered for one cubic metre net (i.e. after deducting 30 % voids from the stack measurement) of such stones as per the prevailing rate of the area or @ Rs. 375/- (Rupees Three hundred and Seventy Five only) or as may be decided by the Railway. The execution of above works with Contractor's boulders should be operated subsequently after consuming the railway rock / boulders or as decided by Authority Engineer of work. The rate per cubic metre net includes royalty, collection, stacking, loading, unloading and transportation of cut spoils which has to be done by the Contractors at his/their cost. The

boulder issued to the Contractor(s) for the above purpose will be used only for the works of the agreement and shall neither be disposed off nor be used for any other agreement.

1.4 The rates includes making reference pillars, supply of bamboos, strings and pegs for profiles, banks and cuttings to final dimensions, breaking clods, dressing etc. The trees so cut shall be the property of the Railway and they shall be stacked as per the directions of the Authority Engineer.

1.5 Earth work required for making level crossings and platforms shall also be paid for at the rate quoted in the schedule.

1.6 The earth obtained from the excavation of foundations, protection works and drains etc. shall be led into the adjacent banks, if found suitable as directed by the Authority Engineer. Payment and the quantity payable under earth work in banks shall be reduced to that extant. However Mechanical compaction will be paid separately under different item.

1.7 If the Earth obtained from excavation of foundations of bridge and protection work is not suitable for formation the same should be dumped at the locations shown by Authority Engineer. Earth so stacked or dumped should be dozed neatly without giving scope for stagnation of water. No extra cost will be paid to carry out above activities by the tenderer.

1.8.1 The contractor shall bail out water from pockets, ditches ponds etc., at his own cost, before commencing earthwork in Bank formation.

1.8.2 Wherever crossing of existing Railway tracks are necessary, all safety precautions shall be observed and such crossings of tracks can be permitted only by the Authority Engineer. The contractor shall be fully responsible for payment of compensation arising out of accident, if any.

1.8.3 The fill materials to be used shall be free from lumps, trees, roots etc, and shall be used only after approval by the Authority Engineer after conducting necessary tests.

1.8.3.1 Soil tests to find out the suitability in bank formation for the earth obtained from outside railway land) shall be carried at specified laboratory/E Co Rly Geo lab at contractor's cost.

1.8.3.2 Soil/Earth having the properties as per specifications as indicated in the para 1.13 will only be allowed in formation of bank.

1.8.4 In conversion/doubling/rehabilitation projects, suitable benching of existing slope shall be done before new earthwork is taken up to provide proper bonding between old and new earthworks (Refer RDSO Drg. No: GT/SK/GL/00259/Rev.0/2002). It should be ensured that there is no humus material left on the benched slope. Care needs to be taken to avoid entry of rainwater into the formation from this weak junction; otherwise this would result in development of weak formation, slope failure, maintenance problem due to uneven settlement etc.

1.8.4.1 For bank formation with earth obtained from outside Railway land, tenderer/contractor has to identify the quarry outside the Railway land and intimate to the railway within three weeks after acceptance with the details such as name of the quarry, distance of quarry from Railway line etc. to enable to inspect the same by Railway official and to take the sample and to give proper authority letter for testing.

1.8.4.2 Tenderer/Contractor has to arrange men to take the sample at site, empty bag to collect the earth for testing, and arranging transportation from quarry site to laboratory at contractor's cost.

1.8.4.3 Contractor has to locate sufficient number of quarries around the work immediately after receipt of formal acceptance letter.

1.8.4.4 Tenderer/Contractor should mobilize the earthwork machinery at site only after approval of earth samples by Authority Engineer after conducting necessary tests in approved lab are in hand.

1.8.4.5 Railway is not responsible for idling of machinery procured by contractor/tenderer on account of delay in testing of samples/failure of sample obtained by the contractor/ Mobilization of machinery at site without approved test results of sample in hand.

1.8.5 Cuttings

1.8.5.1 Cut spoils shall not be dumped within 10 Meters from the top of gullet. In regard to blasting and storage of explosives, the Contractor shall execute the work in accordance with the provisions of Indian Railways unified Standard Specifications (works & Materials) Volume – I & II. Blasting operations should be carried out in accordance with the directions of the Authority Engineer. Special attention is also drawn to the above specifications indicating the responsibilities and liabilities of the contractor while carrying out the blasting operations. Blasting operations by the side of the Railway line will be carried out only with the permission and under the direction of the Authority Engineer with full regard to safety of persons, property, existing structures and traffic on the existing line. Contractor shall provide flagmen under railway supervision at free of cost where ever blasting operations near to track are to be carried out. Authority Engineer or his representative shall train the contractor's flagmen for ensuring safety of track. Blasting shall be done only under line block in the vicinity of the existing Railway line. The Contractor shall have no claim for damages or loss due to any delays established or claimed to have occurred to the progress of the work as a result of taking care and precautions as may have been ordered by the Authority Engineer. The contractor shall make his own arrangements for procurement and storage of explosives, in accordance with the extent rules and regulations.

The safety precautions to be observed by the Contractor should be strictly as per Explosives Act and as per regulations of the Inspector of Explosives and Mining.

1.8.6 The earth work for widening of the existing bank/cutting has to be done abutting the existing running line and the contractors have to take all necessary precautions, wherever considered necessary, to avoid accidents from running trains. The zone of activities for execution of works close to the track shall be clearly demarcated at site by the Contractor, as directed by the Authority Engineer. The contractor shall demarcate the area by providing temporary barricades with bamboos or bullies/ropes to ensure that drivers of all vehicles/Machinery do not go beyond the barricade towards the track. The flagmen will have to be provided by the contractor at his cost as considered necessary by the Authority Engineer. The flagmen will give indication of the running trains and directions to ensure that the work does not interfere with running trains. The work should be executed as per the direction of the flagmen without infringing with the moving dimensions. However, the Contractor shall be wholly responsible for the safety of his men, equipment, machinery and materials. Any damage to Railway or its part during the execution of the work by the Contractor shall be made good at the cost of the Contractor.

1.9 Mechanical compaction of Earthwork and Blanket:

1.9.1 After site clearance all pockets and depressions left in the soil, if any, shall be made good and compacted. The entire area shall be rolled and compacted with suitable roller before the first layer of earth is spread and the contractor shall obtain clearance from the Authority Engineer before spreading the first layer of the earth.

1.9.2 Earth work shall be done in layers of suitable thickness as ascertained in the field trials not exceeding 300 mm thick by vibratory Rollers in the loose state and compacted preferably at or near the OMC with a vibratory Roller to obtain the specified density. The number of passes of the rollers and the optimum thickness of each layer will be fixed after carrying out field trials with roller proposed to be used from time to time and from location to location, the main criteria being to obtain maximum density achievable. Rolling with static roller is strictly prohibited.

1.9.3 Cohesion less soils shall be compacted to get a minimum density index (relative density) of 70 percent as obtained in accordance with IS:2720 (Part XIV -1968). All other types of soil when compacted shall attain at least 98% of the maximum dry density as determined using heavy compaction in accordance with IS: 2720 (Pt.VIII-1974) followed by field trials as per IS:10379-1982).

1.9.3.1 The density of each layer of compacted soil shall be ascertained by taking soil samples collected mostly on both sides of the centre line in each layer in a staged position using sand replacement (as per IS:2720 Pt. VIII, 1974) or core cutter method (as per IS: 2720 Pt. XXIX 1975). The number of tests will be of course depending on the width of the formation.

1.9.3.2 The above tests for quality control may be necessary while mechanical compacting bank with Cohesion-less soils except for top 1m.

1.9.4 Where the moisture content of the earth in any layer is above OMC it shall be left for drying for a suitable period to bring down the moisture content very near to OMC before rolling is commenced. If the soil is dry, water shall be sprinkled either in the borrow pit or over the spread layer, as convenient, in order to attain a moisture content near to OMC before rolling is commenced. Where the natural moisture contents of borrow soil is high compaction at moisture content up to plastic limits can be allowed by the permission of the Authority Engineer.

1.9.5 Each layer shall be compacted to the specified density over its entire width commencing from the two sides, before another layer is started. Each layer shall continue to be rolled until no further settlement occurs. The layers shall be free from ruts.

1.9.6 While compacting, it shall be ensured that there is a minimum overlap of 200 mm between each run of the rollers.

1.9.7 Care should be taken during the compaction operation to slope the surface of the bank to facilitate the shedding and to minimize the absorption of rainwater, particular attention being given to the prevention of ponding.

1.9.8 The density of each layer of compacted soil shall be ascertained by the Railway by testing an adequate number of soil samples. For this purpose necessary arrangement for soil testing at site of work shall have to be arranged and organized by the contractor in accordance with these specifications and as directed by the Engineer and no extra payment shall be made on this account.

1.9.9 The quality of work shall be determined by considering the mean density of the samples in each layer. The mean dry density shall be equal to or exceed the minimum specified density. In no individual case shall the density be less than the minimum value specified by more than 2% otherwise further rolling should be done at the appropriate location.

1.9.9.1 Earthwork of extra width of 500 mm beyond the profile has to be done and shall be rolled on either side. After finishing the bank up to final height, the slope shall be dressed by removing the loose earth on account of rollers not able to compact the soil at the edge of the formation width.

1.9.9.2 Contractor should arrange to demark the edge lines with white shell lime water after completing every three layers of earthwork to check sufficient width of bank is available or not at that particular level. Cost of labour, material etc. to do the above works are already included in the rate, for which separate payment will not be made to the contractor

1.9.10 The Contractor shall be allowed to lay a further layer of soil only after the compaction of a particular layer has been found satisfactory.

1.9.11 Top of the formation should be finished to cross slope of 1 in 30 from one end to other towards cess/drain in multiple lines and from centre of formation to both sides in single line.

1.9.12 In parts of embankment, inaccessible to the specified filling equipment, e.g., edges and side slopes around and in contact with culverts, abutments or in proximity to structures, where it will not be possible to operate rolling equipment, compaction shall be accomplished by and tamping with hand or mechanical tampers of approved type. Earth Movers or Roller shall not be permitted to operate within 1500 mm of masonry/concrete structure and all fill within this distance shall be hand tamped. All materials to be hand tamped shall be spread in layers not over 100 mm thick. The moisture content at the time of tamping shall be such as to produce a degree of compaction equal to that specified for rolled fill. Final rolling of the top layer of the fill shall be completed with a self propelled smooth wheel power driven roller or multiple pneumatic tire wheeled roller or hand tamped to the required profile.

1.9.13 The filling over arches and pipe culverts shall be made up simultaneously from both sides.

1.9.14 Placement of Back-Fills on Bridge Approaches and Similar Locations:

i) The back fills resting on natural ground may settle in spite of heavy compaction and may cause differential settlements, vis-a-vis, abutments, which rest on comparatively much stiffer base. To avoid such differential settlements, while on one hand it is essential to compact the back fill in the properly laid layers of sand, on the other hand, the back fill should be designed carefully to keep;

Settlements within tolerable limits.

Coefficient of subgrade reaction should have gradual change from approach to the bridge.

ii) Back-fills on bridge approaches shall be placed in accordance to para 605 of Indian Railways Bridge Manual 1998, and as per the RDSO drawing GE/SD/0006/Rev-1/2002.

iii) Fill material being granular and sandy type soil (GW,GP,SW), therefore need to be placed in 150mm or lesser thick layers and compacted with vibratory plate compactors or earth movers.

iv) While placing backfill material benching should be made in approach embankment to provide proper bonding.

v) The boulder filling shall consist of well hand packed boulders & cobbles to thickness not less than 600 mm with smaller size towards the back. Behind the boulder filling, back fill materials, shall consist of granular materials of GW, GP, SW groups as per IS: 1498 – 1978.

1.9.15 Adequate arrangements for control of compaction must be ensured during the construction so that the required degree of density is obtained in each layer of earth work.

1.9.16 All work including the surfaces of the fill shall be finished to a smooth and compact profile in conformity with the plans and the contractor must not leave any depressions or irregularities that will hold water or prevent drainage. Slopes shall be finished by hand

shovelling. The inside slopes of embankment shall be neatly dressed to line as the placing of the fill progresses.

1.9.17 In making earth work in embankment or due to movement of compaction equipment, if there is natural subsidence or sinking of the natural ground under the embankment due to any reason, the contractor shall make up the deficiency in the quantity of earth work due to natural sinking at his own cost. No additional payment compensation shall be made on this account.

1.9.18 The contractor has to make arrangements for testing of soils as mentioned in IS-2720 either at field or sent to the specified laboratory as desired by the Authority Engineer of the work.

1.10 Materials for Construction:

Construction of embankment is to be carried out normally with soil available in nearby area with proper design of slope and desired bearing capacity, except soils which are not normally suitable to be used in construction ,as detailed below.

1.11 Unsuitable Soils for Construction:

1.11.1 Soils to be normally avoided are:

Organic clays, organic silts, peat, chalks, dispersive soils, poorly graded gravel and sand with uniformity coefficient less than 2, Clays and silts of high plasticity (CH & MH) in top 3m of embankment.

1.12 Use of Mixed Types Soils:

1.12.1 Different types of fill materials, if used, should be deposited in such a way that all parts of the site receive roughly equal amount of a given material in roughly the same sequence to get approximate homogeneous character of sub-grade.

1.13 Execution of Formation Earthwork

Before taking up of actual execution of work, detailed drawings need to be prepared for the entire length of the project to give alignment, formation levels, formation width at ground level, cross sections of catch water drains & side drains, cross section & levels of subgrade, blanket levels, etc. to facilitate smooth execution at site. Execution of work has to be carried out in systematic manner so as to construct formations of satisfactory quality, which would give trouble free service. The activities and adoption of good practices involved in execution of earthwork are covered under following headings:

Preliminary works

General aspects

Compaction of earth work

Placement of Back-Fills on Bridge Approaches and Similar Locations

Drainage Arrangement in Bank/Cutting

Erosion control of slopes on banks & cuttings

Other aspects

1.14.1 Preliminary works:

Preparation of Natural Ground:

Preparation of natural ground surface may be carried out as follows:

Site clearances: Full formation width at ground level plus additional extra width of 2 m on both sides should be cleared of all obstructions viz. vegetation, trees, bushes, building, fences, abandoned structures etc. and thereafter it should be dressed and levelled. Depressions if any should be filled with suitable soil duly compacted. Finally, levelled surface should be properly compacted by mechanical means to get levelled and uniform ground surface.

1.14.2 When bank is constructed on ground having steep slope then the ground surface should be suitably benched so that new material of bank gets well bonded with the existing ground surface.

1.14.3 Setting out of construction limits:

Centreline of the alignment (@ 100/200 m c/c or so) and full construction width should be demarcated with reference pegs/dug belling about 90 cm away from proposed toe of the bank. Care should be taken not to disturb the pegs during construction. Pegs should be preferably painted for identification.

1.14.4 Selection of borrow area:

a) Borrow area should be selected sufficiently away from the alignment, as far as possible at the extreme of Railway land but normally not less than 3 m plus height of the embankment to prevent base failure due to lateral escapement of the soil.

b) Borrow area should be selected for soil suitable to be used in construction.

Selection of Fill Material:

Except unsuitable soils as per clause 1.14, any type of locally available soil can be used as a construction material. OMC & MDD of the selected fill material should be tested in the laboratory as per laid down frequency.

Use of material should be planned in such a way that soil with higher percentage of coarse-grained particle is placed on the upper layers of the embankment.

1.14.5 General Aspects:

Moisture content of soil should be decided based on the field trial and site conditions. The objective should be to compact near OMC to achieve uniform compaction with specified density in most efficient manner.

Clods or hard lumps of soil of borrow area shall be broken to 75 mm or lesser size before placing on embankment.

Each layer should be compacted with recommended type of roller up to required level of compaction, commencing from the sides, before putting next upper layer.

1.15 Drainage Arrangement in Banks and Cuttings:

Drainage is the most important factor in the stability of bank/cutting in railway construction. Effective drainage of the rainwater in the monsoon season is very important to safe guard bank/cutting from failure. Railway formation is designed for fully saturated condition of soil. However, flow of water should not be allowed along the track as it not only contaminates ballast but also erodes formation. Stagnation of water for long time on formation is not desirable. Therefore, drainage system should be efficient enough to prevent stagnation and allow quick flow of water. Some guidelines on this aspect are given as follows:

1.16 Drainage of Embankment:

In bank cross slope is provided from centre towards end to drain out surface water. Therefore, normally there is no need of side drains in case of embankment. However, there are situations where height of bank is such that blanket layer goes below normal ground level. In such cases, side drains may require to be constructed along the track at suitable distance so that track alignment does not become channel for flow of ground surface water. In case of double line construction, central drain between the tracks should be avoided to extent possible (even if it means resorting to additional earthwork to facilitate flow of water) as it is not only difficult to construct but also difficult to maintain for continuous vibrations caused by moving traffic, problem in proper curing of concrete etc. Only in very rare situations, when drainage of water is not possible without construction of drain, suitable arrangements for construction of drain with pre-cast concrete channel/ subsoil drains along with proper outfall should be made. If distance between adjacent tracks is large enough, suitable slope should be provided in ground to make rain water flow in natural manner. Wherever, there is level difference between two adjacent tracks, suitable non-load bearing dwarf wall may be constructed to retain earth.

1.17 Drainage in Cuttings:

1.17.1 Side Drains: In case of cuttings, properly designed side drains of required water carrying capacity are to be provided. If height of the cutting is less (say, up to 4m), normally only side drains on both sides of the track are to be provided. In case of deep cuttings, catch water drains of adequate water carrying capacity are also required along with side drains. It is

to be noted that blanket material is to be placed like fill/embankment and top of side drains has to remain below the bottom of blanket material.

1.17.2 Catch water drains: Surface water flowing from top of hill slope towards the track in huge quantity needs to be controlled on safety consideration. It is also not possible to allow water from the hillside to flow into the side drains, which are not designed for carrying such huge quantity of water. Therefore, it is essential to intercept and divert the water coming from the hill slopes; accordingly, catch water drains are provided running almost parallel to the track. Depending on site condition, water from the catch water drains may require be diverting by sloping drains and carrying across the track by means of culvert. In some of the situations, depending on topography of top of cutting, there may be requirement of construction of net of small catch water drains which are subsequently connected to main catch water drain so that there is no possibility of water stagnation/ponding up to distance approximately three times depth of cutting from its edge. Catch water drains should be made pucca/lined with impervious flexible material locally available.

a) Considerations in Design of Catch Water Drains:

These should be properly designed, lined and maintained. If catch water drains are kuchha/broken pucca drains, water percolates down to the track through cracks, dissolving the cementing material resulting into instability in the cuttings. Catch water drains should be located slightly away (as per site conditions) from the top edge of cutting and water flow should be led into the nearby culvert or natural low ground. Some additional salient features to be observed are as follows:

- i) Catch water drains shall have adequate slope to ensure development of self- cleansing velocity.
- ii) Catch water drains shall not have any weep hole.
- iii) The expansion joints, if provided, shall be sealed with bituminous concrete.
- iv) Regular inspection and maintenance work, specially before onset of monsoon, should be carried out to plug seepage of water.
- v) Catch water drains shall have well designed out fall with protection against tail end erosion.

Though capacity and section will depend on terrain characteristics, rainfall etc. but following parameters are important for design of catch water drains:

Intensity and duration of rain fall.

Catchment area- shape, size, rate of infiltration etc

Velocity of flow which should satisfy the Manning's formula

Minimum gradient of drain should be in range of 1 in 400 to 1 in 700.

Normally catch water drains should trapezoidal cross section.

The catch water drain should not be given gradient more than about 1 in 50 (but in no case more than 1 in 33) to avoid high water velocity and possibility of washout of lining material.

Rugosity coefficient should be about 0.03.

1.18.1 Use of Construction Equipments for Execution of Earthwork

Any manual methods of construction cannot achieve the desired quality of earthwork. It would be necessary to deploy modern equipments such as earthmover, motor graders, scraper, dumpers, mobile water sprinklers, vibratory rollers, sheep foot rollers etc. as per need, on all projects, so that the quality of work is as per laid down standards. It would be desirable to maintain records of work done by various equipments at a particular site to assess the output and quality control.

1.19 For quality control of compaction of the Earthwork/Blanketing, the contractor shall establish and maintain Field Laboratory at suitable location as directed by Authority Engineer with all required tools and equipment in accordance with RDSO's Guidelines for Earthwork – RDSO/2020/GE: IRS-0004, September -2020 at his own cost. The in-situ moisture content of compacted soil shall be determined according to the any of the procedures given in IS:2720 (Pt.II)-1973. The field dry density should be determined by any one of the methods given in IS:2720 (pt. XXVIII) – 1974 or IS:2720 (Pt. XXIX) – 1975 or IS: 2720 (Pt. XXXIV)-1972. The tests shall be performed after removing top 5cm layer of earth (IS: 10379 –1982).

Contractor is solely responsible for testing & maintenance of records regarding quality control (as per RDSO guidelines) and for providing adequate Team at site to assist Authority Engineer in quality tests.

Technical Specifications to Ballast less Track

GENERAL

These specifications shall be read in conjunction with the other provision in the tender documents forming the part of the contract. No permanent works shall be carried out until all the methods statements, materials, tools and plant have been approved by the Engineer. Unless noted otherwise in the contract, all components and materials shall be handled, transported and stored in accordance with the directions of Authority Engineer.

TECHNICAL REQUIREMENTS

DESIGN REQUIREMENTS:

In designing ballast less track for straight & curved track on Indian Railways, the following parameters may be considered for guidance.

Ballast less Track shall be designed for the following:

Main line for 25T axle load & speed 100 kmph (proposed for goods traffic) & 22T axle load & speed 100 kmph (for passenger traffic)

Loop line for 25T axle load & speed 50kmph.

Dynamic augment may be taken as 2.5 (as prevailing on IR)

Spacing or supports to rails — preferably at every 60 cm (wherever rails are supported on sleepers or discrete supports) so that the permissible bending stress in rails are not exceeded beyond stipulated values. The values of permissible bending stress are as under:

For LWR section - 25.25 kg/mm² (for 11 OUTS)

For SWP - 30.25 kg/mm² (for 110 1-ITS)

For FP section - 36.00 kg/mm² (for 110 UTS)

Upward reaction/ pressure from support base should be clearly mentioned in design.

Design shall be as per relevant codes of practice such as BIS, EN, IRS, IRC and UIC with latest revision/edition). If for any item/work, above mentioned codes are not relevant, best available Engineering practice & International codes shall be mentioned.

Design & details of suitable Transition System for smooth transition from ballasted track to ballast less track on both ends shall be part of the design of ballast less track.

Design and details of Expansion & Contraction joints in ballast less track at suitable intervals shall be part of the design of ballast less track.

Technical parameters required for foundation of Ballast less track shall be suitably considered for Indian conditions and shall be mentioned in the design along with their test code & procedure. A design monograph of varying sub-grade characteristics, if applicable, to be provided by the firm & designers duly proof checking by Proof Consultant/PMS/Engineer.

Design service life ballast less track should be a minimum of 60 years. Concrete for RCC structure should comply relevant Para of Indian Standard IS:456 — 2000 & relevant Para of IRS — Concrete Bridge Code taking care of relevant durability clause for expected life of RCC as minimum 60 years.

No cracks of width greater than the crack width approved at design phase/codal provisions or settlements or separation of parts should be developed during services in the ballast less track leading to impaired service or failure,

Ballast less track should be designed for almost maintenance free conditions except replacement of worn-out fastening components whenever their service life is over. The 2% of the fastening components and other replacement items which are likely to be worn out / damaged are to be supplied as spares for need based replacement in this work. The offer of the firm / JV should be inclusive of the cost of 2% fastening components as spare. No additional cost will be paid for the spares.

Adequate corrosion protection measures must be included in design to minimize corrosion of fastening components of proposed system for ballast less track. Test report of the proposed fastening system should be submitted as per EN 13146—6: 2012- Test methods for fastening system— Effect of severe environmental conditions and EN ISO 9227, Corrosion tests in artificial atmospheres — salt spray tests or as per any international standard being in practice.

The design should be cost effective serving all functional requirements expected of ballast less track.

Any other factor considered necessary by the designer.

Changes in the above parameters (ii) and (iii) may be considered in case the bidder is able to support it with the relevant documents and codes as per practice in other Railways.

Track Details:

Ballast less track for Indian railways shall be designed for following track details:

Rail section: Rail profile shall conform to LJC 60 (110 UTS) and Rail material shall conform to RSI-T-12-2009 class-'A', including manufacturing and testing in accordance with RSI-T-12-2009 with latest amendments.

Schedule of Dimensions (SOD) and Maximum Moving Dimension (MMD) of Indian Railways for BG shall be followed.

Ruling gradient: 1 in 100 or flatter

Rail cant at Rail seat (inward): 1 in 20

Maximum degree of curvature: up to 50 for ballast less track.

Maximum permissible cant: 165mm

Speed potential: Full speed prevailing on main line (100kmph) & loop line (50 kmph)

Traffic: Mixed — passenger & freight.

During service if some parameter goes out in case of any unforeseen circumstances, the leeway / margin available to correct the parameter. Vertical: + 10mm / -3mm, Horizontal: \pm 3mm.

Design temperature range: 70-degree Celsius variation of rail temperature as per zone & chart of Indian Railway LWR manual and 40-degree variation of ambient temperature.

Long welded rails (LWR) are to be used. The proposed design of ballast less track should take into consideration of the forces due to LWR and interaction of LWR.

The LWR plan for the Tendered section shall be prepared by the BLT designer & the same shall be proof checked by the proof checker/PMS/Engineer.

In-situ AT Flash Butt welding as per the Indian Railways welding manuals to be done.

Track Tolerances: Track tolerances over ballast less track when installed and later during service under floating conditions should be as under:

	Parameter	Installation	Service
	Gauge (with reference to 1673 mm, measured below 14 mm rail top) for straight and for curve up to the radius of 350 m.	± 1 mm	± 3 mm
	cross Level on straight and curved track	± 1 mm	± 3 mm
	variation in versine on curved track (20 m chord with half overlapping	± 3 mm	± 6 mm
	Vertical alignment over a 3.6 m chord	± 1 mm	± 6 mm
	Lateral alignment over a 7.2 m chord on straight track	± 1 mm	± 3 mm
	Twist on 3.6 m base	± 1 mm	± 5 mm

The above installation parameters are not sacrosanct and firm/JV can also advise their own limits for the above parameter along with basis for suggesting the changes. Variation in horizontal alignment, vertical alignment, versine, twist and gauge shall not exhibit cyclic pattern.

TRACTION DETAILS:

IR has Diesel / Overhead Electric (25 kV) traction. The ballast less track design should have adequate electrical insulation for correct performance of signalling and traction equipment's even in flooded condition during monsoon for which necessary local field visit may be done and the design should take care of return current as per traction.

SIGNALING DETAILS:

For signalling, the track circuiting is provided through the rails. The ballastless track system should take care of the same with adequate insulation. A minimum electrical resistance of 5 ohms per Km's per Indian Railway Signalling Manual needs to be ensured.

DERAILMENT GUARDS:

Suitable arrangement for prevention of derailment in tunnels & viaduct as per instructions issued by Indian railway from time to time in the form of derailment slab/block shall be provided to keep the detailed wheels in confined space and prevent damage in case of derailment. Derailment guard shall be designed such that in case of derailment:

The wheels of a derailed vehicle under crush load, moving at maximum speed are retained on the viaduct or tunnel etc.

Damage to track and supporting structures is minimum.

BALLAST LESS TRACK STRUCTURE:

Track shall be laid on cast in situ/precast reinforced plinth or slab or sleepers, herein after referred to as the 'track slab' for all purposes. The track slab shall be design as plinth beam or slab type ballastless track structure with derailment guards. Similar arrangement should be in case sleepers or any other arrangement is used. It shall accommodate the base plates of the fastening system. The minimum depth of concrete below the plate should be decided based upon characteristics of underlying base and the design of fastening system. In general, track slab/sleepers on which the fastening and rails are to be fitted shall:

Resist the track forces

Provides a level base for uniform transmission of rail force.

Have geometrical accuracy and enable installation of track to the tolerance laid down.

Ensure drainage.

Resist weathering

Be construction friendly, maintainable and quickly repairable in the event of derailment. The 'Repair and maintenance methods' shall be detailed in a manual to be prepared and made available before completion of work.

Ensure provision for electrical continuity between consecutive plinth/slab/sleepers by an appropriate design.

PERFORMANCE REQUIREMENT OF FASTENING SYSTEM

7.1 General

The fastening system shall be designed to hold the two rails of the track strongly to the supporting structure in upright position by resisting the vertical, lateral and longitudinal forces (including thermal forces) and vibrations.

The fastening shall provide insulation to take care of return current of traction system.

Fastening should satisfy the required performance norms as stated below:

The fastening shall have design service life of 30 years in general. However, its components such as rubber pad, rail clip etc. can be designed for 300 GMT or 15 years whichever is less. Anchor bolts or studs used for fixing base plate to the concrete should not be required to be replaced during service life. Its components must not suffer any degradation during service life to a degree so as to affect the performance and satisfy of the track. Full-service life is to be attained under the following conditions:

Atmosphere ultraviolet radiation.

Proximity of track up to 10m from saltwater source.

Contact with oil, grease or distillate dropped from track vehicles.

Permit quick and easy installation and replacement with special tools.

Be capable of vertical adjustment during service life up to 12mm using shims.

Detailed calculations for the number of anchor bolts/screws required on tangent and curved tracks shall be furnished by the supplier, reviewed by PMS/Engineer and approved by the Railways/ Authority Engineer.

For all fastening components as per approved assembly, the supplier shall furnish detail drawings, specifications and inspections & test plan to PMS/Engineer and Railways.

The supplier should furnish the 'Installation and Maintenance Manual which shall be reviewed by PMS/ Engineer and approved by the Railways.

7.2 Test report of the reputed independent institute or laboratory will have to be submitted. The test report should be accompanied with the drawing of the fastening system including its components which have been tested and reported upon is exactly same as the fastening system including its components that have been proposed by the bidder in the tender. The testing is to be done for Cat-'C' as specified in EN-13481Part-1 2012 & EN-13481-5:2012 with rail section to be used in proposed system, Bidder should submit a statement showing compliance or otherwise, in just aposition to each clause and sub clause of the as specified in

EN-13481-Part-1 2012 & EN13481-5:2012, subjected to review of PMS/ Engineer and approval of Railways.

7.3 The tender should submit the standard specifications, allowable tolerances, dimensions of assembly and components of fastening system. The Tenderer is also required to submit inspection test plan of all components of fastening systems.

7.4 (a) Ballast less track system or fastening system proposed by bidder shall be the same for which proneness has been submitted by bidder. Bidder shall submit performance certificate from user railway administration to the effect that ballastless track system (including fastening system) or fastening system has satisfactory performance record as mentioned in Technical Criteria.

(b) The bidder shall submit details containing but not limited to name of line in which the system is in use for minimum 5 years, details of user railway administration such as name of the railway administration and its contract person, address, telephone number, email ID etc. The bidder shall also submit details of drawing of Ballastless track system or fastening system along with its components that has been proposed by the bidder in the tender.

7.5 Indian Railways shall get the random testing of the fastening system after it has been Supplied from a reputed test lab and system should be able to meet the requirements as mentioned in this document. Cost of the same shall be borne by the contractor.

7.6 The agency will be required to submit third party inspection report for each lot of fittings for the tests conducted as specified in codes referred above. In addition, the agency will also be required to conduct one full assembly test for the actual material supplied by them at site in the presence of Railway officials. Charges of third-party inspector will be borne by Contractor. The agency will have to bear the expenses for conducting the tests.

CONSTRUCTION PROCESS:

Firm/JV are advised to visit local sites locations as specified in tender to get familiar with typical environment, Procedure of construction process of ballastless track should be mentioned in detail suitable to local site conditions. Construction process & system offered should be easy in constructions suitable to conditions prevailing on specified station in tender, clearly demonstrating how it can be constructed & installed within a reasonable time frame.

Codes, Manuals and Specifications: -

9.1 Materials or practices meeting other internationally recognized and accepted standards or codes may be accepted by the Authority Engineer at his discretions; however, any such acceptance shall be subject to the Contractor clearly demonstrating that the proposed standards or code proposed by the Contractor shall be submitted in the English language to the Engineer for his approval. Such submission must be made within (30) days of the Contractor

receiving the notice to commence, and on the completion of the Contract the submitted copies of the said standards or codes shall become the property of the Employer.

The specific codes and standards of the above-named authorities have been used in different sections of the specifications and have been specifically identified as such in each section. The Contractor shall take note of the various references to the standard codes and specifications as set out in each section of the specification and shall maintain on site for the duration of the contract, at least two copies of the latest version or edition of each standard or code to which a reference is made in the specifications.

IS 5878 (various parts)- Codes of practices relating to tunneling and underground excavations.

IS 4081-1967- safety code of blasting and related drilling operations.

IS: 4576-1978- safety code of practice for tunneling.

IS: 9103 Admixtures for concrete.

IS: 9012 Recommended practice for shotcreting.

IS: 3764- safety code for excavation work.

IS: 4138 safety code for working in compressed air.

IS: 7293 safety code for working with construction machinery.

IS: 226 structural steel codes.

IS: 823 manual metal arch welding code.

IS: 456 code of practice for plain and reinforced concrete 2000.

IS: 1786 code of reinforcement bars.

IS: 516 methods of test of strength of concrete.

IS: 1199 methods of sampling and analysis of concrete.

IS: 7861 part I, II code of practice for extreme weather concrete.

IS: 10262 guidelines for concrete mix design.

IRS: Concrete bridge code.

IS: 4990 plywood for concrete shuttering work.

IS: 2750 Specification for steel scaffoldings.

IS: 1786 specification for high strength deformed steel bars and wires for concrete reinforcement.

IS: 1893 criteria for earthquake resistant design of structures.

IS: 800 code of practice for use of structural steel

IS: 2720 code of practice for soil investigation (All parts.)

IS: 1343- Code of practice for pre-stressed concrete.

Indian Explosive Act 1984

Indian Explosive Rules 1940 1 1983

Indian Railway schedule of dimensions (BG).

Indian Railway ways & works Manual

Indian Railway Permanent way manual

Indian Railway LWR manual

Indian Railway Bridge rule.

Indian Railway concrete bridge rule.

Indian Railway sub structure code.

IRS T -12 for Rails.

IRS T-31

IS: Specifications for fine and coarse aggregate from natural sources for concrete IS: 383 of 1970 with up to date correction slips.

IS: 816-1969

IS: 817-1967

IS 1200 part XXV-1971

Relevant UIC Codes.

IS-9862

9.2 The latest addition of all the code of practice along with their up to date correction slips shall be applicable (as revised up to the date of opening/negotiation of the present tender).

9.3 In absence of relevant provision of specification in the above-mentioned IRS/IRC/BIS/EURO Codes, the reference shall be made to the best available Engineering Practice/international codes as per directions of the Authority Engineer.

9.4 The decision of Railways regarding the interpretation of specifications shall be final and binding on the contractor.

9.5 All relevant codes shall be made available by the contractor at site at his own cost

9.6 RAIL WELDING

Welding of Rails (Flash Butt) as per latest Railway specifications/codes/manuals including all tests, etc complete, is within the scope of this work.

BALLASTLESS TRACK INSTALLATION:

GENERAL

The different components of ballast-less system shall be clean and free from any dust / grease. A request for installation shall be submitted to the Authority Engineer, complete with all necessary information to allow assessment, after the following activities and approval must be received prior to the commencement of any follow-on activity.

Rates are inclusive of cement, reinforcement, admixtures etc. required to achieve desired strength/grade of concrete.

REINFORCED CONCRETE PLINTHS FOR TRACK CONCRETE LAYER AND DERAILING BLOCK.

The surface of 1st stage concrete shall be surveyed to achieve the minimum depth below the rail seat. For such of those locations where minimum depth is not achievable, the contractor shall, with complete details, seek Authority Engineer decision.

The contractor shall prepare the surface of supporting structure for laying of base slab/ intermediate slab/track concrete layer/derailing block etc. by its scrubbing the proper bounding as approved by Authority Engineer.

The laying tolerance for various track parameters for the as-installed track shall be strictly achieved in accordance with the relevant clause of technical specifications. The sole responsibility of achieving the stipulated track laying tolerance lies with the contractor.

The Track Concrete Layer (TCL) shall be laid in the track duly making the required provision for cant & vertical curve, horizontal curve for all heights. The values of cant adopted for horizontal curves shall be submitted by contractor in an agreed format for approval by the Authority Engineer.

During the concreting phase, the track fastening devices, temporary gauge holding devices, fastening and rails shall be protected by movable covers/plastic envelopes etc. against possible splattering of concrete.

Each plinth unit shall be built in one single operation, the pouring of the concrete shall imperatively be completed in one go. Formwork may be removed after 24 hours of pouring concrete.

TCL shall be cast by holding the track by temporary track holding devices which shall later be removed and the surface shall be repaired by concrete/cement mortar with addition of non-shrink compound (if required), after the concrete attains sufficient strengths.

The concrete surface of the TCL shall be smooth, devoid of any inclusion, roughness, crack, and without any aggregate visible at the surface near sleepers and in the location of track holding devices.

In TCL, the different rail panels (a group of welded rails) shall be placed with a gap required for AT welding or touching each other for Flash butt welding and holding by C-clamps in true line and level. The panels shall be welded by the other agency later on.

SCRABBLING OF OLD CONCRETE SURFACE:

In order to ensure proper bounding of TCL /De- railing Block with the last pour of tunnel concrete / TCL, the concrete in the tunnel (for the area covered by the track plinths) shall be scabbled 100% by using appropriate pneumatic scabbling tools operated by air compressors of adequate capacity. The area to be scabbled shall be marked on the tunnel by paint before taking up the scabbling. The air compressors deployed for the scabbling must be electric type and for supplying power from DG that is placed outside tunnels, sufficient length of armored power cable has to be used, unless otherwise approved by employer. After scabbling, the area shall be thoroughly cleaned of dirt / muck etc. and the muck shall be disposed off at the location advised by employer. The contractor shall get the scabbled area checked from Authority Engineer before the commencement of placement of reinforcement.

PROVIDING, FIXING OF SHUTTERING FOR THE SLAB TRACK SYSTEM CASTING AND REMOVAL AFTER THE CONCRETING

Submission of the design of steel shutting for Slab Track System casting to the employer and obtaining approval of the same from the employer.

Fabrication and manufacture of the required no. of sets for the above shuttering as per the approved design along with the tumbuckles, nuts, bolts etc and shifting of the same to the worksite. The fabrication of the shuttering shall be done only on getting approval from the employer. The employer may allow the use of old shuttering sets, only if the same are in good condition. The repair of the shuttering as directed by the employer shall be done during the execution of work in order to remove the bends, kinks etc.

Fixing of shuttering to the specified dimensions, line and level (in straight and curved portion of the track) as per drawing, survey details including providing support with tum buckles, applying shuttering oil of approved quality with brushes, fixing of tie rods — if required, tightening with nut and bolts as required including cost of tie rods as with all labour, tools tackles. Depending upon the height of the slab track the end plates shall have to be adjusted to pass the longitudinal rebar by the contractor.

Provision of opening or cut-outs in the concrete track slab as per the requirement of drainage, signalling, electrical, traction or other contractors / Railways shall be made.

Removal of shuttering after concreting, shifting to next location in contractors' own trolleys suitable for further use, cleaning of the shuttering by wire brushing, applying specified quality

of shuttering oil by sponge/brush to the shuttering plates including cost of shuttering oil, wire brushes sponge, brush

Manufacture of cover blocks of grade same as of parent concrete (with wires inserted in the same for tying to the reinforcement) with cost of all materials, curing of the same for 28 days and providing the same for shuttering in the quantity as directed by the employer. The manufacture of cover blocks shall be done in advance.

Sealing in the base of shuttering plates with approved material (sponge or foam) using cement — sand mortar including cost of all materials, tools, labour and tackles. The sealing of the joints shall be done after cleaning of the concrete slabs of slab track system.

Sealing of the shuttering joints by PVC tape I putty as instructed by the employer with cost of PVC tape I putty.

TRANSPORTATION OF RAILS

The free rails / rail panels are required to be transported to actual site of works from the stock yard. Care should be exercised during transportation of these items as any damage occurred during handling shall be debited. For transportation, the required trolleys, dip Lorries and prime movers shall be arranged by the Contractor including all tools & tackles, labour and supervisory staff. For pulling of rails, self-locking come-along clamps shall be used. The rails shall be pulled on rollers. The rail panels shall be placed on wooden battens I blocks along the sides of tunnel. The wooden battens I blocks are to be arranged by the contractor.

SETTING OUT OF TRACK

The track has to be set as per approved drawings. For setting out the track, the contractor has to use the co-ordinate system and use the Total Station with 1" accuracy. The track levels should be set accurately using Digital Level of 0.1 mm accuracy. The installation of benchmarks at suitable intervals is the responsibility of the Contractor. The Contractor is supposed to deploy a qualified surveyor having experience in Railway Track and BLT works.

The Contractor has to submit the method statement for survey work for approval by the Employer before commencement of survey work. The scope of work shall include picking up the as-built co-ordinates of the tunnel and working out the centre line coordinates in case of refinement.

The deployment of survey instruments and qualified survey staff is the sole responsibility of the Contractor.

FINAL ALIGNMENT OF THE TRACK

The track is to be set at the required gauge, longitudinal and cross-level, alignment, rail cant, super-elevation, twist etc within the specified tolerance as given in the technical specifications.

Checking the final rail level, centreline, gauge, versine, cant, cross level, super elevation etc. of the track offered for slab casting. The contractor has to deploy surveyor with an automatic level of least count 0.10 mm for checking the levels. The rail levels are to be checked at every spindle location / at every sleeper location or in between also if required by Authority Engineer.

Submission of the required checklist in the stipulated Performa to Authority Engineer covering the various aspects such as shuttering, Scrabbling, reinforcement, track parameters etc and carrying out required rectification till the section of tracks is approved by Authority Engineer.

Carrying out any welding or gas cutting required including cost of welding rod, gases, welding set, gas cutting set etc.

The contractor has to ensure that the final alignment of the track is not disturbed during the track slab concreting operations. A responsible supervisor shall be deputed for the above job.

FINAL TRACK POSITIONING AFTER THE SLAB TRACK SYSTEM CASTING:

The final positioning of the track is to be done after the completion of curing period. The following is included in the above activity:

Opening of fastening and tightening the same after cleaning as required.

Cleaning of the rail seat and repair of the rail seat, wherever required. The above work shall be done only as per the approved methodology. The repaired rail seat shall be cured for the 14 days with water curing or with approved quality curing compound.

Checking of the final track parameters and carrying out necessary corrections in the track to bring the track to the correct parameters. For the track correction the contractor shall deploy required compressors, generators etc. including its operation and maintenance.

Offering the track for final checking for gauge, level, cross-level, super elevation, cant etc.

Submission of final track parameters to Authority Engineer in prescribed Performa.

MAINTENANCE AND PERFORMANCE MONITORING:

The defect liability period will be for 36 (Thirty-Six) months after the date of completion of work or 24 (Twenty-Four) months after commission of track, whichever is later.

After construction of Ballastless track, Zonal railway will monitor the performance jointly with firm/JV on quarterly basis & for three years. The performance monitoring will be based broadly upon following parameters:

Efficacy of fastening: Fastening system should be able to maintain track geometry (gauge, level, loose fitting etc.) at all times within track tolerance during service without any components breakage, excessive wear & tear.

Track tolerance to be maintained at the time of construction & during trial/ service should be as per Para 2.1 (xiii).

Any track settlement which impairs the functionality of track & washable apron.

Any visible crack of width more than as stipulated in IRS concrete Bridge code — Para 10.2.1) in concrete I RCC portion of slab impairs the functionality of ballast less track.

Any special observation.

The decision of zonal railway about performance of the Ballastless track after monitoring period shall be final.

SUPPORTING OF TRACK DURING CONSTRUCTION

During construction, the track shall be supported by auxiliary fitting at every third sleeper/Base Plate in straights and every second or as required in curves.

DE-STRESSING OF CWR

General

The de-stressing of rail shall not be undertaken until it has been demonstrated to Railways satisfaction that the track has been completed to specified standard and specification and the method of working of de-stressing of the relevant track form has been approved by Railways.

The elementary long welded rail shall be placed on rollers placed on the metal base plates or sleeper rail table, with the rollers at maximum 6M intervals. In any case, rollers shall have suitable diameter to avoid contact between rail and intermediate sleepers/ de-railing block.

After placing the long-welded rail on rollers, it shall be stress relieved by hitting the rail on each side of the head with wooden mallets as approved by Authority Engineer.

For distressing of CWR, guidance may be taken from LWR manual of Indian Railways.

The rails of continuously welded track shall be distressed in accordance with temperature conditions as per Railway manual.

RAIL WELDING

Welding of Rails (Flash Butt) is within the scope of this work.

RECORDS

The manual records of Rail level, cross-level/ cant, gauge, twist, versine along longitudinal location and horizontal alignment with reference to the designed locations shall be presented in hardcopy and the soft copy shall be prepared by survey team.

FINAL TRACK PARAMETER

Finally, the Tracks are to be installed as per IR Specification, latest SOD and requirements and should obtain approval of Railways for further installation.

Explanatory Notes and Tunnel Lightings

SITE INSPECTION:

The tenderers must inspect the site thoroughly and acquaint with the conditions & circumstances before quoting. Later on, no claim shall be accepted.

2. STAFF DETAILS:

The contractor should submit the name, qualification and experience of the engineers, supervisors and skilled staff having license & competency certificate to be employed by them along with their identity card to Authority Engineer and record in site register-cum order book. Only after the approval of competent authority the above personnel will be allowed to execute the work at site. Any changes in personnel employed at any site have to be duly got approved from the Railways by contractor. The delay caused in execution will be on contractors account.

3. SITE OFFICE/STORES:

The contractor is further responsible to built their own Office/stores at the vicinity of the work. The Railway is not responsible for providing any site for Office/Stores for the contractor to execute the work.

4. LIST OF CONSIGNEE:

On behalf of the Railway's Jurisdiction of the work, the following is the list of officer/consignee.

The consignee for the work shall be concerned Authority Engineer as such officer in executive charge of the work who is responsible for ensuring that all the work covered under this contract are carried out in accordance with the approved design drawing and specification as agreed to .

5. Technical Specification.

5.1 All the works shall be carried out as per latest Indian Standard specification/Indian Electricity (ISS/IE) Rules, materials supplied as per relevant Indian Standard Specification (ISS) or Latest and approved drawing. Work should be carried out neatly.

5.2 For all the items in the schedule, ACTM, IRSOD, RDSO/CORE or CEE/ECOR or IS specifications will be followed as indicated unless/otherwise specified in the schedule/ Explanatory notes.

6. Drawing: Supply and preparation of drawings is within the scope of agency as per Railways specifications and guidelines.

7. Inspection:

7.1 The makes of all materials to be supplied by the contractor under contract are to have prior approval of Authority Engineer before taking procurement action. Approval should be obtained immediately after receipt of LOA. In no condition the materials procured without approval of Authority Engineer will be allowed to be used at site. The materials should be procured from Part I approved sources of RDSO/CORE only as per current vendor directory or from OEM or his authorized dealer approved by Authority Engineer before taking procurement action and documentary evidence in this regard has to be submitted to Railway in this regard.

7.2 All materials to be supplied by the contractor have to be inspected by RITES or Railway Officials as nominated by the Authority Engineer. The contractor will bear the inspection charges if any.

7.3 The Railways authorized representative shall be free to visit the manufacturer's work/s at all reasonable times to witness and inspect the testing of equipments. The equipments to be supplied are to be tested as per relevant IS/BS specification. The contractor shall furnish three copies of manufacturer's test certificate for the routine and type tests conducted for equipments offered. If necessary the contractor shall arrange to conduct all the routine tests at the manufacturer's premises in presence of Railways' Authority Engineer.

NOTE:L.T Panels, Distribution Board etc. shall be inspected at manufacturer's premises. The materials which are erected in high structures like towers, poles, panel Boards etc. are to be inspected at site by the authorized Railway representative before erection even though the same has been inspected earlier. On receipt of the equipment/materials at site the contractor shall offer these equipment/materials for inspection of Authority Engineer and under no circumstances the materials shall be erected/commissioned without the approval of Authority Engineer.

8. Execution

8.1 All works are to be carried out as per Indian Electricity Rule with latest amendments and relevant ACTM, RDSO/CORE or IS or CEE specifications and/or drawings.

8.2 The Railway has right to supply any item without any limits even though it is covered under the scope of supply by the contractor. The quantities to that effect will be reduced from the scope of supply accordingly.

8.3 While drilling holes on the Web of the Non-Track circuited Rails for providing all types of Traction Bonds, Gas Cutter shall not be used under any circumstances. Hand/Electric driven Ratchet with suitable Drill bit shall only be used for drilling holes on the rails. The contractor should ensure that, holes on rail for bonding are properly chamfered, holes are made with good workmanship and holes do not have any sharp edges or cracked at the periphery of hole, to avoid point of stress concentration. Hole drilling should be done as per the latest RDSO specification No: ETI/OHE/P/7000 (Rev-F) or latest.

8.5 The contractor shall dress up/repair the site as per the existing surrounding ground/floor/ walls/road. If any minor alteration is necessary, the contractor shall do the same without any extra cost.

8.6 The contract will be governed by Indian Electricity Act 1961 & IE Rule-2003.

9. PRE-COMMISSIONING INSPECTION ON EQUIPMENTS:

The pre-commissioning inspection of various equipment like L.T panels, copper wires, piano type/modular switches, socket etc. including wiring materials such as PVC pipe, boxes and switch Boards, ceiling rose, Angle/batten holder, kit kat fuse/MCB shall be carried out jointly by the contractor with Railways' representative and under no circumstances the above items can be energized without approval of Railways' Engineer. A site register to be maintained by the contractor for recording these tests/inspections duly signed by authorized contractor's supervisor and Railway Authority Engineer.

11. TESTING OF INSTALLATIONS

After successful completion of the entire work/installation a certificate should be furnished by the contractor that the whole work have been carried out as per tender specification. The entire installations are to be tested in accordance with the latest guidelines. The details and data of testing of installations are to be recorded in a register duly signed jointly by the competent representative of contractor and consignee and to be kept at site camp office.

TECHNICAL CONDITIONS FOR TUNNEL WORKS

The principal items of work to be executed under this contract are:

Earthwork in open excavation in all kind of soils and rock etc., Underground excavation for tunnel including temporary provision at the portal etc. Supply, drilling, installation, grouting of all type of rock bolts, Supply, drilling and installation and grouting of fore poling etc.

©Making up reinforcement bar including cutting, hooking, threading etc. Fabrication and erection of lattice girders and all accessories etc.

(d) Shotcrete with designed mix cement concrete in prescribed grade etc.

Design mix Cement Concrete of prescribed grades in RCC & CC works etc., Machine mixed No fines porous concrete in tunnels etc.

Supply of reinforcement bar including cutting, hooking, bending, binding, placing etc.

Providing & fixing of 150×150×6 mm welded wire fabric as reinforcement in primary lining etc.

Supply of Lining Stress Controllers (LSC) etc., Supply of lattice Girders and all accessories including all lead etc.

Providing & installing PVC/HDPE pipes, Drilling holes of various diameter, in concrete/rock/soft ground, Grouting (Cement), Providing, laying & fixing Pipe/Protective felt (geo-textile)/PVC or ECB water proofing, Longitudinal & Transversal earthlings, Cable Ducts of PVC pipe, Pumping water, Rotary core drilling 'NX size, etc.

Drilling of 40mm diameter holes in Shotcrete lining etc., Drilling of 40mm diameter drainage boreholes in rock etc., Exploratory drilling & Drainage holes up to 35m length, 10m overlap etc., Drilling for installation of monitoring instruments up to 90mm diameter in all kinds of rock etc.

Pumping of Water by furnishing, transporting, installing the equipment etc.

Grouting (cement) for ground improvement of filling of voids etc.

Supply of cement 53 grade OPC of approved quality etc. Providing boulder filling, supplying spreading & compacting hard stone, Making, supplying, weaving, shaping & placing wire sausage crates, Providing 1800mm NP-4 RCC pipes etc.

DECLARATION

The information provided are for general guidance only. The tenderers are advised to visit the site themselves and make themselves aware and conversant of all the data relating to site including availability and rates of all labour and materials, service road, land for camp sites and

arrangements for water, climatic conditions, labour laws, power situation, water availability, transport problems etc.

DRAWINGS FOR CONSTRUCTION OF TUNNELS BY UNDERGROUND EXCAVATIONS & CUT AND COVER METHODS

Trolley refuges and man refuges shall be as per requirements of Indian Railway Permanent Way Manual and as per approved Railway drawings. The cross-section of the tunnels and cut and cover in any portion shall be as per the clearance laid down in the "Schedule of Dimensions" for single line broad gauge electrified section. The construction of tunnel and cut and cover if any shall be as per Railway drawings, GAD's of Tunnels have been enclosed.

LIST OF CODES TO BE FOLLOWED

Construction shall be as per various codes of practice of BIS, IRS and IRC; some of them are mentioned below for guidance. The following list is for guidance and is by no means exhaustive and provisions of relevant codes even not mentioned below shall be binding on the contractor. In case of contradictions between provisions of various codes or between codes and clauses mentioned in this document, the decision of the Authority Engineer shall be final and binding on the contractor.

IS 5878 (various parts) - Codes of Practices relating to Tunnelling and Underground Excavations

IS: 4081 – 1967-Safety Code of Blasting and related Drilling Operations.

IS: 4576 – 1978-Safety Code of practice for Tunnelling.

IS: 9103 Admixtures for Concrete.

IS: 9012 Recommended practice for Shotcreting.

IS: 3764-Safety Code for excavation work.

IS: 7293-Safety Code for working with construction machinery.

IS: 2062 Structural Steel Codes.

IS: 823 Manual Metal Arc Welding Codes.

IS: 456 Code of Practice for Plain and Reinforced Concrete 2000.

IS: 1893 Criteria for Earthquake Resistant Design of Structures.

IS: 800 Code of Practice for use of Structural Steel.

IS: 2720 Code of Practice for Soil Investigation (All parts).

IS: 1343 Code of Practice for Pre-Stressed Concrete.

IRS: Indian Railway Concrete Bridge Code.

IRS: Indian Railway Standard for Sub-Structure Code.

Indian Congress specifications for Road & Bridges.

Indian Explosive Act 1984

Indian Explosive Rules 1940 / 1983.

Indian Railway schedule of dimensions (BG).

Indian Railway works Manual & Indian Railway P.Way Manual.

IS: specification for fine and coarse aggregate from natural sources for concrete IS: 383 of 1970 with up-to-date correction slips.

IRS Bridge rules.

IRS Sub-structure code.

IS 816-1969: Code of Practice for use of metal arc welding for general construction in mild steel (first revision) (Amendments 2)

IS 1200 part XXV – 1971: Method of measurement of building and civil Authority Engineer works: Part 25 Tunnelling (Second Revision) (Amendment 4)

IS 10262 code of practice for concrete mix design.

IS 13365-1 : Quantitative classification system of rock mass

Notes:

The latest edition of all the codes of practice along with their up-to-date correction slips shall be applicable. (As revised up to the date of opening/negotiation of the present tender).

In absence of relevant provision of specification in above-mentioned IRS/IRC/BIS Codes, the reference shall be made to best available Engg. Practice / International codes as per direction of Authority Engineer.

The decision of Chief Engineer/Const. regarding the interpretation of specifications shall be final and binding on the contractor.

All relevant codes shall be made available by the contractor at site at his own cost.

SAFETY

The Contractor at his own cost shall provide upon the works to the satisfaction of the Authority Engineer and at such places as he may nominate, proper and sufficient lifesaving, fire fighting and first aid appliances which shall at all times be available for use.

All the safety precautions for open and underground excavation as per relevant ISI codes as well as 'Safety Manual' published by National Hydroelectric Power Corporation, Delhi shall be observed by the contractor / tenderer.

Besides above the contractor/tenderer shall be bound to carry out the other instructions of Authority Engineer may deem necessary for safety arrangements.

The contractor's responsibility for safe working shall not be limited to any instructions as may be given to him by Authority Engineer. The contractor/ tenderer also shall on his own ascertain and adopt all necessary safety precautions.

The cost of all safety arrangements including cost of all labour and material, tools and plants and shuttering/ scaffolding/ shoring wherever required is deemed to have been included in various rates quoted in schedule of items, rates and quantities and nothing extra is payable under this contract.

Work in vicinity of High-Tension Lines and Sources of Electro Magnetic Radiation: Special precaution are necessary, specially so when blasting is to be carried out, in the vicinity of high-tension electric lines and sources of electromagnetic radiation. All rules and procedures laid down by Electricity Authority in this regard shall be strictly followed.

VENTILATION

The Contractor shall design, install and operate ventilation system for the Underground Works and provide an underground atmosphere monitoring system.

The Contractor shall check and record concentrations of noxious or other harmful gases and dust throughout the works at every shift. Allowable concentrations shall be as stated in the applicable laws/standards for underground construction. All items of inspection records and automatic record data of instruments shall be included in a daily working report and shall be maintained for the duration of the works.

All parts of the Works shall be maintained in a state which will not be injurious to the health of the personnel. The air in underground works shall contain no less than 20 % oxygen (by volume) and shall not contain concentration of gases, vapours or dust greater than that which is safe for the health or workmen, having regard to the effects of time, temperature, humidity and the combined effects of contaminants.

The ventilating system shall be kept in operation also after break-through in tunnels in order to maintain the fresh air- volume requirements stated hereinafter.

Intermediate fans attached to the main duct line shall be provided as required to ensure satisfactory removal of contaminated air. All ventilation ducts shall be maintained in an airtight condition.

Ventilation ducts shall be firmly fixed to the vaults in such position that a minimum clearance of 20 cm remains between the duct and the extremities of vehicular traffic employed in the Underground Works.

The CONTRACTOR shall ensure the required quantity of fresh air at the heading face. The check of the air-tightness or joints and control of the air ducts for leaks shall be performed periodically. Any deficiency discovered or reported by the Authority Engineer shall be immediately repaired by the CONTRACTOR.

No work shall be permitted to be carried out unless the ventilation is provided to the satisfaction of the Authority Engineer.

Ventilation System for Tunnel Excavation

Operational requirements:

The ventilation system used may be either an exhaust or forced fresh air system or a combination of both.

Exhaust ventilation: Blasting fumes shall be extracted as close as possible to the excavation face. Exhaust air and blasting fumes shall be discharged sufficiently away from the portal areas in such a way that they will not be re-used in any other working place or re-circulated in the fresh air supply system.

Forced fresh air ventilation System shall be adopted during the tunnel construction.

All labour shall be evacuated from the heading face area to a safe place before blasting and re-enter the heading face area only after blasting fumes have been completely removed from the working area by ventilation.

Blasting fumes shall be discharged from the underground works into a filter system or diverted adequately to ensure that concentrations of noxious or other harmful gases or dust are kept to the minimum limit as stated in the applicable laws/standards or the limits specified in the contract.

All equipment and ventilation duct shall be maintained in sound working order at all times. Any damage to ventilation duct shall be repaired within 12 hours of the damage.

During excavation by hand or machines without use of explosives the ventilation system shall provide the fresh air quantity requirements listed below in Clause: 0 at all times in the underground works.

For effective control of air pollution caused by machinery exhaust, the CONTRACTOR shall select machinery and vehicles in good condition and maintain them in good condition.

Gasoline-operated equipment for underground work is not permitted.

All diesel engines used in the underground works shall be provided with means, which shall be maintained in efficient order, of cooling exhaust gases and reducing the concentration of toxic gases to acceptable levels, filtering particulates and preventing emission of flames or sparks.

Ventilation ducting shall be of non-combustible material

The ventilating system shall be of such efficiency that the average air velocity in the largest excavated profile is not less than 0.3 metre per second. In case the presence of methane gas is detected or suspected, this value shall be increased to 0.5 metre per second.

The quantity of air supplied for ventilation shall not be less than 4.25 cubic meters of free air per minute per person in tunnels. Each diesel kilowatt (kW) of power applied for plant and equipment underground shall require a minimum of 3.5 cubic meters per minute of air supply. These fresh air volumes shall be cumulative and the CONTRACTOR shall allow, in his design calculations, for the maximum number of persons and diesel-powered equipment deployed in the Underground Works at any one time. Any estimated losses, e.g. due to the leaks in the ducts, shall be added to the figures stated above.

The following are maximum allowable concentrations of some common hazardous gases:

H ₂ S	10 ppm	(8h)
SO ₂	2 ppm	
CO	50 ppm	
NO	25 ppm	
CO ₂	5000 ppm	

Silica dust concentration.....10 mg/m³

Instruments to register the concentration of common noxious gases (CO, NO, CO₂), flammable gases, dust and oxygen, etc. shall always be available on the site in good working order, condition and in sufficient numbers. These shall be supplied, maintained and used throughout the duration of the underground work.

Where any concentration of methane is found to be present, precautions against flames, sparks and overheating shall be enforced including prohibition of burning, welding and of smoking. If concentrations cannot be kept consistently below 0.25 % in the general body of the air, explosion protection of equipment shall be provided.

When a methane concentration of 1.25 % is present, all persons other than those essential for safety shall be withdrawn from all parts of the tunnel. The use of explosives and locomotives shall be prohibited and all electrical equipment not intrinsically safe shall be disconnected.

All persons shall be withdrawn if the methane content exceeds 2%.

Control of Dust, Silica and Noxious Gases in Underground works

The CONTRACTOR shall install and operate equipment for the monitoring and control of dust, silica and noxious gases in Underground Works as described herein under.

Dust and Silica

To reduce the amount of dust, only wet drilling will be allowed and during mucking, muck piles shall be kept constantly damp by sprinkling with water. The use of high pressure water jets for this purpose will not be permitted.

The CONTRACTOR shall measure and monitor the concentration of fine dust and content of silicon dioxide (SiO₂) in all dust producing underground operations by a method to be approved by the Authority Engineer.

Air Samples for this purpose shall be taken within 10 days of commencing underground excavation, at 30 days intervals thereafter and within 20 days following major changes in tunnel excavation operation, or whenever required by the Authority Engineer. Samples shall be taken from actual working areas. The sampling and testing shall be performed by a qualified person or laboratory to be proposed by the CONTRACTOR and approved by the Authority Engineer. A copy of the test results shall be submitted to the Authority Engineer within 2 weeks of the sampling date.

The concentration of fine dust (diameter less than 0.005 mm) may not, in general exceed the value of 8.0 mg/cum of air and in relation to the silicon dioxide content in the rock this value is lowered as follows:

Content of SiO ₂ in fine dust In percent by weight	Concentration of fine dust in Milligrams per cum of air
1-5%	8.0 mg/cum
20%	6.0 mg/cum
30%	4.0 mg/cum
60%	2.0 mg/cum
80%	1.5 mg/cum
100%	1.3 mg/cum

Should the concentration of the fine dust exceed the limits stated above, the CONTRACTOR shall undertake such necessary measures and install such additional equipment which will ensure that the dust concentrations are within the specified safe hygienic limits.

Noxious Gases

Use of internal combustion engines, other than approved mobile diesel-powered equipment will not be permitted in underground construction Sites.

The CONTRACTOR shall provide and maintain equipment for measuring and monitoring the content of noxious gases and oxygen at each heading face throughout the duration of excavation works. Tests for determining concentrations of carbon monoxide, carbon dioxide, nitrogen dioxide, methane, other inflammable gases, and oxygen shall be made before and after each blasting and at the beginning of each shift by qualified personnel. A record of reading shall be maintained and be made available to the Authority Engineer as and when asked for.

Gas concentrations in underground Sites may not exceed the following limits:

0.005 %	(Fifty ppm) of carbon monoxide
0.5 %	(Five thousand ppm) of carbon dioxide
0.0005 %	(Five ppm) of nitrogen dioxide
0.001 %	(Ten ppm) of hydrogen sulphide
0.1 %	(One thousand ppm) of methane
0.01	milligrams per litre of nitrous oxide

Concentrations of other inflammable gases shall not exceed 40 % of the lower explosive limit at the heading face and 20 % of the lower explosive limit elsewhere in the tunnel.

If concentrations of noxious gases or other inflammable gases exceed the permissible limits set forth above, all operations shall be interrupted immediately and personnel shall be removed to a safe area. All sources of ignition shall be extinguished or removed. All equipment with the exception of ventilation equipment shall be shut down.

LIGHTING

The whole of the approaches, tunnel face and inside the tunnel where plants and machinery is operational and where labours are working shall be adequately lighted by Electric light by the Contractor at his own cost.

The CONTRACTOR shall install, operate and maintain a lighting system in the underground works during construction. The lighting intensity along the tunnel shall be at least 75 lux.

Each working face shall be brightly illuminated by one or more additional high intensity movable lamps. Emergency lighting equipment shall be placed within 100 m of the face.

Suitable high-intensity movable lamps shall be provided by the CONTRACTOR to illuminate any area in the underground works where testing or other inspection is carried out. The

CONTRACTOR shall install a switch connector at every 50 m along the tunnels to provide lighting for the surveying and monitoring work.

Burned-out fluorescent or incandescent lamps shall be replaced every shift.

Burned-out high intensity lamps shall be replaced as soon as possible from a reserve stock, which shall be kept as close as practicable to the working face.

All lighting shall be weather-proof.

Upon completion of the work, all temporary lighting systems shall be left in place by the CONTRACTOR, with the exception of the power supply source.

SETTING UP OF FIELD LABORATORY

1. The Contractor shall establish a field laboratory for ensuring quality control measures for the Works. The Contractor shall submit a list of testing equipment together with his bid.

2. 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 Railways 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.

3.0 Upon receipt of Railways' approval, the Contractor shall construct, maintain and operate an integrated laboratory which provides sufficient rooms and equipment to test aggregates, concrete samples, soil and rock samples etc. The laboratory shall be established as early as possible as but not later than three months from the date of issue of Letter of Acceptance.

4.0 The Contractor shall collect the samples, carry out the relevant tests, prepare the complete reports and submit them to the Railways.

Concrete Laboratory: This laboratory shall be of the size and equipped with all testing facilities recommended in Indian or other equivalent standards.

6.0 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.

7.0 The laboratory shall be provided with light, ventilation, water supply, tank for curing, toilet, etc. and be spacious enough in order to store the test samples.

COMMUNICATION SYSTEM

1.0 The Contractor shall install and maintain in operating condition, communication system by telephone or preferably an underground radio system approved by the Railways between each face and entrance to the underground works.

2.0 This communication system shall have its sources of energy independent of the energy supply for underground works.

3.0 The availability of the communication between tunnel and above ground shall be ensured at all times throughout the duration of the underground construction.

4.0 Authorized employees of Authority Engineer shall have free use of such communication and signal facilities.

The entire cost of providing and maintaining such a communication and signal system shall be deemed to have been included in the unit rates tendered for underground works in schedule of item rates and quantities.

PAYMENT FOR SITE INSTALLATIONS AND SERVICES

All costs for mobilization of Constructional Plant and materials to the Site, planning, designing, installing, operating, maintaining and removal of all temporary works, site installations, and other misc. services and facilities as specified in this section, making submittals to the Railways, recruiting and transferring staff, obtaining rights of way, providing and maintaining access roads, provision of captive power generation along with 100% power backup for construction purposes, clearing and grading areas for temporary facilities, and any other costs involved in preparation to carry out the Permanent Works shall not be paid separately, but shall be deemed to have been included in his quoted rate.

SURVEYING:

1.0 The Contractor shall render all services for topographical surveys and measurements required for the performance of the Work.

2.0 These services cover in general 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 Invoicing.

3.0 Such surveys shall be based on the control points, center line, bench marks already established in the project area.

4.0 It shall be the Contractor's responsibility to check the nets and their compatibility over the whole project area and to perform the tunnel survey so that the tunnel alignment remains within the specified accuracy.

The Contractor shall specify all his equipment for surveying works in his Method Statement.

The Contractor shall have the overall responsibility for all surveying works.

MATERIALS AND INSTRUMENTS

1.0 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.

2.0 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.

3.0 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 duly accompanied with "Fit to use" and "Permanent adjustment carried out" certificate by the manufacturer valid at the start of works.

4.0 During the construction period the survey instruments shall be checked and, if necessary, adjusted/calibrated at regular time intervals.

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.

The number of sets of instruments shall be sufficient to meet the requirements of the construction time schedule. Delay of start of construction or construction progress caused by insufficient quantity and quality of survey equipment including provision of professional staff shall be at the Contractor's responsibility.

EXECUTION OF THE SURVEY

For the execution of the survey/ setting out for work the Contractor shall employ and provide experienced professionals and auxiliary staff. All survey and measurement work shall be properly recorded and filed thoroughly.

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

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

The Railways 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.

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 Railways whenever requested.

If, in the opinion of the Railways, 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 Railways at the Contractor's expense. The Contractor shall be solely responsible for accuracy of Survey maps and drawings prepared out of the surveys.

PREPARATORY WORKS FOR SURVEY

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 monuments, taking into consideration future construction work which may affect the survey: points, monuments and benchmarks. Based on these investigations, a survey plan shall be developed comprising existing basic data, the survey grid to be developed, the equipment 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 Railways in charge for approval.

SURVEY OF GROUND PROFILES

1) All survey / setting out works shall be done with greatest care and precision.

2) Original Ground Profiles

3) The Contractor shall inform the Railways 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 Railways over the entire area to be occupied or disturbed. Such survey may again be required after removal, of vegetation, topsoil or other overburden. The information so obtained shall be recorded by the Contractor and the Railways. The Contractor shall then provide the Railways with a non-shrinkable and reproducible copy of each drawing (on RTF) to serve as a permanent record of the purpose of determining the quantities of excavation or earthworks carried out in the construction of the permanent structures, and the extent to which Temporary works shall be removed or temporary excavations shall be refilled upon completion of the works.

4) The Contractor shall survey all excavated and final surfaces for the purpose of recording as constructed details, and for the measurement of quantities.

on completions of excavation and prior to placing concrete or other work;

on completion of works.

SETTING OUT OF WORKS

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

2)The number of points required for setting out as well as between these points shall be determined by the Contractor in accordance with the type of work. The Railways 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.

SETTING OUT CHECKS

1)The Railways will perform check surveys during the course of construction and the Contractor shall cooperate with and provide assistance to him as required.

2)The Contractor is expected to liaise with the Railways 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 Railways, every cooperation and assistance in this regard including but not being limited to the provision of survey equipment, drainage, lighting, ventilation and the removal of Contractor's equipment and other obstructions such that they do not interfere with the setting out checks.

TUNNEL ALIGNMENT AND GRADIENTS

The Contractor shall establish and maintain at suitable distances from tunnel portal at least two (2) reference monuments and benchmarks on the extended tunnel axis/alignment, to warrant that control surveys during "tunnel construction can always be referred to such reference monuments. They shall be secured by auxiliary fixed points permitting the location control of the reference monuments in case these have suffered during tunnel excavation periods.

Establishing and control surveys of the tunnel alignment and the gradient shall always be referred to such reference monuments.

Underground alignment and level survey and control thereof shall be performed by the use of suitable precision instruments preferably of the pulsed laser type of equivalent instruments, and auxiliary equipment. Underground survey equipment and methodology shall be subject to the approval of the Railways.

TOLERANCES

a) The tolerance given below 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) Determinations of centre lines for alignment of tunnels shall meet the following criteria:

10 mm / Km horizontal and vertical offset of the tunnel axis

max. 25 mm horizontal and vertical offset of the tunnel axis at the break- through points of the headings

d) Slopes and Slope displacements must be measured with an accuracy of +5mm.

SUBSIDIARY MONUMENTS AND BENCHMARKS

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

HANDING-OVER OF BASIC SURVEY DATA

General Requirements

a) Prior to the commencement of the survey work, the Railways shall hand over to the Contractor all information and data of the survey, benchmarks and control points 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 and accuracy 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 Railways of this fact, and the Railways shall give instructions regarding the re- establishment of such datum points and bench-marks.

c) Should it become necessary that basic datum points and benchmarks be removed because of foreseeable construction works, the Contractor shall inform the Railways 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, upon handing over, inconsistencies within the datum points, benchmarks and control points are detected by the Contractor, he shall inform the Railways immediately thereof and produce the evidence. The Railways 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 or the existing points, and meet the accuracy requirements.

Data and Documents Available

a) Existing topographical maps issued by client covering the area of the works can be made available to the Contractor upon request to the Railways.

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. Surveys works for his construction roads also shall be performed by the Contractor including preparation of maps.

Survey Records and Documentation

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 Railways put at his disposal all records and documentation or provide copies thereof in any format as directed.

PRIMARY TUNNEL SUPPORT

This section covers the requirements for the selection of materials, type, strength & quality required and its method/procedure and application in the primary tunnel support which are necessary for tunnel lining etc. to achieve the stability of the excavated tunnels.

General Requirements: Construction Method

The CONTRACTOR shall understand the technique and design concepts of the construction method, the function and adequacy of each component of the tunnel support.

Submissions

Prior to the commencement of works, the CONTRACTOR shall submit to the Authority Engineer for approval a comprehensive programme for material testing and quality assurance plan (QAP) covering all elements of the tunnel support before, during & after the execution.

Manufacturer's certificates certifying that the materials used meet Specification requirements shall be submitted.

The method of installation of each type of support element including description, Specification and pertinent manufacturer's literature for drilling, rock bolting etc. shall be submitted by the CONTRACTOR to the Authority Engineer.

Records

Comprehensive records containing all particulars of the tunnel support actually installed and its performance in the course of work shall be prepared and maintained by the CONTRACTOR and made available to the Authority Engineer. These records shall include type, quantity and location of support elements installed, the clearance profile after installation of support, deviations from the standard support systems, observations of excessive deformations, Shotcreting cracking, etc. Observations of excessive deformations, Shotcreting cracking shall be notified immediately to the monitoring agency engaged by railway / the Authority Engineer.

The CONTRACTOR shall keep a record of the chainage of each face position and shall update it as the face progresses and this record shall be available for consultation at any time.

All the above records will be submitted by the contractor daily to the Authority Engineer for approval.

Implementation of Tunnel Support Work

The type and amount of tunnel support to be installed immediately after excavation is directly related to the rock classification as established. The standard primary support associated with

the established rock classification system is shown on the drawings. However, as a consequence of deviations from the anticipated rock conditions, the standard support systems may require modifications / adjustment during construction as directed by the monitoring agency engaged by railway approved by the Authority Engineer

The CONTRACTOR shall ensure that support elements will be installed or applied in such a manner and sequence so as to prevent avoidable disintegration and loosening of the rock mass surrounding during excavation.

Equipment and Material Supply

Plant and equipment required for installation of underground support shall confirm to current Indian safety regulations & adequate capacity and specified performance to fulfil production requirements in terms of the construction programme.

Proper maintenance of equipment and adequate provision of spare parts shall be ensured by the contractor for support installation whenever underground excavation works is in progress.

Unimpeded supply of materials to all working faces required for support construction shall be ensured at all times. For excavation in poor rock, this is an essential pre-requisite for ensuring safety of tunnel construction.

The CONTRACTOR shall provide each tunnel heading with the necessary materials and equipment to deal quickly and effectively with emergency situations, such as unexpected unstable rock conditions, heavy water inflows etc., which cannot be handled with the regular procedures of tunnel support installation.

The CONTRACTOR shall maintain on site or have immediately available at least one month's supply of any of the support elements required according to the rock classification as per the drawings and work programme to avoid delays.

The CONTRACTOR shall maintain constant and adequate supply of Shotcreting and required T&P at tunnel face during excavation.

The CONTRACTOR shall Provide adequate means of identifying the materials delivered to the site with the corresponding certificates. The identification shall remain with the material up to a convenient location adjacent to the element for which it is intended.

Shotcreting for Primary Lining

General

Shotcreting shall be wet mix Shotcreting unless otherwise directed by the Authority Engineer. This Section specifies basic and minimum materials and construction standards for coarse-aggregate Shotcreting (both wet & dry type) for use as structural support for underground works and for application on excavated slopes.

Standards

Shotcreting/Steel Fibre Reinforced sprayed concrete materials, production methods or application testing and admixtures shall conform to the RDSO specification (Guidelines for Design & Construction of Tunnels: -RDSO/2012/GE: G-0017)/Indian Standards with latest correction or, where not covered by these standards, should conform to the equivalent International Standards. In case of conflict between the standards and the specifications given herein, the decision of Authority Engineer shall be final & binding.

Shotcrete materials, production methods or application testing and admixtures shall conform to the following Indian Standards or, where not covered by these standards, to the equivalent International Standards. In case of conflict between the following standards and the specifications given herein, the specifications shall take precedence and the decision of Authority Engineer shall be final & binding.

Indian Standard:

IS: 456 – 2000, Plain and Reinforced Concrete - Code of Practice

IS: 269 – 1989, Specification for 33 grade ordinary Portland cement

IS: 383 – 1970, Specification for coarse and fine aggregates from natural sources for concrete

IS: 516 -1959, Method of test for strength of concrete

IS: 9012 – 1978 (Reaffirmed 1987), Recommended practice for shotcreting

IS: 2645 – 2003, Integral Waterproofing Compounds for Cement Mortar and Concrete - Specification

IS: 9103 – 1999, Concrete Admixtures - Specification

IS: 12269 – 1987, Specification for 53 grade ordinary Portland cement

IS: 8112 – 1989, Specification for 43 grade ordinary Portland cement

European Standard:

European Specification for Sprayed Concrete, EFNARC 1996

EN 480-12 Admixtures for concrete, mortar and grout. Test methods. Determination of the alkali content of admixtures

EN 14889-1 Fibers for concrete - Part 1: Steel fibres - Definitions, specification and conformity

UNI EN 14487-1:2006 Sprayed concrete - Part 1: Definitions, specifications and conformity

UNI EN 14487-2:2007 - Sprayed concrete - Part 2: Execution

UNI EN 14488-1:2005 Testing sprayed concrete - Part 1: Sampling fresh and hardened concrete

UNI EN 14488-2:2006 Testing sprayed concrete - Part 2: Compressive strength of young sprayed concrete

UNI EN 14488-3:2006 Testing sprayed concrete - Part 3: Flexural strengths of fibre reinforced beam specimens

UNI EN 14488-4:2005 Testing sprayed concrete - Part 4: Bond strength of cores by direct tension

UNI EN 14488-5:2006 Testing sprayed concrete - Part 5: Determination of energy absorption capacity of fibre reinforced slab specimens

UNI EN 14488-6:2006 Testing sprayed concrete - Part 6: Thickness of concrete on a substrate

UNI EN 14488-7:2006 Testing sprayed concrete - Part 7: Fibre content of fibre reinforced concrete

UNI EN 14721:2007 - Test method for metallic fibre concrete - Measuring the fibre content in fresh and hardened concrete

UNI EN 934-5:2008 - Admixtures for concrete, mortar and grout - Part 5: Admixtures for sprayed concrete - Definitions, requirements, conformity, marking and labelling

American Standards for Testing Materials:

ASTM C150 - Standard Specification for Portland Cement

ASTM C33 - Standard Specification for Concrete Aggregates

ASTM A820 - Standard Specification for Steel fibres for Fibre-Reinforced Concrete

ASTM C 1018-89 – Standard test method for flexural toughness and first crack strength for fibre reinforced concrete

American Association of State Highway and Transportation Officials (AASHTO):

AASHTO T26 - Standard Method of Test for Quality of Water to be used in Concrete.

British Standards Institution:

BS 5328 – Methods for specifying concrete, including ready-mixed concrete

Definitions

Shotcrete is concrete which is conveyed to the place of installation in a closed hose or tube, applied and compacted by jetting onto a surface at high velocity from a nozzle to produce a dense homogeneous mass.

Wet shotcrete method is mixture of cement and aggregate weigh batched and mixed with water at site or in mixer trucks prior to being conveyed through a pipeline to a nozzle where air is injected and the mix projected without interruption into place.

Dry shotcrete method is a mixture of cement and aggregate weight or volume batched, thoroughly mixed dry and fed into a purpose-made machine wherein the mixture is pressurized, metered into a dry air stream and conveyed through hoses or pipes to the nozzle before which water as a spray is introduced to hydrate the mix which is projected without interruption into place.

Nozzle is an attachment at the end of the shotcrete material hose from which material is jetted.

Rebound is material having passed through the nozzle which does not conform to the definition of shotcrete as defined above

The early strength development of shotcrete with time from the time of spraying until 24 hours after spraying is as specified.

Final strength of shotcrete is the strength at an age of 28 days.

Reference shotcrete is made of the same mix as in-situ shotcrete, but not containing accelerator. Reference shotcrete shall be sprayed into panels by means of the same shotcrete equipment and sampled, cured and tested in the same conditions as shotcrete.

Accelerator is an admixture to produce a fast setting and early strength development of the shotcrete.

All materials like

Cement

Aggregates

Admixtures

Steel ribs

Bolts

Shall be furnished by certified supplier, previously agreed by the Railways.

For all mentioned material & minimum of two suppliers shall be agreed.

Test for every combination of shotcrete and concrete mix design shall be carried out for the certification on site.

All mentioned material shall be stocked on site at the minimum quantity and amount to allow the supply substitution without break of stock and consequent stop of excavation progress. The wire mesh can be substituted by steel fibres, equally stocked on site.

Cement

The type of cement to be used for shotcrete shall be according to IS 456: 2000 and approved by client.

A specific fineness of the cement after Blaine between 4,000 and 5,000cm²/g is recommended to achieve sufficient early strength of the shotcrete.

The maximum temperature of the cement in the mixing plant silos should be limited to 70°C and it should not exceed 60°C at the time of mixing. Cement should be fresh and stored in a dry area / silo.

Aggregates

Maximum aggregate size shall be 12mm for wet concrete and 16mm for dry concrete.

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 Railways. Aggregates shall confirm to the requirements of IS 456: 2000.

The aggregates shall be clean, strong and durable, suitably graded and shall not contain detrimental amounts of dust, mud, clay or organic impurities.

The content of chloride ion shall not exceed 0.35% by mass of cement.

The coarse aggregates shall not contain a large quantity of long stone pieces.

The maximum size of the aggregates shall not exceed 12 mm for wet process or 16 mm for dry process. The proportion of aggregate larger than 8mm in size should not exceed 15% for the wet process in order to minimize rebound.

The grain size distribution shall be as shown in Table 1 below.

It is the responsibility of the Contractor to choose the most suitable grading for the process and materials available.

Frozen aggregates shall not be used. Minimum temperature of the aggregates shall be 5°C.

The amount of fine particles under 0.1mm shall not exceed 8%.

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

Standard	Sieve Size [mm]	Passing in %
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Sieve		
ASTM	12.5	96-100
IS	10	92-98
IS	4.75	70-80
IS	2.36	50-60
IS	1.18	24-34
IS	0.60	20-28
IS	0.30	10-17
IS	0.15	5-12

Table 1. Recommended grain size distribution of aggregates for wet-mix shotcrete

Admixtures

Admixtures shall be conforming to IS:9103 for the improvement of performance, workability, etc. may be added, with the approval of the Railways.

Technical criteria, approved documentation, test reports and test certificates shall be furnished to the Railways for approval.

Admixtures shall be stored under the conditions specified and recommended by the manufacturers. The related storage Specifications and recommendations shall be presented to the Railways before approval of such admixtures.

The manufacturer's safety instructions shall be observed.

Plasticizers and super plasticizers are used to achieve pump-able concrete with minimum water content. Plasticizers shall be checked regularly, or as required by the Railways, for setting time, water reduction and development of strength as compared with the base concrete. Compatibility of plasticizers with cements, latent hydraulic binders and accelerators shall be verified by observation in the field suitability tests. The effects and optimum dosages of plasticizers and super plasticizers shall be determined by the field suitability test to achieve the shotcrete properties as required in this Specification.

Accelerators

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 as specified.

The dosage rate to be used shall be determined by field suitability tests to produce early and final strength of shotcrete. The compatibility of the accelerator with the cement used shall be verified through conformity with the required early strength and maximum strength loss as specified below.

Only alkali-free accelerators shall be used. The alkali content shall be less than 1% mass (Na₂O-equivalent, EN 480-12).

An addition to the dosage rate determined by the field suitability tests shall not exceed 2% of the cement content of the mix design by weight. The dosage of accelerator shall be kept to the minimum required for spraying in situ.

Automatic devices shall be used to add the accelerator.

Hydration Control Admixtures

Hydration Control Admixtures are added to the concrete to prevent cement hydration and thus maintain workability and extend the open time from mixing to application.

To reactivate and neutralise the hydration control effect, a suitable accelerator (activator) is added during spraying. The activator shall be compatible with the hydration control admixture following the manufacturer's recommendation.

The effects and optimum dosages of hydration control admixtures shall be determined by the field suitability tests to the approval of the Railways to achieve the required open time and workability and the shotcrete properties as required in this Specification.

Internal curing admixtures may be added to the basic mix of the shotcrete to reduce loss of water and thus shrinkage and cracks and improve the strength and the bond to the substrate and between layers. They can replace the use of external curing agents or other types of curing. The effects shall be determined by field suitability tests. The use of internal curing admixtures is subject to the Railways' approval.

Water shall comply in all respect with IS 456: 2000.

Additives

Additives, such as fly ash, ground granulated blast furnace slag and silica fume for the improvement of performance, durability, workability etc. may be added, with the approval of Authority Engineer. The performance of the shotcrete mix with additives shall be determined by field suitability tests.

Additives intended to be used shall be included in the tests as described in paras below.

Additives shall be stored under the conditions specified and recommended by the manufacturers. The related storage Specifications and recommendations shall be presented by the Contractor to the Railways for approval before use of such additives.

Mix Design

The mix for shotcrete shall be designed by field suitability tests to meet the requirements of this Specification. The following factors should be taken into consideration:

Material and gradation curves of aggregates

Cement content

Water-cement ratio

Plasticizer or super plasticizer type and dosage, if any

Hydration control admixture type and dosage, if any

Internal curing admixtures, if any

Accelerating admixtures

Early and final strength

Strength loss to reference shotcrete

Rebound

Temperature of the mix

Establish target slump and slump retention of the mix for optimum performance and placement

Other additives, if any

Cement Content

For the dry shotcrete process the quantity of cement shall not be less than 350 kg/m³ dry mix.

For the wet shotcrete process the minimum cement content shall be 400 kg/m³.

Variation from the above cement content for special cases may be agreed on site between the Railways and the Contractor. The cement content shall be designed to meet the strength requirements of shotcrete applied in the field.

Requirements for shotcrete

Early Strength

The early strength of shotcrete shall conform to the early strength class J2 according to Figure 2. below.

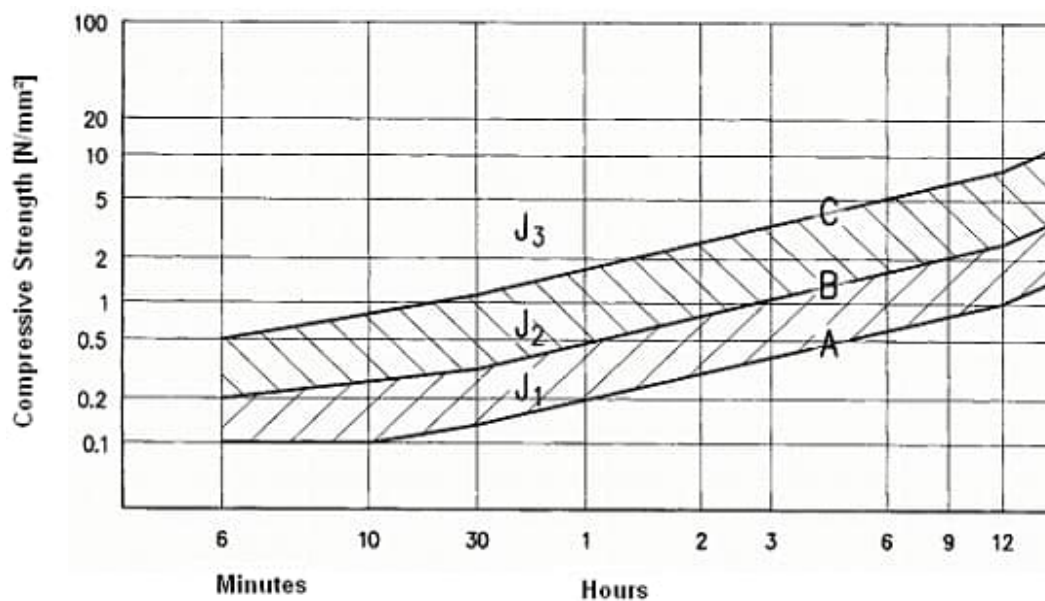


Figure 2: Early Strength Requirement for Shotcrete

The measurement of early strength shall be done by using the penetration needle, Hilti Shot-bolt system (or equivalent). Cores stronger than 10N/mm² should be used for testing of shotcrete.

Further Strength Development

The 72 hours' strength of the shotcrete shall be at least 12.5 N/mm².

The strength of the shotcrete after 7 days shall be at least 70 % of the specified 28-day strength of the mix.

Final Strength

The final strength of shotcrete shall conform to the values specified in Table 2. In addition, the long-term strength shall be determined at a sample age of 6 months. Any decrease of the long-term strength compared to the 28 days' strength shall lead to further investigations and possible adjustments in the mix design.

A factor of 0.85 between the Field Suitability tests and the Quality Control tests allows for effects of in-situ installation conditions.

GRADE (acc. to IS 456 : 2000)	M25	M30
Characteristic compressive cube ¹⁾ strength at 28 days (determined by Field Suitability Tests ²⁾) [N/mm ²]	25	30

In-situ strength requirements (determined by Quality Control Tests2)) [N / mm2]	21	25.5
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Table 2 – Required final strength of shotcrete characteristics

- (1) Cylinder specimen with a diameter of 100mm and a length of 100mm are considered equivalent to cube.
- (2) Specified strength is based on statistical minimum strength (5% fractal). Data based on the average of tests shall exceed the specified strength by 5 N/mm2.

Batching, Mixing and Transportation

Truck mixers to be used for the transportation of shotcrete underground must be fitted with approved exhaust filters.

Dry Shotcrete Process

Cement and aggregates shall be batched in the proportions specified and designed. Measurement shall be done by weight. At the time of batching all aggregates shall have been dried or drained sufficiently to result in a stable moisture content, which shall not exceed 7 %.

Mixing of cement and aggregates shall be performed mechanically with a pan type mixer. Shotcrete shall not be used unless placing can be completed within a period of 90 minutes from the time of mixing unless a hydration control admixture is used that is suitable to inhibit setting and retain consistence for the time span required until placing the shotcrete. The hydration control admixture must be approved by the Railways.

The mixing time shall be in accordance with BS 5328.

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 Railways for inspection.

For the dry process, powder or liquid type accelerating admixtures shall be added to the dry-mix. The powder type accelerator shall be proportioned and added just before the dry mix enters the shotcrete machine through a mechanical device (dispenser). Periodic calibration checks shall be performed in accordance with the manufacturer's recommendation. Liquid type accelerator is delivered by a special dosage pump and added to the dry-mix at or near the nozzle. Dosage pump and the hoses to the nozzle shall be kept in good order.

Dry-Mix delivered to the shotcrete machine shall have a minimum temperature of 5°C and a maximum temperature of 32°C.

During hot weather periods the water content of the aggregates for the dry process shall be kept above 4%, in order to avoid cement loss at the rotor of the shotcrete machine.

During transportation the dry mix shall be effectively protected against the influence of weather.

Wet Shotcrete Process

Only liquid types of accelerator apply to the wet process; these shall be added at or near the nozzle. The delivery from the accelerator pump must be controlled to be proportional to the output of the concrete pump. Accelerator pump calibration shall be periodically checked in accordance with the manufacturer's recommendations. The nozzle must be such as to ensure a homogeneous mixture of the accelerator with the wet-mix.

Shotcrete shall not be used unless placing can be completed within a period of 120 minutes from the time of mixing unless a hydration control admixture is used that is suitable to inhibit setting and retain consistence for the time span required until placing the shotcrete. At high temperatures hydration control admixtures shall be used at all times to ensure fresh concrete and sufficient open time.

Concrete delivered to the shotcrete machine shall have a minimum temperature of 15°C and a maximum temperature of 32°C.

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 Railways for inspection.

Placing of Shotcrete

Rock or previously applied shotcrete surfaces to be shotcreted 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 optimum distance between nozzle and surface of application is 1.0 to 1.5 meter. The nozzle shall be positioned at right angles to the surface of application.

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).

Steel ribs, roof ties, wire mesh and other reinforcement shall be embedded in shotcrete as shown on the drawings.

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 Railways.

In sound rock the shotcrete shall follow the rock surface with proper rounding of notches and corners. At projections of sound and hard rock edges, the actual shotcrete thickness may be locally reduced to two thirds of the specified thickness. This shall apply only to rock with UCS > 30 N/mm².

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.

Under no circumstances rebound material shall be worked back into the construction. The work shall be continuously kept free of rebound material.

Measures to establish the thickness of shotcrete shall be set up by the Contractor and approved by the Railways. These may include visual guides installed prior to shotcreting, holes drilled after completion of shotcreting or a full control by laser scanning.

If deemed necessary by the Railways, curing of the shotcrete shall be performed by water spraying or other appropriate measures subject to the approval of the Authority Engineer in the first 48 hours after application.

Major ground water seepages shall be drained off prior to spraying or after application of a first sealing layer.

Nozzle men shall be trained in the correct application of shotcrete.

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 G8.3.3 for dry process.

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.

Testing of Shotcrete

Field Suitability Tests

Field Suitability Tests shall be carried out to determine Early and Final Strength and establish a suitable range of accelerator dosage of shotcrete applied in the field.

For each type of accelerating admixture and mix design a trial mix shall be sprayed into test panels (3 nos. per trial mix) under site conditions. At least 3 different dosages of the accelerating admixture shall be tested following the recommendation of the accelerator manufacturer. The range of accelerator dosage shall confirm to the recommendations by the accelerator manufacturer.

The ambient temperature for the test shall be in accordance with the actual conditions in the tunnel.

The compressive strength development up to 1.2 N/mm² shall be determined indirectly by the Penetro-meter.

The compressive strength development in the range between 1 and 16 N/mm² may be determined using the HILTI shot bolt method (or equivalent).

The compressive strength in the range above 10 N/mm² shall be determined by crushing of cylindrical shotcrete specimens. After spraying, the test panels shall be covered and not be moved for 18 hours after spraying. Cores for strength testing shall be obtained from the panels between 18 and 24 hours after spraying. The cores for determination of Final Strength shall be stored in water until 3 days before testing. The specimens shall have a diameter of 100mm and be cut to a height of 100mm. The Railways may also require the drilling of cores from the test panels perpendicular to the spraying direction.

The average value of five test results shall exceed the strength requirements for Field Suitability Tests by 5 N/mm².

It must be demonstrated in field tests that a shotcrete thickness of min. 150mm can be applied within 5 minutes in any direction.

Quality Control Tests

To ensure the specified quality of shotcrete in the structure, quality control tests shall be performed as follows.

Aggregate

During construction, the aggregate gradation shall be tested every 14 days or as directed by the Railways and shall comply the Specifications.

In-situ Early and Final Compressive Strength

One test shall be made for every 100m³ to 300m³ of shotcrete applied, measured in theoretical quantities and as directed by the Railways. The early strength shall be tested up to 30 minutes according to the requirements specified above. 12 cores shall be drilled per test from the tunnel wall. Each 4 cores shall be tested at 1 day, 3 days and 7 days.

Every 500m³ of shotcrete applied, measured in theoretical quantities, the in-situ final strength of shotcrete shall be tested. The specimens shall be prepared by means of core drilling at random places from the lining 1 to 2 days before testing. The specimen shall have a diameter of 100mm and cut to a length of 100mm. The average 28 days strength of 4 cores shall exceed the strength specified in Clause 00 for quality control tests by 5 N/mm². The Authority Engineer may call for such testing also at 56 days.

Shotcrete Thickness Testing

The Authority Engineer may call for confirmatory shotcrete thickness testing of the in-situ tunnel lining. 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 Railways shall propose remedial measures and/or further drill testing.

Slump Testing

The Railways may from time-to-time request slump testing at the pump, in order to confirm that the delivered mix is within $\pm 25\text{mm}$ of the target slump range established by the trial mix/suitability test work.

Additional Testing for Design Purpose

The Railways may call for permeability tests as required for design purposes. Permeability tests shall be on in-situ cores taken from the tunnel. One set of cores shall be taken from the top heading and/or bench away from the construction joints, in order to give information on the permeability of intact shotcrete. Another set of cores shall be taken at the top heading-bench joint in order to give information of the permeability of construction joints.

The Railways may call for additional compressive strength tests on cores taken from test panels in the direction perpendicular to the spray.

Compressive Strength Failures

This Clause deals with the course of action to be taken in the event of cores not meeting the strength requirements as specified.

Failure of 1, 3 or 7-day compressive strength tests:

Inform the Authority Engineer in writing.

Immediate examination of tunnel lining in suspect area is to be done.

Immediate examination of elements concerned in making, transporting and placing of shotcrete is to be done.

Assess the results of the geotechnical monitoring program

Prepare to take further tests, including in-situ cores

Take further compression tests as soon as possible

The Railways may order measures for strengthening of the area

If the strength is lower than 80% of the specified stress the Railways may reduce the unit rate for shotcrete accordingly as specified or as decided by Authority Engineer. Decision of Authority Engineer will be treated as final and binding.

Failure of Final Strength tests:

Inform the Railways

Further cores shall be taken from the tunnel lining in the vicinity of the failed specimen to establish the area of non-conformance

Assess the results of the geotechnical monitoring program

The Railways may order measures for strengthening of the area

If the strength is lower than 80% of the specified stress the Railways may reduce the unit rate for shotcrete accordingly.

Measurement

For surface works (slopes) the quantities of shotcrete to be paid for shall be measured by the unit of cubic meters of shotcrete installed as shown on the drawings and/or directed by the Railways herein before described and accepted with all its additional requirements in accordance with the Unit Rate quoted in the Bill of Quantities. No separate remuneration for filling of over breaks will be made unless Clause (3) below applies.

For the primary lining of the tunnel, the quantities of shotcrete to be paid for shall be measured by the unit of square meters of shotcrete installed at the specified thickness as shown on the drawings and/or directed by the Railways herein before described and accepted with all its additional requirements in accordance with the Unit Rates quoted in the Bill of Quantities. No separate remuneration for filling of over breaks will be made unless Clause (3) below applies. For face sealing, filling of over breaks under Clause (3) below and for widening of top heading footings, the quantities of shotcrete to be paid for shall be measured by the unit of cubic meters of shotcrete installed as shown on the drawings and/or directed by the Railways herein before described and accepted with all its additional requirements in accordance with the Unit Rate quoted in the Bill of Quantities.

If geological over break was unavoidable and exceeds "Boundary Surface "Z" and 2 m³ in volume, separate payment shall be made for the filling of that over break beyond the pay line with shotcrete according to the Unit Rate accepted in the Bill of Quantities. The cavity or void formed by over break shall be measured in-situ and shall be quantified and approved by the Railways and certified for payment at the following rates:

At full unit rate for quantity beyond "Boundary Surface Z";

(ii) At 50% of the unit rate for boundary between the pay line and the Boundary Surface Z.

Where fore-poling is required, no separate remuneration for the additional shotcrete will be made other than according to the drawings, i.e. the costs for the additional shotcrete shall be included in the primary shotcrete lining costs. Additional costs for shotcrete for the widening of top heading footing shall be compensated for by a separate item in the Bill of Quantities.

Payment

The accepted quantity measured as provided above shall be paid for at the Unit Rates shown in the Bill of Quantities which price and payment shall be full compensation for all labour, supervisors, materials, the Contractor's equipment, transportation, preparations, storage, cleaning of application surfaces, operating, removal of rebound, temporary protection, testing, curing and all costs required for production and application of shotcrete and for any other contingencies as well as the costs of obtaining shotcrete test cores and of testing holes backfill.

For the purpose of payment, shotcrete surface area shall be considered at the pay-line, which in this case is defined at the exposed face of the theoretical shotcrete lining, inclusive of the design deformations tolerance as applicable, as per the drawing. The thickness defined for the current Section Type defines the Unit Price to be paid.

Steel Fibre Reinforced Shotcreting

General

If deemed appropriate and approved by the railway/the monitoring agency engaged by railway, the Contractor may spray steel fibre reinforced Shotcreting in the locations in the underground structures where plain Shotcreting is indicated on the drawings. In that case, the thickness of the steel fibre reinforced Shotcreting shall be the same as shown on the drawings for plain Shotcreting

For application of fibre reinforced Shotcreting, the Wet Method shall be used.

When steel fibre reinforced Shotcreting is used, the installation of reinforcement mesh, as shown on the Drawings, shall be omitted unless otherwise requested by the railway/the monitoring agency engaged by railway.

The provisions of ITA guidelines shall be followed on priority for steel fibre reinforced shotcrete.

Material

Cement, aggregates, except for grain size distribution, and admixtures shall be in accordance with the specified requirements.

The maximum grain size of the aggregates shall be 8mm. The grain size distribution of Table 1 above shall be adjusted accordingly and shall be approved by the Railways.

The types and dimensions of steel fibers shall be suitable for shotcrete application and the requirements of shotcrete reinforcement. The steel fibers shall be supplied by a supplier approved by the Railways before their use in the Works.

Steel fiber shotcrete shall have a minimum flexural toughness of 2.5 for index (I 5) and 5.0 for index (I10) according to ASTM C 1018-89.

Testing

Testing for steel fiber reinforced shotcrete, shall be carried out in the same manner as specified.

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.

The actual fiber content of steel fiber shotcrete shall be tested by washing out and weighing the steel fibers from a container of fresh shotcrete. Three tests shall be performed for every 100m³ of steel fiber shotcrete applied.

Construction Requirements

The production transport and application of steel fiber reinforced shotcrete shall be as detailed above.

The wet shotcreting method shall be used. For the shotcrete equipment, the manufacturer's specification shall explicitly include that the equipment is designed for the use of fiber reinforced shotcrete. All equipment shall be approved by the Authority Engineer before use.

The quantity of steel fibers in the shotcrete shall be as determined during the suitability tests. Any change to that quantity needs to be supported by test results during construction and requires the approval of the Railways. The minimum amount of steel fibers in the shotcrete shall be 30 kg/m³

During storage, steel fibers shall be protected from corrosion. Corroded steel fibers shall not be used.

Reinforcing Steel

General

For specifications of steel reinforcement of in-situ concrete ECoR Standard specifications will be followed. This Section includes additional requirements for steel reinforcement of the primary support.

WIRE MESH (WELDED WIRE FABRICS)

Material

Steel wires shall be of strength grade Fe 500 according to IS 1786. The dimensions of the steel wire mesh shall be as specified in the Tender Drawings. The steel wire mesh shall be delivered to the site in flat mats or pre-bent to the specified shape.

Installation

The steel wire mesh shall be installed such that it follows as closely as possible the irregularities of the excavation surface or previous layers of Shotcreting. It shall be firmly fixed to prevent vibration and change of position during spraying of Shotcreting. The steel wire mesh shall be installed in the longest practical length. The overlap of the steel wire meshes applied in the Shotcreting lining shall be at least twice the pitch distance in circumferential and one pitch distance in longitudinal direction.

Roof Ties

Materials

For roof ties, reinforcing bars of strength grade Fe 415 according to IS 1786 shall be used.

Installation

Roof ties shall be attached securely to the rock and in front of the previously placed wire mesh. The position of the roof ties shall correspond to the line of the rock bolts to be installed and so that the rock bolts will pass through the section of the roof tie.

Reinforcing Steel Bars

For support purposes, reinforcing steel bars are required as an additional reinforcement of the Shotcreting lining in heavily stressed areas, depending on the local ground conditions and as shown on the Tender Drawings.

Materials

Reinforcing steel bars shall be of strength grade Fe 500 according to IS 1786.

No reinforcement bars shall contain flash welds.

Water quenched and heat tempered reinforcing bars will not be permitted.

Installation

Reinforcing steel bars shall be attached securely to the previously placed Shotcreting layer or wire mesh.

Overlaps shall be arranged as shown on relevant drawings.

STEEL RIBS

General

This Chapter applies to the supply and installation of the steel ribs required and used as support in underground excavations (HEB 140 and equivalent ISSC 140 Fe 275 minimum, Lattice Girders Fe 500 minimum)

References

National Standards:

IS: 2062 – 1992 Steel for General Structural Purposes - Specification

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

American Society for Testing and Materials (ASTM):

ASTM A36/A36M - Standard Specification for Carbon Structural Steel

American Welding Society (AWS):

AWS D1.4 - Structural Welding Code - Reinforcing Steel

General Requirements

Steel ribs shall be effective as primary support immediately after excavation and shall subsequently act as reinforcement and load distributing members for the shotcrete lining.

The steel ribs shall be manufactured to meet the geometrical requirements for the excavation geometries for each Section Types including the relevant tolerances.

When handling and shipping steel ribs, prevent bending, scraping or overstressing members.

Block projecting parts likely to be bent or damaged during handling should be repaired with wood or other material.

Replace pieces bent or damaged unless repair is possible.

Submission

Shop Drawings for the fabrication of the steel ribs

Prior to the beginning of the work, the following shall be submitted:

Complete fabrication details of the steel ribs

Installation procedures and layout

Details of joints, connections, spacers, geometry etc.

Certificates of compliance of the materials.

Design of steel ribs

Steel ribs are three-dimensional, steel frames manufactured in compliance with the required excavation geometry of the tunnel.

In case of fabrication on site, the Contractor shall submit a detailed method statement for approval to the Railways.

The manual metal-arc welding process shall be employed. The manufacturer shall be responsible for ensuring that the capacity of the welding plant and ancillary equipment is adequate for the welding procedure to be used and for maintaining all welding plant and ancillary equipment in good working order.

Covered electrodes complying with UNI EN ISO 2560 shall be used. Electrodes shall be selected with regard to the particular application (welding position, joint design). Electrodes shall be stored in their original containers in a dry, preferably heated place adequately protected from the effects of the weather and in accordance with the manufacturer's Specification.

Surfaces to be welded shall be dry. Fusion faces and the surrounding surfaces shall be free from heavy scale, moisture oil, paint or any other substance which might affect the quality of the weld. Slag shall be removed from each run of weld metal before a further run is superimposed. The most favourable welding position for each case shall be chosen.

For the cutting of the steel profiles the manual flame cutting process may be employed. Also sawing is permitted.

Further preparation of joint and fusion faces shall be done by grinding.

Parts to be welded shall be assembled such that the joints are easily accessible and visible to the operator.

Slag shall be removed from all welds in order to allow visual inspection.

Welding operations shall be supervised by a suitably trained supervisor who shall have particular production experience. The welding supervisor is responsible for the following duties listed hereunder:

Employment of the welders or skilled operators and supervision of their work

Selection, use and storage of suitable welding filler metals and auxiliary materials

Selection and use of satisfactory welding apparatus, welding plant and welding fixtures

Visual and dimensional checking of the weld seams.

Welders shall pass the acceptance test.

Prior to commencement of each welding connection type three sets of joints shall be manufactured by each welder under conditions of the regular manufacturing process for inspection. These joints shall be inspected by the Railways.

Routine inspection of welded joints shall be done by spot checking of not less than 10 per cent of the welded joints.

Acceptance Test and Routine Inspection shall be done in accordance to the criteria as described in Table 3. Visible defects exceeding the limits as shown in Table 3 shall be removed and replaced by adequate means.

Table 3 - Acceptance Test

Undersize welds	0.1 (10 %)
Undercuts	Permitted to a limited extent
Visible pores	Some, 10% by area
Visible slag inclusion	Permitted to a limited extent not continuous
Open end craters	Slight depressions permitted
Lack of fusion	Permitted, but no large and no continuous areas
Cracks	Individual small local cracks permitted
Excessive asymmetry of welds	Side ratio <1.0 : 0.6

Installation of Steel ribs

Install to conform to the excavated shape. Consider inaccuracy of construction and tolerances of materials.

Steel ribs shall be erected to the lines and levels as indicated on the drawings. The exact excavation levels will however be determined by the Contractor to match best his equipment and construction method subject to the approval of the Railways.

Secure steel ribs by use of spacers as well as temporary wood blocking, mortar sacks or other appropriate means to maintain position during shotcreting.

Steel ribs shall be embedded in shotcrete, in order to get contact between rock and steel ribs by a solid shotcrete packing which shall have a minimum cover to steel of 50 mm.

The steel ribs shall be erected perpendicular to the tunnel axis.

In case sufficient over break at ribs footing, this has to be primarily filled by concrete or shotcrete up to the theoretical footing level.

Lattice Girders

General Requirements

Lattice Girders are primary support system after excavation and act as reinforcement and load distributing members for the Shotcreting lining.

These are fabricated to meet the geometrical requirements for the excavation geometry for each rock class within the relevant tolerances as specified under sub-head "Manufacturing of Lattice girder".

Care to be taken to prevent bending, scraping or overstressing members during handling/transportation.

During handling, projected parts should be protected with wood or similar material.

Bent or damaged components should be replaced.

Contractor is required to submit documents pertaining to:

Shop Drawings for the fabrication of the lattice girders

Prior to the beginning of the work, the following shall be submitted:

Complete fabrication details of the lattice girders

Installation procedures and layout

Details of joints, connections, spacers, geometry etc.

Certificates of compliance of the materials.

Design of Lattice Girders

Lattice girders are three-dimensional, lightweight steel frames manufactured of round or corrugated steel bars to suit to required excavation geometry of the tunnel.

Lattice girders consist of three primary bars, connected by stiffening elements as per approved design. They shall be designed so as to:

Facilitate Shotcreting penetration into and behind the girder, thereby minimizing the creation of projection shadows.

Provide bonding between the steel and Shotcreting so as to form a continuous reinforced Shotcreting lining.

Minimum 5% of the total moment of inertia shall be provided by the stiffening elements. This percentage is calculated as an average value along repeatable lengths of the lattice girder.

To ensure stability against buckling, the maximum spacing between stiffening elements shall be less than three times the cross-sectional depth of the girder.

In case of fabrication on site, the CONTRACTOR shall submit a detailed method statement for approval to the Authority Engineer.

The CONTRACTOR shall submit related detailed drawings of the lattice girders for approval by the Authority Engineer.

Materials

Each of the primary bars of a lattice girder segment shall be composed of only one piece of high strength steel having a yield strength of 500 MPa or stronger.

The connecting elements at the end of lattice girder segments shall be constructed of structural steel angle sections having a yield strength of 250 MPa or more, or of welded flat steel of equal strength.

Manufacturing of Lattice Girders

Geometry:-

The lattice girders shall be fabricated to meet the functional requirement duly satisfying the minimum requirement for placement inside the concrete.

Welding of Lattice Girders

Testing of materials and workmanship shall be carried out in accordance with relevant IS/other international standard specification. The contractor should engage an approved testing agency and carry out welding as described below: -

The manual metal-arc welding process shall be employed. The manufacturer shall be responsible for ensuring that the capacity of the welding plant and ancillary equipment is adequate for the welding procedure to be used and for maintaining all welding plant and ancillary equipment in good working order.

Covered electrodes complying with German Standard DIN 1913 shall be used. Electrodes shall be selected with regard to the particular application (welding position, joint design). Electrodes shall be stored in their original containers in a dry, preferably heated place adequately protected from the effects of the weather and in accordance with the manufacturer's Specification.

Surfaces to be welded shall be dry. Fusion faces and the surrounding surfaces shall be free from heavy scale, moisture oil, paint or any other substance which might affect the quality of the weld. Slag shall be removed from each run of weld metal before a further run is superimposed. The most favourable welding position for each case shall be chosen.

For the cutting of the steel profiles the manual flame cutting process or sawing may be followed.

Further preparation of joint and fusion faces shall be done by grinding.

Parts to be welded shall be assembled such that the joints are easily accessible and visible to the operator.

Slag shall be removed from all welds in order to allow visual inspection.

Welding operations shall be supervised by a suitably trained and company certified supervisor.

Certified welders or skilled operators to be engaged

selection, use and storage of welding filler metals and auxiliary materials, welding apparatus, welding plant and welding fixtures etc. should be as per manufacturer's recommendations.

Visual and dimensional checking of the weld seams should be as per item no. 12 below.

All Welds shall pass the acceptance test laid down at item no. 12 below.

Prior to commencement, three no of joints shall be welded by each welder under conditions of the regular manufacturing process for inspection. These joints shall be approved by the agency engaged by the Railway.

Routine inspection of welded joints shall be done by spot checking of not less than 10 per cent of the welded joints in compliance with item no.12 by the Authority Engineer.

Acceptance Test and Routine Inspection shall be done in accordance to the criteria as described in Table 1. Visible defects exceeding the limits as shown in Table 1 shall be removed and replaced by adequate means.

Undersize Welds	0.1 a permitted (10%)
Undercuts extent	Permitted to a limited
Visible pores some, 10 % by area	
Visible slag inclusion extent not continuous	Permitted to a limited
Open end craters slight depressions permitted	
Lack of fusion permitted, but no large and no continuous areas	
Cracks Individual small local cracks permitted	
Excessive asymmetry of welds	Side ratio $\leq 1.0:0.6$

Table 1: Acceptance Test

INSTALLATION OF LATTICE GIRDERS

These are installed to conform to the excavated shape, Consider inaccuracy of construction and tolerances of materials.

Lattice girders shall be erected to confirming the lines and levels as indicated on the drawings. The exact excavation levels will however be determined by the CONTRACTOR to match best with his equipment and construction method, subject to the approval of the Authority Engineer.

Secure lattice girders by using spacers as well as temporary wooden blocks, mortar sacks or other appropriate means to maintain position during shotcreting.

Butt plates to be provided for steel girder segments and expansion unit in invert as required. Tight connection of all elements to be ensured so that the static efficiency of the cross section is maintained.

Lattice girders shall be embedded in Shotcreting, in order to ensure contact between rock and lattice girder by a solid Shotcreting packing with minimum cover to steel of 20 mm.

The lattice girders shall be erected perpendicular to the tunnel axis.

MEASUREMENT

The quantities of lattice girders, which act as part of the primary support, to be paid in metric tons. Measurements shall be based on the length of the lattice girder as shown on the approved shop drawings.

Steel work used for temporary work will not be measured or paid for.

FOREPOLING

General

Fore poling is a pre-excavation support element required for tunnel excavation works. Fore poling shall be applied in rock and soil conditions, which tend to produce overbreak, collapses or material inflows immediately following excavation. Fore poling may be applied locally or systematically as required for the safety of the works and to prevent overbreak. All forebodings must be fully embedded in the mortar.

Material

Boreholes stable:

Steel pipes with a minimum outer diameter of 40 mm shall be used. Wall thicknesses of steel pipes shall not be less than 4 mm. Grout mortar shall comply with specification covered under "Cement-Mortar Grout" & "Grout Mortar".

Dowels (spiles) consisting of deformed high yield steel bars of grade Fe 415 with a minimum diameter of 32 mm may be used instead of steel pipes, if approved by the Authority Engineer.

Boreholes not stable:

Self-drilling bolts shall be used as fore poling elements where stability of the predrilled boreholes cannot be achieved, due to the poor ground conditions. Self drilling bolts shall be installed as per instruction of the Authority Engineer and shall have a yield load of at least 200 KN. The grout used for self drilling bolts shall be in accordance with the requirements of the

bolt manufacturer. Wherever required by the Authority Engineer, grouting shall be carried out simultaneously with drilling to achieve a better grouting effect along the bolt.

Installation

Fore poling shall be done as shown on the drawings or as instructed by the railway/the monitoring agency engaged by railway and approved by the Authority Engineer. Fore poling requires installation of Steel Ribs.

Fore poling elements at 300 to 500 mm intervals shall be inserted into the predrilled holes (steel pipes or dowels) at the face or drilled into the face (self drilling bolts) from the face of the drive towards the unexcavated ground as per the drawing/design.

The length of fore poling elements shall be as per the drawings or at least 1.50 meter longer than the applied length of round, as instructed by the Authority Engineer.

Grouting of fore poling pipes and dowels with cement mortar, either before or after the insertion of the pipes, to be determined by the Authority Engineer /the monitoring agency engaged by railway.

Fore poling shall be properly supported by the lattice girder and the Shotcreting above the lattice girder. Therefore, the gap between lattice girder and rock at the fore poling location shall be filled with Shotcreting after fore poling.

Spacing between consecutive fore poling pipes or bars around the crown of the excavation profile must be as per the drawings and suit to the prevailing geological conditions of the tunnel face.

Pipe Roof

A pipe roof is a special type of long fore poling (typically 9 – 15 m). The fore poling elements shall consist of steel pipes with a minimum outer diameter of 76 mm and a minimum yield load of 1200 KN. The length and spacing of the pipes shall be as shown on the drawings. The pipes shall be grouted with cement mortar.

Measurement

The quantities of fore poles to be paid for shall be the theoretical length of the steel pipes, dowels or self drilling bolts as shown on drawings or as directed or authorized by the Authority Engineer.

Rock Bolts

General

Rock bolts are installed either locally or in a systematic pattern in the roof, side walls, and invert of the tunnels. Rock bolts are part of the primary support, with the purpose of achieving

the coordinated action between the surrounding rock and the Shotcreting and contributing to the load bearing capacity of the primary tunnel lining. Rock bolts are also required for supporting the tunnel face.

Rock bolts shall be of specified lengths and patterns as shown on the drawings for each relevant standard support system unless otherwise determined by the Authority Engineer /the monitoring agency engaged by railway.

Definitions

SN-type rock Bolts are made of deformed steel bars and fully bonded with the surrounding rock by cement mortar. The hole is filled with grout before insertion of the bolt. The abbreviation SN descends from the mine "Store Norfors" in Sweden where it had been applied first.

Self drilling type rock bolts are a combined system of rock bolt and drill rod. During drilling, the bolt is used as the drill rod fixed with a drill bit. Rod and bit remain in the hole as a rock bolt, which is grouted through the flushing hole. In case of collapsing boreholes, this system of installation of rock bolts can be adopted. Grouting to be carried out simultaneously with the drilling operation to achieve a better grouting effect.

Swellex-type rock bolts (friction anchored rock bolts) are mechanically folded steel tubes. High water pressure inflates the tube which fits into the shape to the irregularities of the borehole.

Materials

(A)SN-Bolts

SN-type Rock bolts and its accessories like nuts, bolts, washers, anchor plates, coupling etc. shall be made of deformed steel of Fe 415 grade. One end shall be fitted with a suitable thread which is to receive an anchor plate and fixing nut.

Anchor plates of size of 200 x 200 mm x 12 mm shall be used unless instructed otherwise by the Authority Engineer /the monitoring agency engaged by railway as per support necessities. The shape shall allow a uniform seat, even if the bolt is not installed exactly perpendicular to the surface below.

Washers and nuts shall allow the secure transfer of the anchor force to the anchor plate.

(B)Self drilling Rock Bolts

Self drilling bolts including its accessories like nuts, bolts, washers, anchor plates, coupling etc. installed in tunnels shall have a minimum yield load of 200 KN, those installed at slopes shall have a minimum yield load of 230 KN & those installed as micro piles shall have a minimum yield load of 450 KN.

Self drilling bolts for pipe roofs shall have a minimum yield load of 1200 KN.

Deformed steel bars are only to be used.

(C) Swellex-type Rock bolts

Swellex-type Rock bolts for local or systematic rock bolt patterns shall have a minimum yield load of 150 KN.

Bolt face plates shall be such as to allow transfer of the anchor force at the head of the rock bolt to the Shotcreting, steel girder or rock surface.

For inflation of bolts, equipment as recommended by the manufacturer of the bolts shall be used.

(D) Cement - Mortar Grout

The cement mortar grout shall consist of sand, cement and water or neat cement and water.

Ordinary Portland cement (OPC) of 53 Grade shall be used.

Sand for grouting purpose shall be clean mineral sand, uniform in quality and from an approved source. This material shall be approved by the Authority Engineer before use. Water shall be clean, free from oil, acid, alkaline, organic and other deleterious substances.

Additives for the improvement of workability may be used.

The cement mortar grout shall be mechanically mixed to produce a uniform consistency.

The cement mortar grout shall be of grade M20 or richer grade design mix.

(E) Fiber glass bolts

In case of Road Header excavation fibre glass bolts of similar ultimate load as steel bolts shall be used for face bolting. These shall be either threaded rods or self drilling bolts and shall be grouted with cementitious material or similar in accordance with the manufacturer's requirement.

Execution

The cement mortar grout to be injected into the borehole by pump or compressed air displacement vessel. The installation procedure of specialized products shall be as per the procedure/ method specified by the manufacturer and approved by the Authority Engineer.

SN-type of Rock Bolts

Boreholes for all rock bolts shall be drilled to the depth as required for the respective rock class and rock-bolt/coupled rock bolt. The minimum diameter of the boreholes shall be 10 mm larger than the diameter of the rock bolts/couplings installed.

The boreholes shall be cleaned of all muck, sludge and debris etc.

Prior to the insertion of the rock bolt, the entire borehole shall be filled with cement mortar 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 no air void remains as the hole gets filled. The bolt is then pushed into the hole.

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

In case of confined working space and/or large length of rock bolts, coupling shall be permitted. The number of coupled parts shall be kept to a minimum. However, the load capacity of such coupled rock bolts shall not be less than that of a standard integral rock bolt. Special attention shall be paid to the grouting procedure in order to ensure full embedment of the bolt by grout.

In case of coupled rock bolts, partly collapsed boreholes, or water flows out of 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 till such time the grout comes out from the end of the tube.

Self drilling Rock Bolts

Self drilling bolts shall be used in ground conditions where installation of other types of rock bolts is not effective or possible.

Self drilling bolts shall be placed by drilling the rod into the ground without withdrawing the rod.

These are then grouted through the flushing hole immediately after completion of the drilling operation or simultaneously with the drilling, as advised by the Authority Engineer. For grouting process, the grouting pump and the grout mix, grouting pressure and quantity shall be recommended by the manufacturer and approved by the Authority Engineer.

Swellex-type Rock bolts

Boreholes for those type of rock bolts shall be drilled to the depths as required and then cleaned of all drill cuttings, sludge and debris.

The installation of rock bolts shall be done not later than two hours after drilling of the borehole.

Installation / inflation of the bolts should be as per the manufacturer's recommendations and inflation plant as recommended by him shall be used. The rock bolt shall be drained after inflation.

Testing

Grout Mortar

Prior to acceptance tests of rock bolts, trials shall be carried out to determine an appropriate mix design to achieve the specified strength and workability using the specified grouting equipment.

Additives may be used to improve workability. The influence of the additive to the strength development shall be followed by tests as described under this Clause.

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 drive from the grouting hose at the nozzle. Preparation and evaluation shall follow the procedure as described above.

Pull Out Tests on Rock Bolts

Pull-out tests shall be performed as directed by the Authority Engineer.

Proof Tests

A detailed test program shall be approved by the Authority Engineer prior to all testing work.

Specifically deviations from the ISRM suggested method shall have the approval of Authority Engineer.

A test report shall be issued immediately after completion of the tests for approval to the Authority Engineer.

For each type of rock bolt, test report shall comprise of:

type of bolts

testing equipment

location and installation records

applied testing loads and records of deformation

otherwise the evaluation of test results as specified in ISRM's document

interpretation and suggested action for failed pull-out tests

Proof tests shall be carried out for all types of bolts proposed to be used prior to the commencement of tunnelling to determine the effect and the service capacity of the bolts in the field.

The tests shall be performed in similar geological ground conditions as expected during tunnel drive. The location of the bolts to be tested shall be selected by the Authority Engineer.

A minimum of five bolts of each type shall be tested. Depending on the testing procedure and the test results the Authority Engineer may ask for further testing.

Recommended testing equipment, shall be provided to record bolt elongation, movement of the bolts and tension forces.

The maximum load to be applied shall be the bolt's yield load or as approved by the Authority Engineer.

Testing during Tunnel Driving

The Authority Engineer will select rock bolts for testing of production bolts. For each type of rock bolts five bolts will be selected from the first 100 bolts placed in the tunnel. From the remaining bolts five per 500 bolts will be selected for testing purpose. The design force to be applied shall be equal to 80% of the bolt's yield load.

Bolts which fail the tests or which are pulled out shall be replaced.

For each failure, further bolts to be tested in the vicinity as required by the Authority Engineer.

Installation Records

Comprehensive records about details of the installation of rock bolts during drive, such as grout consistency, drilling depth, length and type of rock bolts, deviations from the theoretical position, type and time of grouting, time of tightening, special observations, etc. shall be maintained for each round by the CONTRACTOR and countersigned by the Authority Engineer .

Groundwater Control Measures

General

This Section specifies minimum requirements for materials, equipment, and construction standards for groundwater control measures in tunnels. For the removal of water from surface and underground work sites, Clause "Dewatering, Drainage & Pumping" of this Specification is to be referred.

Pilot and Drainage Drillings

Pilot (exploratory) drilling shall be carried out where unfavourable geological conditions are anticipated and groundwater spouting is occurring at the face.

Pilot drilling that the CONTRACTOR requires and the Authority Engineer has approved or that the Authority Engineer directs to perform shall be measured and paid for. However, when tunnelling is interrupted because of such kind of drilling, the CONTRACTOR shall not claim to extension of time therefore. Pilot (exploratory) drilling shall be paid for with prior approval of Authority Engineer. However, no extension will be granted on this account.

The CONTRACTOR, if necessary in his opinion, may drive pilot hole prior to excavation at his own cost. Probing ahead of the tunnel face shall be carried out by drilling systematic probes such that information on the presence, pressure and quantity of water in the ground is maintained for a distance of at least 10m in front of the tunnel face. Further information such as colour of flushing water, fines, drilling time, etc. shall be recorded.

Equipment

The CONTRACTOR shall provide drilling machine capable of drilling in any direction and at any inclination angle for drilling. Where core drilling necessary, the drilling machine shall be capable of drilling exploration holes and other drilling holes for coring.

All the drilling machines shall be of sufficient capacity for placing down casing and taking it back and getting rock cores with a specific diameter.

The drilling machines shall be fitted with equipment for washing holes continuously with water during or after drilling.

Measurement

The payable quantities of pilot and/or drainage drillings shall be in linear meter for various diameters and drilling length as per the drawings and/or directed by the Authority Engineer. The measurement shall be made from the upper end of the hole to its bottom with an accuracy of 0.1 m.

Strata Grouting

General

This section provides specification for pressure grouting in rock strata for consolidation of fractured rock or for filling of cavities and voids in the rock surrounding the tunnel (e.g. karst cavities).

Ground treatment includes grouting or other ground improvement methods required to stabilize weak, permeable or potentially unstable ground to control the flow of water or for any other purpose.

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 Authority Engineer.

The need for ground treatment shall be based on:

Geotechnical investigations

Monitoring results

Probes and probe holes

Water-flow quantities at tunnel faces

Existence of karst cavities

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

Submission: The contractor is required to submit the following:-

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

Mix designs for proposed grout mixtures to be utilized.

Products to be used & the mix design to be adopted should have prior approval of the Authority Engineer.

Records to be maintained.

Method Statements shall be prepared by the contractor which should include but shall not be limited to:

Plans for grouting work

Work plan: A detailed work plan specifying:

- Basic type, objectives and principles of ground improvement scheme.
- Analysis to support the grout application design.
- Location, size and depth of each grout hole.
- Target grout volumes at each location.
- Details of grout type and application method, and proposals to demonstrate suitability of the grout type.
- Grout pipe installation procedures.
- Injection procedures and sequences.
- Data recording and reporting methods.
- Field quality control procedures and quality assurance.

- Schedule of the grouting work and relationship to anticipated tunnel excavation or filling work.
- Locations and types of instrumentation.

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

- Layout plans of grout pipes showing the depths of injections, the angles, and other data prior to tunnelling.
- Complete details and sequence of operations relating to the grout plant, including the manufacturers' catalogues concerning each component of the plant.
- Detailed procedure for each type of grouting
- Estimate of the quantity of grout to be used

Grouting Records: The contractor is required to:-

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.

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

Maintain 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.

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

Furnish records of each point of injection with the quantity and type of grout used, the pressure applied, and the depth of the hole.

Quality Assurance

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.

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.

The names of grouting crew & grouting supervisor along with their experience certificates shall have to be furnished to the Authority Engineer and only after approval of the Authority Engineer; those persons can be engaged in the work.

Material

(1) Chemical Grout

Chemical grout shall be non-toxic and so designed that the same remains effective during the period for which it is intended for. Chemical grout should not contaminate or alter the chemical and physical properties of the groundwater.

The reagent to be used should be in conformity with the grouting procedure being used. The type, temperature and means of mixing the grout constituents shall be such that the gel time can be kept constant.

The viscosity of chemical grout shall be kept to a minimum and constant until gelling time.

Material for chemical grout shall be continuously mixed, not batch mixed.

(2) Cement Grout:

Cement used in grouting works shall be as specified in the tender document or sulphate resistant cement, if required, based on the geotechnical investigation.

Chemical additives shall be approved by the Authority Engineer prior to use & the same should be compatible to the type of cement being used.

(3) Compaction Grout:

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

100 % passing the No. 4 sieve;

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

The clay content shall be less than 1%.

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

Water: Potable water as specified in IS 456 : 2000 shall be used.

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. Any mix exceeding 50 mm slump shall not be used.

(4) Protection of Materials:

Materials are to be delivered by the contractor in undamaged, unopened containers bearing the manufacturer's original labels and the same should be stored and handled in accordance with the recommendations of the manufacturer.

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

Drilling

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

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.

Only water shall be used for flushing during drilling unless otherwise directed by the Authority Engineer. 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.

Water Pressure Tests

The CONTRACTOR shall propose maximum pressures to be used for grout injection at each location. The pressures specified shall be got approved from the Authority Engineer.

Water pressure tests shall be carried out as per direction of Authority Engineer.

Mixing of Grout

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

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

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

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.

Grouting Operation

Provisions shall be made to permit accurate control of grouting pressures and volumes as detailed under "Mixing of Grout".

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

Grouting operation shall be performed without major interruptions.

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

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

Grouting in the tunnel shall be performed in such a manner that pressures are equally distributed and do not overstress the initial tunnel lining.

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.

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

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

Grouting should be stopped, when the required pressure is kept constant over a period of 10 minutes.

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, countersigned on site by the Authority Engineer supervising personnel and submitted to the Authority Engineer.

Plant and Equipment

All plant and equipment to be used in ground treatment works are to be designed for the procedure/purpose for which it is to be used. It shall be maintained in good operating condition at all times during execution of the work.

Execution

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

Gauges are to be installed adjacent to the point of injection to measure the grout injection pressure.

Field Quality Control: The contractor is required to exercise the following field checks to ensure quality of grouting:

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

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.

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.

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.

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.

Measurement

The quantities of strata grouting to be paid for shall be the number of metric tons of the cement used. It shall be measured by the Authority Engineer for payment as herein described and accepted with all its additional requirements.

DEWATERING, DRAINAGE AND PUMPING

Scope of Work

The specifications described herein under relate to the work of dewatering, drainage and pumping to be carried out by the CONTRACTOR, which shall include supply of all labour, construction plant and materials and performance of all services required to remove service water and natural surface flow of ground water seepage from the working areas on the surface as well as from the underground sites for the construction of various structures covered under the contract.

(ii) The CONTRACTOR shall design, furnish, build, install, operate, maintain and remove all the temporary dewatering facilities as specified herein or as required by the Authority Engineer.

Submittals

Within 30 days after the date of issue of the Letter of Acceptance, the CONTRACTOR shall submit, to the Authority Engineer, the detailed design of dewatering system which shall include:

Design assumptions and calculations

Layouts of drainage facilities

Layout and capacity of pumps and pipes, sumps, drains both open and covered, well points etc. and details of standby dewatering arrangements.

Any other arrangements or installation, the CONTRACTOR may propose for dewatering of the working areas both in open and underground Construction sites.

At least 30 days prior to the scheduled construction of the particular work, the CONTRACTOR shall submit, to the Authority Engineer, full details of the equipment to be installed and all necessary construction details required for dewatering purpose.

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

General

Dewatering of the surface as well as the underground construction sites shall be undertaken by gravity, wherever possible. Where, however, dewatering by gravity is not possible, pumping shall be resorted to after approval by Authority Engineer.

Where, in the opinion of the Authority Engineer, water inflows or potential water inflows into the excavation, flow of water is to be reduced or controlled by grouting. The Authority Engineer may direct that these inflows be grouted in advance, in accordance with the provisions set out under Section "Ground Water Control Measures".

Whenever more than one agency are working in the same or adjacent areas, the CONTRACTOR, who has already provided the drainage facility, shall extend this facility to the other agencies also, who shall pay for such facility at mutually agreed rates. In case of dispute, the apportioning of such expenditure shall be decided by the Authority Engineer, whose decision shall be final. In no case shall any CONTRACTOR be permitted to stop the drainage system.

In case there is flow of water passing through the sites of two or more agencies, the drainage shall be attended to the extent directed by the Authority Engineer by the agency in whose site the origin of the water is located. Out of the sites of both the agencies, the agency working on the upstream side of the flow shall attend to the drainage as directed.

The pumped water carried in pipes or flumes shall be discharged at point sufficiently away from the edge of foundation excavation as directed by the Authority Engineer. Care shall be taken to ensure that there is no seepage and flow of water back to the pit working area.

DEWATERING OF SURFACE CONSTRUCTION SITES

General

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

Design and construction of drainage, ditches, pits and pump sumps.

Design, furnishing, operation and maintenance of dewatering equipment.

Relocation of dewatering facilities required for the performance of other works.

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

Dewatering of surface construction sites located near a river/stream shall be done up to the existing water level in the river/stream by gravity as directed by the Authority Engineer. 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 d/s of the construction site.

Requirements and Design

The CONTRACTOR shall design and install complete facilities at the surface construction sites.

The surface water dewatering systems shall be designed to accommodate, without undue disruption to the work, any rainfall event and taking into account the extent of the sites to be dewatered and the dewatering arrangements proposed.

Claims for extension of time due to delays caused by unfavourable weather conditions will not be considered. The design of the drainage system should consider all eventualities.

The CONTRACTOR shall provide adequate pumping capacity, including standby units, to handle all water entering into any of surface construction sites. In addition, he shall provide sumps and pumps in the immediate vicinity of the of the structure foundation 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.

Power for operating the dewatering system shall be arranged by CONTRACTOR. The CONTRACTOR shall also make his own arrangement for sufficient standby power at his cost to carry on the works during any interruption of power.

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.

The dewatering systems shall be designed and installed in such a way that modifications and extensions to the systems with a view to capacity augmentation are possible while they are in full operation.

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.

The approval by the Authority Engineer 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 Railway against claims made by a third party arising out of any such failure.

Materials and Execution

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 flow freely at all times.

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.

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 damage to structure foundation.

In trenches and foundations, the dewatering shall at all times enable to carry out the excavation work in dry, and in a manner, that will prevent loss of fines from the foundations.

Upon completion of dewatering, temporary pipes and pumps, sumps beneath permanent structures shall be closed off and completely filled with grout, mortar or concrete as required by the Authority Engineer.

DEWATERING OF UNDERGROUND CONSTRUCTION SITES

General

The CONTRACTOR shall perform all works necessary to collect and drain service and infiltrating ground water, convey it to main conduits, and lead it out from underground works.

The Work shall include, but not be limited to, the following:

Design and construction of pits and trenches

Design, furnishing, operation and maintenance of dewatering equipment.

Relocation of dewatering facilities required for the performance of other underground works.

All auxiliary works required for the safe and continuous dewatering of the underground sites.

Probe holes shall be drilled to provide information on the inflow of water into the tunnels as the excavation proceeds. Where the indications are that flows are likely to be large, grouting to seal off the water flows and drilling of drainage holes may be ordered by the Authority Engineer.

Requirements and Design

The CONTRACTOR shall design and provide a complete dewatering system for both the downstream and the upstream headings.

After breakthrough in the tunnel, the drainage water from the downstream heading shall be taken over by the upgrade dewatering system of the upstream heading (dewatering by gravity).

All excavated areas shall be drained off all service and ground water. In order to keep the construction areas free from water, the dewatering systems shall be able to operate at any time during the whole construction period in any part of the works at the required design capacity.

The CONTRACTOR shall provide adequate pumping capacity, including a sufficient number of standby pumping units, to handle all water entering into any portion of Underground works. These units shall be connected to the dewatering systems in such a way that proper and uninterrupted drainage is guaranteed throughout the entire construction period.

Power for operating the dewatering system shall be arranged by the CONTRACTOR. The CONTRACTOR shall also make his own arrangements for sufficient standby power at his cost to carry on the works during any interruption of power.

All components of the system shall always be maintained in ready-for-service condition and all access to pumps and other equipment shall be kept in good condition under the most adverse conditions.

The CONTRACTOR shall ensure that all drainage water is disposed off without causing interference to his own or other CONTRACTOR's operations elsewhere on the site, and that no drainage water runs into adjacent works.

The dewatering system shall be designed and installed in such a way that modifications and extensions with a view to capacity augmentation, to the system are possible while they are in full operation.

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

The approval by the Authority Engineer 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 Railway against claims made by a third party arising out of any such failure.

Materials and Execution

The CONTRACTOR shall construct the drainage trench at the invert of the tunnel as required at site.

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

Special care shall be exercised where excavation passes through material which is liable to soften or swell when it comes in contact with water. In such locations, water entering the excavated space shall be collected as soon as possible and conveyed away/disposed off in such a way that the water does not come in contact with such material. Should the CONTRACTOR neglect to observe this requirement and a deterioration of the tunnel invert results from water being allowed to flow over or stand upon the sensitive or swelling material, the Authority Engineer may order the removal of the affected material and its replacement with concrete. The Authority Engineer may order installation of additional rock supports in connection with such remedial work.

If any water from another portion of the underground works flows into a lower section where concreting is being done, which is likely to be affected by water, all such water shall be diverted past this area in such a way that no damage occurs to the concrete. The length of the

affected sections over which water has to be diverted shall be ordered by the Authority Engineer.

The CONTRACTOR shall perform regular checking and cleaning of the drawing trench and all dewatering equipment and accessories during the construction period.

The dewatering facilities shall be kept in operation according to the approved schedule, which be related to the progress of the work. No pumps shall be stopped, no pipes, ducts, trenches, etc. shall be taken out of service without the permission of the Authority Engineer.

Any openings such as pipes, boreholes, ducts, pumps sumps etc. used for temporary drainage purposes in any part of the work shall be completely sealed by filling with grout, mortar or concrete when no longer required, unless otherwise directed by the Authority Engineer in writing. The CONTRACTOR shall notify the Authority Engineer in writing before any such openings are permanently closed.

All auxiliary works required

The unit rate of dewatering shall hold good for any quantity of dewatering to be done by the CONTRACTOR without any variation/ deviation.

The CONTRACTOR shall install necessary meters for registering the total pumping being done and get it approved by representative of the Authority Engineer. In the event of a diesel pump being utilized, the HP of the pump will be converted into KWHr as per the standard conversion formula.

Dewatering of Underground Construction Sites

Measurement for payment and payment for dewatering the underground construction sites will be made in: the same manner as discussed above in cl.18.6.1.

The scope shall include, but not be limited to, the following:

- Design of all dewatering system
- Excavation of drainage trenches and sumps etc.
- All costs of furnishing, transportation, installation and removal of all pumps including pneumatic pumps, sumps etc.
- Furnishing installation and removal of pipe lines and all other accessories
- Moving of the pumps and pipes as necessary between different locations
- Operation and maintenance of the dewatering system and disposal of all water up to the disposal points specified by the Authority Engineer.

The Unit Rate of dewatering shall hold good for any quantity of dewatering to be done by the CONTRACTOR without any variation/ deviation.

The CONTRACTOR shall install necessary meters for registering the total pumping being done and get it approved by representative of Authority Engineer. In the event of a diesel pump being utilized, the HP of the pump will be converted into KWHr as per the standard conversion formula.

Exclusions

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

Diverting and discharging water during any concreting operations except for pumping in the downstream headings in case such concreting is carried out prior to the break-through.

Any work or materials required as a result of CONTRACTOR's non-observance of the requirements concerning sensitive or swelling ground when the excavated surface have been allowed to become unsuitable due to the action of ground or service water.

Any dewatering done by pumping by the CONTRACTOR in contravention of the instruction of the Authority Engineer.

WATERPROOFING AND PROTECTIVE FELT/GEOTEXTILE

General

This section covers the waterproofing for all underground structures by means of a continuous waterproofing membrane installed to the outside of the final (inner) concrete lining. It does not include provisions for other elements such as water stops in concrete, sealing of joints etc.

The waterproofing shall be such that all underground structures with waterproofing are watertight. In case of leakage, provision shall be made for these to be repaired.

Tunnel sections along which the installation of a waterproofing system will be required, will be determined by the Engineer.

Description

The purpose of the membrane waterproofing to underground structures is to prevent leakage of groundwater into the tunnel and to protect the final concrete lining against deleterious chemical influences. Waterproofing shall be applied to crown and sidewalls above footing or invert arch level. The waterproofing membrane shall always be located between primary shotcrete lining and the final concrete lining. No membrane waterproofing will be provided for tunnel inverts.

The waterproofing system shall consist of two layers: the first shall consist of a protective felt fastened to the shotcrete surface; the second layer shall be the actual waterproofing membrane properly fixed by special means as recommended by the manufacturer.

While the sealing function shall be provided by the membrane, the layer of felt is required to protect the waterproofing membrane against damage from contact with the shotcrete surface, to prevent interlocking between concrete and shotcrete in case of differential movements of primary shotcrete lining and final lining, and to provide a drainage layer allowing to drain off groundwater into the longitudinal lateral drainage pipes, thus preventing a build-up of hydrostatic pressure on the tunnel lining.

Submissions

The following submissions shall be furnished for approval in accordance with the contract requirements:

Certificates of compliance attesting that the materials meet specifications requirements.

Manufacturer's instructions for installation of felt backing and waterproofing membrane, including procedures for preparation, fixing, welding and splicing, flashing etc.

Manufacturer's and installer's qualifications to include evidence of experience of the manufacturer and the installers, as well as resume of lining installation supervisors.

Samples as listed hereafter:

Membrane: One square meter of each type membrane.

Protective felt: One square meter of each type of felt.

Welded splice: 1 m of welded membrane splice for each type of membrane.

Fixings and fittings: 10 samples from different lots of rondels and nails, 2 samples of sealing flanges for projections passing through the membrane.

Shop drawings shall be submitted for approval showing all necessary installation details for felt and waterproofing membrane, including installation sequence, position of joints, treatment of projections, connection to waterproofing of structures in open cut, local reinforcements etc.

Quality Assurance

General

Supply and install suitable products designed and manufactured specifically for application in tunnels under conditions similar to those encountered on this project and having had acceptable performance.

Manufacturer's Qualifications

Select a manufacturer (or manufactures) who are (are) regularly engaged in the production of similar materials for tunnel structure and has demonstrated successful application on at least five recent projects of comparable nature.

Supervision and Training

Manufacturer's representative shall be present at least during the first 10 working days of installation and later as often as necessary.

Execute all installation and testing under the direct supervision of an individual with recent, continuous, acceptable experience in the installation of tunnel membrane linings.

Provide all personnel involved in lining installation and testing with adequate training prior to beginning lining work.

Installation records are to be submitted to the Authority Engineer for approval with all relevant data for all seam checks etc. these records shall form part of the submission to obtain approval to proceed with the installation of the inner concrete lining.

Materials

Protective Felt/ Geotextile

The protective felt shall be a continuous filament non-woven poly-propylene geo-textile of uniform thickness and surface texture meeting the requirements listed below.

Property	Specified Value
Unit weight	700g/m ² min
Thickness at 0.02 bar	4.0 mm min
Tensile strength	1000 N/5cm min
Extension at break	70 % min
Extension at 30% of tensile strength	20 % min
Permeability in plane	
at 0.02 bar	5x10 ⁻¹ cm/s min
at 2.00 bar	5x10 ⁻² cm/s min
Resistance against acid and alkaline solutions, pH 2-13	Loss of strength 10% max.
Resistance to Punching	2000 N

Table - Protective felt required characteristics

Waterproofing Membrane

The waterproofing membrane shall be made of Flexible Polyolefin based upon polyethylene or poly-propylene (FPO) or Polyvinyl Chloride (PVC), or similar and shall meet the requirements listed below.

The membrane shall be supplied with a signal layer, i.e. a thin sheeting of different colour, bonded to one side, which is intended to facilitate the detection of damages.

Table - PVC Waterproofing Membrane characteristics

Property	Specified Value	Standard
Thickness (mm)	≥ 2.0	EN 1894-2
Tensile strength at break (N/mm ²)	≥ 17	EN 12311-2
Elongation at break (%)	≥ 300	
Resistance to tearing (N/mm)	≥ 100	EN 12310-2
Puncture static test (kN)	≥ 2.5	EN ISO 12236
Water tightness (B method – 24 hours at 0,5N/mm ²)	Watertight	EN 1982
Change of dimensioning after heating at +70°C for 2 hours	Stable	EN 1110
Cold bending (°C)	≥ -35	EN 495/5
Resistance to acidic and alkaline at 28 days	20% maximum elongation	DIN 16726
Resistance of joints (N/mm ²)	≥ 10.5	EN 12317-2
Fire reaction classification	Class E	EN 13501-1

Accessories

Fixing material, flashing, reinforcement for expansion joints, sealing flanges and preparation of corners and intersections shall be made as recommended by the manufacturer of the membrane.

Execution

Surface Preparation

All surfaces to which waterproofing is to be applied shall be sufficiently clean, smooth and free from deleterious materials and projections.

The following treatment of surfaces shall be performed prior to the installation of waterproofing:

For the fixing of the protective felt and the waterproofing membrane, a minimum shotcrete cover of 50 mm to rock is required.

Irregularities of the shotcrete lining surface shall be eliminated by means of additional shotcrete. The ratio of the diameter to depth of irregularities shall be not less than 5:1 (see Figure 11.1). Rounding at rock bolts (where applicable), etc. shall have a min. radius of 0.3 m.

Transitions and intersections of tunnel profiles shall be rounded off with a minimum radius of 500 mm.

Protruding steel bars, wires, spacers, pipes etc. shall be cut off unless treated with additional shotcrete cover.

Exposed steel parts such as rock bolts, if not intended to remain accessible, shall be covered with shotcrete.

All shotcrete surface shall finally be smoothened with fine-graded shotcrete (rounded aggregates, grain size 0 - 4 mm), applied in a layer of 20 mm minimum thickness.

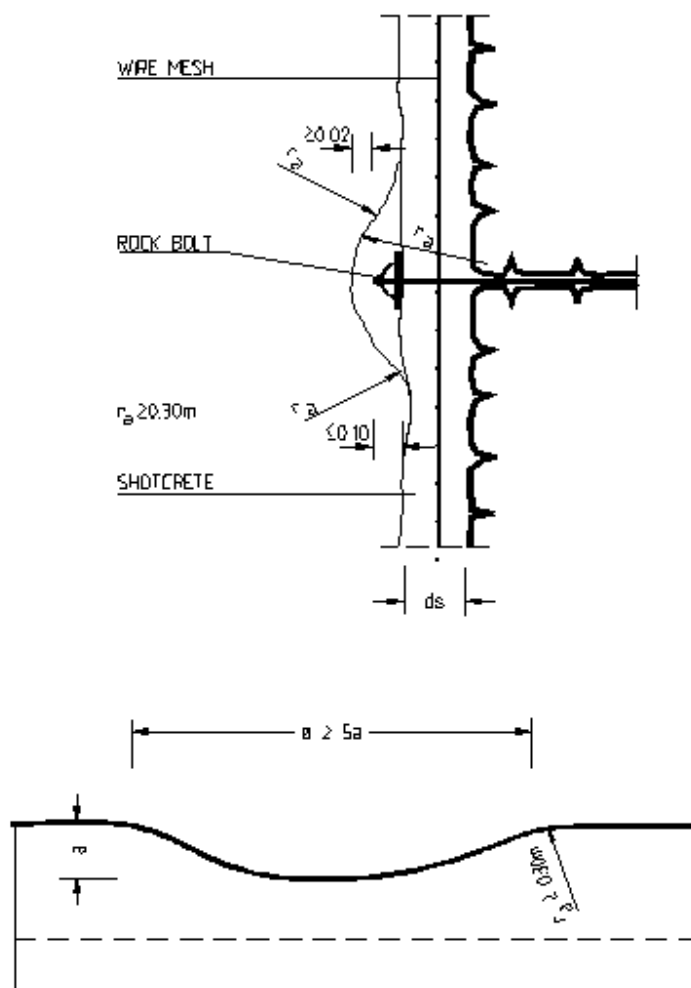


Figure - Requirements on surface irregularities of shotcrete.

Application

General

Prior to the application of the waterproofing, all surfaces to which it shall be applied, shall be inspected and approved by the Engineer.

The application shall follow the written instructions of the manufacturer. Generally procedures are the following:

Preparations

Special preparations will be required for waterproofing at tunnel intersections and for projections passing through the membrane. They shall be carried out according to the manufacturer's recommendation.

Fixing of Felt

The protective felt shall be attached to the shotcrete surface using suitable fixings specified by the manufacturer. Depending on the location 2 to 4 nos. fixing elements shall be used per square meter. The felt shall be laid with sufficient slack to avoid overstress during concreting. Adjacent sections of felt shall be overlapped by 100 mm and joined by point welding or similar suitable method. Along the bottom of the tunnel side walls the felt shall extend sufficiently to cover the lateral drainages as shown on the drawings.

Fixing of Waterproofing Membrane

The waterproofing membrane shall be installed to cover the felt and shall be attached to the felt fixings by means of thermal welding. No perforation of the membrane shall be allowed for installation purposes. The waterproofing membrane shall be laid with the single layer towards the inside and with sufficient slack to prevent overstressing during concreting. Adjacent sheets of waterproofing shall be joined by a double weld. Along the bottom of the tunnel side walls the membrane shall extend sufficiently to cover the lateral drainages as shown on the drawings. Connections to the waterproofing of structures in open cuts shall be carried out according to drawings to be furnished by the supplier.

Testing of Seams

General

All seams shall be tested and records of these tests shall be submitted by the Contractor to the Engineer.

Seam Test with Compressed Air

For seams between adjacent sheets of waterproofing membrane the testing for tightness shall be carried out by means of compressed air pumped into the test channel which is formed by the double welded joint. Initial test pressure shall be 2 bars for a test period of 5 minutes or 1.5 bar for a test period of 10 minutes. The joint shall be considered waterproof if the loss of air pressure is in both cases not more than 20%.

Seam Test with Vacuum Equipment

For the testing of areas of membrane of limited size such as special configurations of joints or local repairs with patches, vacuum equipment shall be employed, as instructed by the Engineer. This equipment consists of a vacuum bell which, after being fitted tightly over the area to be tested, is evacuated by pumping in order to detect leaks in the membrane.

Protective Measures

Every care shall be taken not to damage the waterproofing membrane during or after installation. Any damages occurred shall be repaired and tested before the casting of the final concrete lining.

Measurement and Payment

The quantities of the protective felt and waterproofing membrane to be paid for shall be measured by the unit of square meters installed. The finished area shall be measured after the fixing and finishing of the work and shall not include overlaps, folding, welding seams and any wastage etc. The accepted quantity measured shall be paid for at the unit rates shown in the Bill of Quantities. The payment shall include all materials and work required to carry out the work in accordance to specifications and shown on the drawings or as instructed by the Engineer.

Permanent Groundwater Drainage

General

This Chapter applies to the installation of the permanent groundwater drainage system in the tunnel & covers the requirements for the permanent groundwater drainage system inside the tunnel.

The drained groundwater will flow from the highpoint of the tunnel alignment to low point. The drainage pipes will follow the gradient as per the formation.

The permanent groundwater drainage of the tunnel shall consist of a main collector pipe along the entire length tunnel and lateral drainage pipes (perforated) with transversal connection pipes to the main collector pipe at every 50 m along tunnel sections where major water inflow occurs. Along tunnel sections without major water inflow, the lateral drainage pipes (including the corresponding connection pipes) will not be installed. The decision of the groundwater drainage system to be installed along a certain tunnel section will be made by the Authority Engineer.

Drainage gutters shall be located along the entire length of the tunnel at the bottom of either tunnel side wall for collecting groundwater possibly entering through the tunnel lining. The water shall be diverted into the main collector pipe by means of transversal connection pipes at every 50 m.

Along tunnel sections with lateral drainage pipes and without invert arch, a perforated pipe will be installed at the bottom of the tunnel as invert drainage.

At the intersections of the main collector pipe with the transversal connection pipes (i.e. at every 50 m), maintenance manholes shall be installed. Manholes shall also be installed for the maintenance of the invert drainage (every 50 m).

For the maintenance of the lateral drainage pipes, cleaning access pipes shall be installed at every 25 m.

Materials

The lateral drainage pipes shall consist of circumferentially slotted, hard-PVC pipes with a minimum diameter of 200 mm as shown on the drawings. The upper section of the pipe shall

be longitudinally corrugated. The slots shall be within the corrugated area. The width of slots shall not exceed 1.0 mm. The total area of the slots for water intake shall be more than 100 cm² per metre length of pipe.

The main collector pipe shall be a hard-PVC pipe with a diameter of 400 mm.

The transversal connection pipes shall be hard-PVC pipes with a minimum diameter of 150 mm.

The cleaning access pipes shall be hard-PVC pipes with a minimum diameter of 150 mm.

The invert drainage pipe shall consist of circumferentially slotted, hard-PVC pipes with a minimum diameter of 150 mm as shown on the drawings. The upper section of the pipe shall be longitudinally corrugated. The slots shall be within the corrugated area. The width of slots shall not exceed 1.0 mm. The total area of the slots for water intake shall be more than 100 cm² per metre length of pipe.

No-fines porous concrete shall be used for embedment of the lateral drainage pipes. No-fines porous concrete shall be composed of Ordinary Portland Cement and single-sized aggregate of nominal size of 40 mm according to IS 383 (with a maximum grain size of 40 mm). The ratio of aggregate to cement shall be 8:1 by volume or 10:1 by mass.

Maintenance manholes as well as the drainage gutters shall be made of concrete grade M35 according to IS 456: 2000.

Execution

The water appearing and/or collected during construction behind the waterproofing membrane shall be diverted permanently into the lateral drainage pipes installed at the bottom of each sidewall of the tunnel.

The lateral drainage pipes shall be covered and protected by no-fines porous concrete.

Inspection recesses shall be installed in the inner concrete lining for permanent maintenance (flushing) of the lateral drainage pipes as shown on the drawings.

The CONTRACTOR shall ensure that the permanent ground water drainage system is used only for the control of groundwater. Throughout the construction regular inspection and servicing shall be provided.

All pipes for control of the ground water shall be installed to line and grade as shown on the drawings.

No-fines porous concrete shall be mixed by machine or by hand to a uniform colour and consistency before placing. The quantity of water used shall not exceed that required to coat all of the aggregate particles without forming excess grout. The no-fines porous concrete shall be compacted by hand only.

Concreting in Underground and Open Works

Tunnel Concrete Lining

General

This section contains specifications for the construction of the inner cast in-situ concrete tunnel lining (also called final lining or secondary lining), the foundation beams and the invert arch. These structures will in general be reinforced.

Cast in-situ foundation beams will be installed throughout the entire length of the tunnel. A cast in-situ concrete tunnel lining as well as a concrete invert arch will be installed along tunnel.

Description

The inner cast-in-situ concrete lining increases the safety factor of the tunnel lining system and improves the water tightness of the tunnel lining.

The foundation beams form the abutments for the final tunnel lining. They also form the connecting link in the case an invert arch is required.

The invert arch forms the ring closure of the tunnel lining (tunnel tube) where poor geological conditions prevail. The concrete invert arch has to resist ground pressures and to provide stability for the whole tunnel structure.

The formwork or shutters for the foundation beams, the invert, side walls and roof arch provide the necessary tools for the construction of the final in-situ concrete tunnel lining. They shall be constructed of steel in such a manner that the shape, dimensions and surface finish of the concrete are obtained, as specified.

Contact grouting is the injection of grout material under pressure to fill voids between in-situ concrete lining and the rock or Shotcreting or the membrane lining (waterproofing). A systematic contact grouting shall be carried out in the roof section of the tunnel after hardening of the concrete lining, and satisfactory results from the 28 day cube test. Provision shall be made in the roof arch shutter for the casting of the necessary holes for contact grouting. Positioning of these grout holes shall be approved by the Authority Engineer.

Submissions

Working drawings shall be submitted by the contractor showing the camber of formwork as required for compensation of deflection by concrete placing operation.

Separate shop drawings for the formwork for the tunnel cross section and the niches shall be submitted by the CONTRACTOR for approval by the Authority Engineer.

Test reports shall be submitted for the concrete to be used in accordance with IS: 516.

Method statement, plant and material description for contact grouting shall be submitted to the Authority Engineer for approval before commencement of final lining concreting works.

Job Conditions

The inner lining in the tunnel shall not be placed until the displacements of the Shotcreting lining at any position on the tunnel periphery have, in the opinion of the Authority Engineer, practically stopped.

The inner lining shall not be placed before the reprofiling operations have been accepted and approved by the Authority Engineer.

The inner lining in the tunnel shall not be placed before the waterproofing system installed is accepted and approved by the Authority Engineer.

Materials

Formwork

Formwork shall be sufficiently rigid to maintain the forms in their correct position, shape and profile so that the final concrete structure is within the limits of tolerances (+/- 10 mm).

The formwork shall be made of steel and suitable for repetitive use.

The formwork shall be provided with openings along each side wall and in the crown. The opening shall be so designed as to permit the use of vibrators for compacting the concrete, and to permit inspection of the concrete during placing and of the hardened concrete surface prior to the striking or the removal of the formwork. They shall be a minimum of 600 mm square. Openings for pouring of concrete shall be located at such heights as to prevent segregation of the concrete. Joints in the forms shall be sufficiently tight to prevent leakage of grout and absorption of water from concrete.

The forms shall be maintained at all times in good condition as accuracy of shape, strength, rigidity, water tightness and smoothness of surface is warranted. All forms shall be kept clean, free of corrosion and in good repair.

The design of the formwork shall be to the approval of the Authority Engineer.

The upper sector of the formwork shall have facilities for mounting external vibrators at regular intervals to ensure thorough compaction of the arched soffit.

The steel form shall be furnished with suitable devices for the erection of stop ends and to enable chamfers along the periphery at the start/end of each concreting section in order to produce a clean cut between subsequent pouring and regular surface between pours where the tunnel is on a curve.

Concrete

The concrete grade for inner lining arch, foundation beams and invert arch shall be M30 or richer mix and shall conform to IS 456-2000.

Maximum aggregate size shall be 40 mm for the foundation beams and the invert arch and 20 mm for the inner lining. ?

The consistency of the mix shall be chosen to allow placing of concrete by pumping. However, the water /binder ratio shall not exceed a value of 0.65 (the term "binder" shall refer to all cementitious materials used for the concrete).

Admixtures may be used in the concrete mix to improve flow and compaction. Details of such additives shall be submitted to the Authority Engineer for approval prior to their use.

Grout for Contact Grouting

Grout shall be based on a mixture of cementitious materials, water, additives etc. as per design mix, subject to the Authority Engineer approval. All sources of water to be used with cement shall be approved by the Authority Engineer. If at any time during construction, water from an approved source becomes unsatisfactory, the CONTRACTOR shall provide satisfactory water from other main sources.

Cementitious materials shall conform to specified Standards. The grout shall be a uniform mixture of which the consistency shall be sufficiently fluid but not more so to ensure that the grout flows freely under pressure into all parts of the void.

The grout mix shall have low or no bleedability and low shrinkage characteristics. When set, the grout should have the lowest permeability possible.

Execution

Preparation of Formwork before Concreting

The inside surface of forms, except permanent formwork or unless otherwise agreed by the Authority Engineer, shall be coated with an approved nonstaining mould oil to prevent adhesion of the concrete.

Release agents shall be applied strictly in accordance with the manufacturer's instructions and shall not come into contact with reinforcement and anchorages. The composition of the release agent shall be such that it will not interfere with future surface treatments.

Before concreting, all forms shall be thoroughly cleaned. Faces of formwork in contact with concrete shall be free from undulations, adhering foreign matter, projecting nails etc.

The formwork shall be erected and anchored in such a way that it rigidly retains its shape and position during concreting and that surface irregularities in the concrete are avoided.

Formwork shall be erected to such levels as to make allowance for anticipated deflection of the formwork under load.

The CONTRACTOR shall not place any concrete in the forms until the Authority Engineer has given written approval.

The Contractor shall prepare the formwork for final lining taking into account the final alignment of the tunnel. The formwork shall be suitable for the cast of the final lining both in the straight and curve sections of the tunnel and for all the recesses, niches, cross passages, trolley refugees, lay-bys and junctions.

Preparation for Placing Concrete

Before the concrete lining is cast the CONTRACTOR shall thoroughly clean from the loose or unsound fragments of rock, mud, debris, standing water, oil and any other foreign matter the invert, sides and roof of the excavation.

Placing of Concrete

The CONTRACTOR shall submit to the Authority Engineer full details of his proposed tunnel concrete placing methods, including a description of the equipment to be used.

Concrete shall be placed by a displacement type pump or by such method as may be approved by the Authority Engineer. The concrete pump shall produce a continuous stream of concrete without air pockets so as to avoid segregation etc.

The casting of the foundation beams and the structural invert arch shall be done in separate operations before placing the inner lining arch of the tunnel. The method of placing concrete in the invert shall be subject to approval of the Authority Engineer.

The concrete beams on each side shall be used as abutments for the rails which are necessary for moving the tunnel formwork. They shall be cured for at least 7 days before the formwork for the inner lining arch is allowed to be placed.

Concrete shall be pumped into the formwork through suitable temporary openings.

Concrete in the walls and crown of tunnels shall be brought up in horizontal layers not exceeding 40 cm, evenly distributed over the concreting section.

Maximum level differences shall not exceed the values as specified by the manufacturer of the formwork.

Concrete shall not be pumped into the crown of the arch. The walls & invert are to be concreted first & the process should gradually move upwards to the arch. Concrete shall be forced into all irregularities in the ground or initial support surface by submissive vibrators to fill the void between that surface and the formwork.

Special care shall be taken to ensure the complete filling of the crown of the tunnel arch. Air pockets in the tunnel roof shall be relieved by ventilation hoses wherever necessary beyond the relevant stop-end of the formwork.

Cold joints in the inner lining shall be avoided wherever possible. A standby concrete pump and placement line shall be kept during concreting operations. In the event of continuous placing being interrupted by equipment breakdown or for any other reason, the CONTRACTOR shall thoroughly consolidate the concrete at such joints to a reasonably uniform and stable slope while the concrete is plastic and any concrete which remains unconsolidated shall be removed.

In-situ concrete inner lining for tunnels shall be cast in sections of 10 to 12 meters length measured along the tunnel axis. Each section shall be cast in one continuous operation without interruption and construction joints. All construction joints at the ends of the sections shall be perpendicular to the gradient.

Compaction of Concrete for Inner Lining

The concrete shall be compacted by external vibrators anchored to the formwork and immersion vibrators operated through the inspection openings in the formwork.

The operating time of the external vibrators shall be kept short in order to avoid segregation.

Removal of Formwork

Formwork shall be so designed as to permit easy removal without resorting to hammering or levering against the surface of the concrete or injuring the concrete.

Any damages occurring during striking of the formwork shall be made good by the CONTRACTOR to the satisfaction of the Authority Engineer.

Form removal shall not be started until the concrete has attained sufficient strength so that most unfavourable load conditions do not cause any damages to the structure. The strength of the concrete shall be measured after removal of the stop-end shutter in the tunnel roof. The minimum strength for removal of the formwork must satisfy the structural requirements for "dead load" of the lining. This strength shall be checked by a Schmidt pendulum type hammer, or similar approved, for low strength concrete, with a piston of 40 mm diameter. Prior to the commencement of concreting works, the instrument shall be calibrated for each approved concrete mix under particular application.

Contact Grouting

Prior to the commencement of inner lining works, the CONTRACTOR shall submit to the Authority Engineer for his approval, full details of the working method and equipment to be used for contact grouting.

At all times, the CONTRACTOR shall ensure that the grouting operation is under the direct control of skilled and experienced personnel. The CONTRACTOR shall state the maximum pressures to be used for the approval by the Authority Engineer.

Grouting and ventilating pipes shall be positioned prior to concreting.

On completion of grouting, the CONTRACTOR shall cut off all surplus lengths of pipes and make good the surface to the satisfaction of the Authority Engineer.

The CONTRACTOR shall provide the Authority Engineer with records of areas grouted, injection pressures, grout consumption and mix details as the Authority Engineer may so require.

The CONTRACTOR shall carry out tests as directed by the Authority Engineer to confirm that the grout mix and its constituent materials are in accordance with the Specification and submit the results for approval of the Authority Engineer.

Where dry pre-mixes of grout of an acknowledged manufacturer are used, they shall be mixed to the manufacturer's specifications. All grout mixes shall be prepared using high speed, high shearing action mixers.

The CONTRACTOR may choose to propose a method of concreting in order to eliminate contact grouting of the tunnel lining. However, if the proposed method is accepted by the Authority Engineer the requirements of Clause (5) above must still be met and the cast-in holes used to check that the tunnel lining is complete as directed by the Authority Engineer.

Concrete in R.C.C. Frames/Walls/Slabs

Concrete shall be placed in lifts of heights as shown on the approved drawings or as directed by the Authority Engineer. Within each lift, concrete shall be deposited in approximately horizontal layers about 40 cm in thickness unless otherwise directed by the Authority Engineer.

At locations where lift heights are not shown on the drawings, the CONTRACTOR shall submit to the Authority Engineer for approval, details of the placing procedure he proposes. No concrete shall be placed at such locations without the prior approval of the Authority Engineer.

Slabs shall be placed in one lift unless otherwise indicated or directed by the Authority Engineer.

The placement of concrete shall be carried out at such rate and in such a manner that the formation of cold joints is prevented.

Where slabs and beams are placed continuously with walls and columns, the concrete in walls and columns should be placed for at least 2 hours or for a longer period when so directed by the Authority Engineer before placing concrete in the slabs and beams.

Chipping and Roughening of Concrete Surfaces

Surface upon or against which additional concrete is to be placed shall be chipped and roughened to a depth not more than 25 mm.

The roughening shall be performed by chipping, sand blasting or other satisfactory methods and in such manner as not to loosen, crack or shatter any part of the concrete beyond the roughened surface.

After being roughened, the surface of the concrete shall be cleaned thoroughly of the loose fragments' dirt and other objectionable substances and shall be sound and hard and in such condition so as to ensure good mechanical bond between old and new concrete.

All concrete works which is not hard, dense and durable shall be removed to the depth required.

Defective and Damaged Concrete

Concrete which is damaged and which is not placed and compacted in accordance with specifications and is found to have lower strength, density etc. than specified, as determined from test samples or core samples, shall be removed and replaced free of cost by the CONTRACTOR.

Finishing of Concrete

Finishing of Formed Surfaces

Except as otherwise specified or directed, all permanently exposed concrete surfaces and other waterway surfaces requiring durability under water shall be finished in the following manner:

Any damage to finished concrete resulting from the action of removing formwork or from any other cause shall be repaired to the satisfaction of the Authority Engineer. Immediately on removal of the form, the surface shall be examined and all porous honeycombed or defective concrete removed and repaired as specified herein.

All imperfections or ridges due to joints in the formwork, shall be removed by light chipping or grinding down if necessary, to produce a smooth surface.

When the treatment of a surface has been completed, the surface shall be cured.

All patches and mortar filled pits on exposed surfaces shall be neat with similar colour, texture etc.

The finished surfaces of concrete shall be sound, smooth and free from fins, offsets, pits, depressions, voids, blemishes, surface irregularities etc.

Finishing work shall be done only by skilled workman in the presence of the Authority Engineer or his representative and shall be performed within 4 weeks of placing.

Before final acceptance of the work, CONTRACTOR shall clean all exposed concrete surfaces of all encrustation of cement, mortar or grout, to the satisfaction of the Authority Engineer. Concrete shall not be considered finished until all required repair work and finishing have been completed.

Finishing of Unformed Surfaces

Unformed surfaces shall be finished by one or more methods of screeding, floating and trowelling and working of the surfaces shall be done wherever required, employing experienced men and shall be sufficient to produce the desired finish.

Screeding

it gives the surface its designed shape by striking off surplus concrete immediately after completion. It shall be done by moving a straight edge or template with a swing motion across wood or metal strips which have been established as guides.

Where the surface is curved, a special screed shall be used.

Floating

Shortly after the concrete is screeded, the surface shall be brought true to form and grade by working it sparingly with a wooden float. If a coarse textured finish is specified or if the surface is to be steel trowelled, a second or final floating shall be performed after surface moisture film or shine has disappeared.

Trowelling

If a smooth dense finish is desired, floating shall be followed by steel trowelling some time after moisture film or shine has disappeared from the floated surface and when the concrete has hardened sufficiently. Excessive trowelling at an early stage would produce cracking or result in surface that is too hard to finish properly, shall be avoided.

Trowelling shall, therefore, be done at the appropriate time to achieve the surface smooth, even and free of trowel marks and ripples. A fine textured surface that is not slick shall be obtained by trowelling lightly over the surface with a circular motion keeping the trowel flat on the surface of the concrete. Where a hard steel trowelled finish is required, trowelling shall be continued until it no longer produces noticeable compaction and the surface has a glossy appearance, trowelling pressure being increased gradually as the operation progresses.

The use of any finishing tool in areas where water has accumulated shall be prohibited. Operation on such areas shall be delayed until the water has been absorbed or has evaporated or has been removed by draining, mopping or other means.

All joints and edges on unformed surface, that shall be exposed to view, shall be finished with suitable moulding tools with rounded, bevelled or filleted edge, as directed by the Authority Engineer. Unless the use of other slopes or level surface is indicated on the drawings as

directed, narrow surfaces such a top of wall or tunnel portals shall be sloped approximately 9 mm per 300 mm of width. Boarder surfaces as walls, roadways platforms and deck shall be slopped approximately 6mm per 300mm.

Where separate floor finish is specified or directed, the concrete shall be stuck of sufficiently below grads to allow for the subsequent placing of a finished floor. The surface of such concrete shall be left rough.

As soon as the condition of the base permits and before it has hardened fully, all dirt, laitance and loose aggregate shall be removed from the surface, by means of water jets and wire brooms leaving the coarse aggregate slightly exposed and the surface made suitable for taking further concrete.

Curing and Protection of Concrete

Plant and material required for curing and protection of concrete shall be available at the location of each concrete placement before concrete placement is started and the water used for curing shall meet the requirements set out in standard specification.

All concrete shall be protected against injury until final acceptance.

Exposed finished surfaces of concrete shall be protected from the direct rays of the sun for at least 72 hours after placement.

Fresh exposed concrete shall also be protected from the action of the rains, flowing water and mechanical injury.

No fire shall be permitted in direct contact with concrete at any time.

Concrete in which standard Portland cement is used shall be kept continuously moist for not less than 14 days, for normal concrete and 21 days for concrete containing pozzolana, by covering with water saturated materials or a system of perforated pipes.

Construction joints shall be cured in the same manner as the other concrete and shall also, if practicable, be kept moist for at least 72 hours prior to the placing of additional concrete upon the joint.

(viii) Horizontal surfaces shall be cured by sprinkling water or by covering with damp sand or may be cured by the use of wet quilts or mats which will satisfactorily supply the required curing water. If damp sand or quilt is used for curing, it shall be completely removed. The time of applying damp sand shall be specified by the Authority Engineer before which curing shall be carried out by other approved methods.

The method of keeping formed concrete surface moist shall be continuous sprinkling or spraying of water as may be necessary to prevent any portion any portion of the surface from drying during the specified period.

The water and other methods of curing shall be so handled as not to stain concrete surfaces, which shall be exposed.

The actual method of curing adopted shall subject to the approval of the Authority Engineer.

In limited areas and for special purpose, the use of an approved and properly applied compound may be permitted at the discretion of the Authority Engineer to restrict the evaporation of the mixing water. Such curing compound shall be of the surface membrane type which will thoroughly seal the surface. Curing compounded shall not be used on joints where bonding is required.

Curing compounds shall be applied according to the manufacture's recommendations to provide a continuous uniform membrane over all area. Curing compounds shall be applied only after moist curing has been carried out for at least 24 hours.

A curing compound shall not be used on any unformed surface, where, in the opinion of Authority Engineer, the irregularities in that surface would prevent the membrane forming an effective seal, on any surface which has a temperature lower than manufacturer's recommended application temperature, or nay surface where a bond is required for additional concrete, or where a curing compound is placed on a surface where a bond is required, it shall be removed by sand blasting or by other means satisfactory to the Authority Engineer.

Curing membranes shall be protected from damage at all times.

Care shall be taken not to disturb the steel reinforcement projecting from any placement for at least 24 hour after the completion of such placement.

Finished concrete surface shall be projected from stains or abrasion and surface or edges likely to be injured during the construction period shall be kept properly projected by leaving forms in place or erecting protective covering satisfactory to be Authority Engineer.

In case, the curing operations are inadequate or unsatisfactory, the Authority Engineer shall be entitled to take such steps as he may deem necessary to make good the deficiencies and defects.

Repair of Concrete

General

Repair of concrete shall be performed by skilled workmen and in the presence of the Authority Engineer.

No repair work shall be carried out until the Authority Engineer, has inspected the location of the proposed repair and accepted the method of repair.

The CONTRACTOR shall correct all imperfections on the concrete surfaces as necessary to produce surfaces that shall conform to the required standards.

All materials procedures and operations used in the repair of concrete shall be subject to approval by the Authority Engineer.

Surface of concrete finished against forms shall be smooth and free from projections. Immediately upon the removal of forms and within 24 hours thereof, wherever practicable, all unsightly ridges or fines shall be removed and any local bulging on exposed surfaces shall be remedied by tooling and rubbing. All holes left by the removal of fasteners from the tie rods shall, after being reamed with a toothed reamer, be neatly filled with dry pack mortar.

All honeycombed, porous, fracture or otherwise defective concrete and surface concrete in which, in the opinion of the Authority Engineer, additions are required to bring it to the prescribed lines, shall be removed by chipping concrete.

The chipped openings shall be sharp edged and keyed, and shall be filled to the required lines with fresh concrete or as found suitable. Where concrete is used for filling, the chipped openings shall be not less than 100mm in depth and the fresh concrete shall be reinforced and doweled to the surface of the openings as directed by the Authority Engineer.

Dry pack mortar shall consist of one part of cement to two parts of sand by volume and just enough water so that the mortar as used sticks together on being moulded into a ball by slight pressure of the hands and does not free water when so pressed but leaves the hands damp. The mortar shall be fresh when placed and any mortar that is not used within 30 minutes, after preparation shall be wasted with all consequences to the CONTRACTOR.

The mortar shall be placed in layers not more than 25mm thickness after being compacted and each layer shall be thoroughly tamped to the satisfaction of the Authority Engineer. Each layer except the last shall be roughened thoroughly to provide effective bond with the succeeding layers. The last or finishing layer shall be smoothened to form a surface continuous with the surroundings concrete. Dry pack mortar shall be used for filling behind reinforcement or for filling holes that extend completely through a concrete section. Shotcreting shall be used for holes too wide for dry pack mortar filling and too shallow for concrete filling and no deeper than the far side of the reinforcement that is nearest to the surfaces.

All patches shall be bonded thoroughly to the surface of the chipped opening and shall be sound and free from shrinkage cracks and tummy areas.

Concrete surfaces where high velocity flows may occur and as required by the Authority Engineer repair to the surfaces having F3 and U3 finished shall be bonded with an epoxy adhesive acceptable to the Authority Engineer.

All repairs to the surface of concrete for flowing water shall be ground smooth to meet the tolerances set out in these Specifications.

Construction Joints

Concrete surfaces, which become so rigid, by reason of limitations in the rate of placing of concrete imposed by these specifications or by reason of delay in construction progress, that in the opinion of the Authority Engineer, the new concrete cannot integrally incorporated with that previously placed, shall be defined as construction joints.

Construction joints shall be located in the positions shown on the drawings or as directed by the Authority Engineer and the CONTRACTOR shall not be permitted to make any additional joints or deviate from the joints indicated on the drawings without the written authorization of the Authority Engineer.

Joints as exposed surfaces of concrete shall be straight and continuous as shown on the drawings or otherwise directed.

The concrete of the earlier pour shall be hacked to produce a rough surface or green cut with air-water jet or by sand blasting after the concrete has hardened sufficiently as directed by the Authority Engineer. Before placing new concrete, the surface shall be restored to the condition existing immediately after hacking or green cutting by means of another washing with air-water jet, vigorous brushing, sand blasting etc.

All the points shall be cleaned by the CONTRACTOR to the satisfaction of the Authority Engineer. All intersections of construction joints with concrete faces, which will be exposed to view, shall be made straight, level and in plumb.

All exposed construction joints shall conform to the requirement of aesthetics and their pattern shall be subject to the approval of the Authority Engineer. Surfaces of the construction joints which have been permitted to dry by reasons of the succeeding layer not placed within the specified moist curing period shall be kept for at least 72 hours prior to placing the succeeding layers.

Horizontal construction joints shall be arranged wherever possible to coincide with joints in the form-work.

To prevent feather edges, the construction joints at the tops of horizontal lifts near sloping exposed concrete surface shall be inclined near the exposed surface so that the angle between such inclined surface and the exposed concrete surface shall not be less than 50 degree.

When the work has to be resumed on a surface which has hardened, such surface, shall be roughened and new concrete placed after taking all measures as per approved methods statement of CONTRACTOR.

The use of a retarder shall not relieve the CONTRACTOR of the responsibility of producing surfaces at construction joints as specified and to the satisfaction of the Authority Engineer.

Disturbance of surface concrete at the joints shall be avoided during the early hardening period. Before placing the succeeding layer, the surface of the construction joint shall be thoroughly cleaned and loose, defective concrete shall be removed satisfactorily.

Expansion and Contraction Joints

Expansion and contraction joints shall be constructed at such points and of such dimensions as indicated on the drawings or as required by the Authority Engineer. The method and material used shall be subject to the approval of Authority Engineer.

Standard bitumen sheets, impregnated with saw dust or any other filler material and sealing compounds, required to be placed in the expansion joints, shall be fixed in position as shown on the drawing as directed by the Authority Engineer.

Embedment in Concrete / Rock

Anchor Bars

Wherever indicated on the drawings or directed by the Authority Engineer, holes shall be drilled into rock to receive bars for anchoring to the rock, concrete or masonry structures or parts thereof.

The type and dimensions of the anchor bars, locations, diameter and depths of anchor bar holes shall be as shown on the drawings or as directed.

Anchor rods shall be thoroughly cleaned before being placed in the drill hole. The hole shall be filled with grout. The grout shall be workable 1:1 sand / cement mix with low water cement ratio. Admixtures for fast setting low shrinkage may also be required.

Wherever practicable, anchors shall be installed before the concrete is placed, except when otherwise provided or permitted.

Drilling for the installation of anchors in the concrete shall not be carried out except with the prior approval of the Authority Engineer.

Where the installation of anchors prior to placing of the concrete, is not practicable, satisfactory formed openings shall be provided for holes drilled for the purpose and the anchors grouted in the openings at some late date.

The anchors shall be protected against disturbance for minimum of 48 hours after installation or more as required by the Authority Engineer

Embedded Parts

Before placing concrete, care shall be taken to ensure that all embedded parts are firmly and accurately fastened in place as indicated on the drawings or as directed.

All embedded parts shall be thoroughly cleaned, free from all foreign matter such as scale, rust, oil etc.

The CONTRACTOR shall not place concrete on embedded parts unless these are checked and approved by the Authority Engineer.

If concrete is placed by the CONTRACTOR without correctly placing in position, the necessary embedded parts, concrete shall have to be removed and replaced by him to enable such embedded parts to be installed in position, without any extra payment to him.

Care shall be taken not to disturb or displace embedded parts during concrete placement.

Water Stops

Bentonite strip water stops shall be furnished and installed for water tight construction at various locations of concrete structures / components covered under these specifications. In order to ensure proper alignment and fixing of Bentonite strip water stops in correct position / place, the same shall be rigidly secured to the form work or reinforcement steel as direct/approved by the Authority Engineer. Number of joints in Bentonite strip water stops, when installed in place shall be the barest minimum and joints, thus made, shall be suitably welded by the use of best method/ engineering practice satisfactory to the Authority Engineer.

All types of Bentonite strip water stops shall be tested in a recognized laboratory prior to transport to the site. Test specimens shall be furnished by the manufacturer and the tests shall be carried out at the manufacturer's place.

Bentonite strip Water stops shall be tested as to their tensile strength, elongation, duration, water absorption, specific gravity, effect of alkali and impact resistance.

The Contractor's shall submit to the Authority Engineer for approval the test results from recognized institution showing that the material supplied meets the requirements specified. The Authority Engineer may carry out the additional tests, for which the Contractor shall supply specimens from the same material to be used in the work. Test specimens, if required shall be of the shape and dimensions as required in the individual test methods.

The material should have the following physical and mechanical properties:

Minimum cross section of 25 mm by 20 mm;

Free expansion in distilled water at least six times the initial volume without loss of cohesion of mass;

Mass greater than 1.10 kg / in (ASTM D 71)

Pressure of swelling after 48 hours greater than 600 kPa. (DIN 1048-5)

Pressure of swelling after 6 hours less than 100 kPa. (DIN 1048-5)

Stability in salt solutions, and aggressive resistance to inhibition of calcium and magnesium ions

Resistance to hydrostatic pressure, to over 60 meters of hydrostatic water pressure, under both continuous immersion and wet / dry cycling. (DIN 1048-5)

FORMWORK :Scope of Work

The Specification described herein under relate to the Formwork. This Work shall include all labour, plant and materials, and services related to the design, fabrication, supply, erection, maintenance and removal of formwork and falsework to be carried out by the CONTRACTOR under this Contract.

The formwork shall be fabricated and erected to the dimensions of finished surfaces of concrete as shown on the drawings or as otherwise directed by the Authority Engineer.

Submittals

At least 60 days prior to the construction of steel formwork for the tunnel lining as also the formwork for other concrete works, the CONTRACTOR shall submit, to the Authority Engineer the following:

Shop drawings, details and structural computations of the formwork construction.

Details of materials which the CONTRACTOR intends to use for the fabrication of formwork.

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

General

Forms of formwork shall mean the mould into which concrete is placed.

Falsework or shoring shall mean the structural supports and bracing for forms used in any part of the Works.

All exposed concrete surfaces having slopes of 1.5:1 or steeper, shall be formed unless otherwise directed.

4) Where the character of the natural material cut in, to receive concrete is such that it can be trimmed to the prescribed lines, the use of forms shall not be required provided the other precautions of concrete placing are carried out by CONTRACTOR.

Materials

Forms shall be timber, steel or other approved material, except that the sheeting for all exposed surfaces, where form lining is not specified shall, be of tongue and groove timber of uniform width unless otherwise by the Authority Engineer.

All materials used in formwork construction shall be of adequate strength and quality for their intended purpose and shall be satisfactory to the Authority Engineer.

Timber shall be sound, straight, free from warp, decay and loose knots, and shall be dressed smooth.

Where plywood is used, it shall be non-wrinkling and manufactured with special water proof glues. Plywood sheets shall be of uniform width and length.

The surface of steel or steel lined forms shall be smooth. Forms with dents, buckled areas or other surface irregularities shall not be used.

Reuse of forms and form lumber shall be allowed only if they are thoroughly cleaned and repaired and capable of producing the finish required for the concrete. Timber or plywood forms required with metal patches shall not be used unless permitted by the Authority Engineer.

Damaged forms or forms which have deteriorated through usage shall not be used.

Form oil used on surfaces of timber or plywood forms shall be a straight, paraffin base refined, pale, mineral oil. The oil used on the surface of steel forms shall be specially compounded petroleum oil and other oils of animal or vegetable origin and gums or resins which are heavier in body and frequently darker than straight petroleum oils shall be used in the case of steel lining forms. The CONTRACTOR may use any other material also for coating of the formwork with the approval of the Authority Engineer.

Forms of like character shall be used for similar exposed surface in order to produce a uniform appearance.

The type, size, shape, quality and strength of all materials from which forms are made shall be the sole responsibility of the CONTRACTOR but subject to the approval of the Authority Engineer.

In general, forms for permanently exposed surface shall consist of or shall be lined with matched or dressed edge grain timber of appropriate thickness, free from loose or cracked knots.

Metal forms or metal-lined forms shall be permitted for permanently exposed surfaces only when an entire surface is to be built completely with such forms.

Design, Fabrication, Erection and Maintenance of Formwork

Forms and falsework shall be designed, fabricated, erected and removed in accordance with the applicable provisions of the Recommended practice for concrete formwork of IS:456-2000 as required by the Authority Engineer and as specified herein.

All falsework shall be designed to withstand safely all live and dead loads, necessary pressures, ramming and vibrations without significant deflection from the prescribed lines, which might be applied to the falsework during all stages of construction, service and removal.

The CONTRACTOR shall be solely responsible for the design, construction and maintenance of all formwork and falsework required in the work.

Detailed drawings of shoring and falsework shall be prepared by the CONTRACTOR. The calculations and drawings shall show the size and specification of the falsework, including the type and grade of all materials used in the construction, design load on falsework supports, horizontal forces imposed on the falsework and used for design purpose, and details of splices and connections, including nails, spikes and other fasteners. If mechanical equipment such as concrete buggies, screening machines, etc., are to be used, this information shall be shown on the drawings.

Falsework shall be constructed only after the falsework drawings have been approved by the Authority Engineer.

The approval by the Authority Engineer of CONTRACTOR's drawings shall not relieve the CONTRACTOR of his responsibility for the adequacy of form and falsework, or for the successful completion of the work.

The CONTRACTOR shall construct the falsework strictly in accordance with the approved falsework drawings, one set of which shall be kept on the site at all times, and no changes shall be allowed without prior written acceptance of such changes by the Authority Engineer.

Forms shall be designed to permit the concrete to be deposited, as nearly as is practicable, directly in its final position, and to allow inspection, checking and clean up of the formwork and reinforcement to be completed without delay.

Formwork and falsework shall be designed, constructed, erected and maintained such as to confine the concrete without loss of mortar and produce finished surface which are within the tolerances specified.

Forms for concrete against which backfill is to be placed or which shall not be exposed to view, may be constructed of smooth tight boards not less than 25 mm nominal thickness.

Forms for concrete exposed to flow of water or exposed to view shall be constructed of steel or ply wood which is smooth and free from defects with matched and sanded joints to give a symmetrical pattern over the entire area. Chamfer strips, 40 mm by 40 mm, shall be used on all exposed corners, unless otherwise specified or required by the Authority Engineer.

Form ties, supports, anchors, braces, spreaders and other similar devices which shall be embedded in the concrete for holding the forms shall incorporate threaded metal bars to facilitate removal of forms. Wood spreaders shall not be left in the forms. Any metal remaining embedded in the concrete shall be at least 50 mm from the surface of concrete. Holes left in the concrete by removal of parts of form ties or similar devices shall be well filled with cement mortar and neatly finished to match the adjacent concrete.

Form inserts or other similar permanently embedded items shall be accurately located and securely fastened in place. The number and location of form ties and bolts shall be such as to ensure that forms fit tightly against the concrete previously placed and remain in tight contact during operations.

Forms shall be set and maintained within the specified tolerance limits such that the complete concrete surfaces are within these limits.

All form surfaces shall be thoroughly cleaned before erection and shall be lubricated with a non-staining mineral oil. All excess oil shall be wiped off the forms prior to placement of concrete. Oil shall not be allowed to come into contact with reinforcing steel or other embedded items. For use of timber forms, the oil shall be capable of penetrating the timber and keeping it sufficiently oily to eliminate sticking and preventing absorption of water and consequent warping.

The oils shall be applied by brush, spray or swab and the forms shall be covered fully and evenly without excess or drip. Care shall be taken to prevent oil from getting in the surface of construction joints. Special care shall be taken to oil thoroughly the form strips for narrow groove seats.

Immediately before concrete is placed, all forms shall be inspected to ensure that they are properly placed, sufficiently rigid, clean, tight and properly surface treated and free from encrustations of mortar, grout or other foreign materials. No concrete shall be placed until formwork has been inspected and accepted by the Authority Engineer. Where forms of continuous surfaces are placed in successive units, the forms shall fit tightly over the surface so as to prevent leakage of mortar from the concrete and to maintain accurate alignment of the surface.

The formwork for the gate groove areas shall be accurately drilled to be held with first stage anchor couplings/plates to be embedded in primary concrete, both shall be fixed through formwork into the first stage anchor couplings/plates to ensure that the couplings/plates remain flush with primary concrete face and the couplings do not get plugged.

Where timber forms are used, the laying shall be in the direction which will blend architecturally into the lines of the structures, as decided by the Authority Engineer.

Curved and special forms shall be such that these will result in smooth concrete surfaces. They shall be designed and constructed so that they will not warp or spring up during erection or placing concrete.

When metal sheets are used for lining forms, the sheets shall be placed and maintained on the form with the minimum number of wrinkles, humps or other imperfections. The use of sheet metal to cover imperfections in the lining of timber faced forms for surfaces that shall be permanently exposed to view, shall not be permitted.

Where plywood or hardboard is used for form lining, the joints between the sheets shall be smooth and as perfect as practicable and no patching of the plywood or hardboard shall be permitted for permanently exposed surfaces. Minor imperfections in the ply wood may be corrected by the use of plastic wood secured firmly in place and sand papered smooth.

Wire ties shall be permitted for the forms when specially approved by the Authority Engineer and shall be cut off flush with the surface of concrete, after the forms are removed. Wire ties shall not be used when permanently exposed finished surfaces are required.

Forms shall be so constructed that the finished concrete surfaces shall be of uniform texture in accordance with the type of finish specified for concrete surfaces in these Specifications.

The erection of formwork in position shall be rapid enough, rigid and strong to withstand concreting operations and maintain the alignment. Panels of similar shape shall be identical and inter-changeable.

For special section/shapes, timber/steel form shall be used, as approved by the Authority Engineer.

The CONTRACTOR shall strengthen or modify the formwork, whenever required by the Authority Engineer.

Unless authorized, suitable mouldings shall be placed to level all exposed edges, at construction joints Authority Engineer . The final detailed drawings shall show any formed recesses, slots, blackouts and similar construction details, which have to be kept into account in fixing the formwork.

Forms shall be maintained, at all times, in good condition, particularly as to size, shape, strength, rigidity, tightness and smoothness of surface.

The Authority Engineer will, at any time, have the right to reject formwork which he considers to be no longer fit for use.

Removal of formwork

Forms shall not be removed until the concrete has hardened and has attained a crushing strength of at least twice the stress which the concrete may be subjected to at the time of removal of forms.

Duration for which the forms shall remain in place shall be decided by the Authority Engineer with reference to weather condition, shape, position of the structure or structural members and the nature and magnitude of dead and live loads. The forms shall not be removed without the permission of the Authority Engineer.

The following minimum intervals of time shall generally, be allowed between completion of placing of concrete and removal of forms but the period shall increase in case of wet or cold weather and also at the option of the Authority Engineer.

Structure Period in days with normal Portland cement

(a)	Beam sides, walls columns	3
(b)	Slab and arches (Props Left under)	4
(c)	Props to slabs and arches	10
(d)	Beam Soffits (Props left under)	8
(e)	Props to beams	21
(f)	Mass concrete	2

The above minimum periods are only recommendatory. The CONTRACTOR, may, where he so desires, extend the above to longer intervals. This shall not, however, constitute any reason for any claim for extension of time or damage to concrete etc.

If the CONTRACTOR desires to remove the forms earlier than the period stated above by addition of cement and/or suitable admixtures in the concrete, so as to gain early strength without affecting long term strengths, the matter shall be examined by the Authority Engineer in each case and his decision in the matter shall be final and binding.

Heavy live loads shall not be permitted until the concrete has reached its design strength.

The forms shall be removed with great caution and without jarring the structure or throwing heavy forms upon the floor. In order to achieve this end, wedges and clamps shall be used whenever practicable instead of nails.

In order to avoid excessive stress in the concrete that might result from swelling of the forms, wood forms for wall opening shall be loosened as soon as this can be accomplished without damage to the concrete. Forms for the opening shall be constructed so as to facilitate such loosening.

The CONTRACTOR shall be solely responsible for any damage that may be caused by negligence, lack of proper precautions or hastiness etc. in the matter of removal of forms and shall make the same good to the satisfaction of the Authority Engineer.

Measurements and Payments

No separate payment shall be made for formwork and the rates for formwork are deemed to be included into the quoted rates of relevant items.

GEOLOGICAL MAPPING

Introduction

The purpose of geological mapping is the documentation of rock - and rock mass conditions as encountered during excavation. The documentation shall enable the verification of the suitability of the designed support and excavation measures, the prediction of rock mass conditions ahead as well as the interpretation of results of the geotechnical monitoring concerning ground deformations.

The mapping and documentation of encountered geological conditions during the excavation shall be based on a uniform legend and shall use uniform terms for the description of features which have to be recorded.

To facilitate this procedure form sheets shall be used which include all the topics which have to be recorded if encountered.

In general, the mapping shall be performed in a scale 1:100. If necessary, details shall be mapped in a suitable scale.

Based on the follow-up mapping a vertical as well as a horizontal cross section shall be drawn, where the actual mapping results are incorporated continuously on a daily basis.

The vertical section shall be located along the axis of the tunnel. The horizontal section has to be fixed according to the chosen excavation cross section (full face, top heading - bench etc.). In case the tunnel is excavated by top heading - bench excavation the horizontal cross section shall be drawn on the level of the invert of the top heading. The proposed scale is 1:200 or 1:500; horizontal and vertical scale shall be the same.

Geological Documentation

General

The geological documentation shall include one page showing the mapping of the exposed rock face in a scale 1:100, the full periphery mapping of the crown and side walls in a scale 1:100 as well as a data sheet with all recorded features.

Mapping shall be performed at fresh excavated faces, right after installation of measures, which enable safe entry to the excavated section.

Terms as given in Clause 0 are examples and can be adjusted or supplemented according to the encountered features.

Terminology

Rock Types / Rock Mass Types

The rock types shall be filled in with standardised names and terms.

The rock mass can occur in different qualities according to the influence of weathering, tectonic stress and/or strain (shearing, faulting, folding). Therefore the rock mass type shall be described when different qualities can be distinguished.

Discontinuities

Possible types of discontinuities and abbreviations:

B : bedding plane

S : schistosity

J : joint

SL : slickenside

F : fault

A : axis (of fold etc.)

ST : striation

Orientation of discontinuities:

Discontinuities shall be measured in dip direction / dip angle.

Shape of discontinuities and abbreviations:

P : planar

U : undulating

S : stepped

Roughness of discontinuities and abbreviations:

P : polished

S : smooth

R : rough

Persistence of discontinuities and abbreviations:

The persistence of discontinuities shall be related to the size of the unsupported area (e.g. tunnel face).

H : high, discontinuities can be traced in a length exceeding the unsupported area

M : medium, discontinuities can be traced within the unsupported area exceeding the half of its span

L : low, discontinuities can be traced within the unsupported area less than half of its span

Spacing of discontinuities:

The spacing of discontinuities shall be classified according the following ranges:

> 60 cm, 20 - 60 cm, 6 - 20 cm, 2 - 6 cm, < 2 cm

Filling/Thickness of discontinuities and abbreviations:

The type and the thickness of fillings of open discontinuities shall be described. Possible types with abbreviations are stated below.

Cl : clay (weathering product)

Qu : quartz

Ca : calcite

Gy : gypsum

MFG : mylonitic fault gouge

MFB : mylonitic fault breccia

MCB : mylonitic crush breccia

O : open without filling

The thickness shall be measured in cm

Jointing of Rock Mass

The jointing of the rock mass shall be described by determination of the maximum average spacing of discontinuities using the prepared chart shown on the data sheet, and the degree of dilation of the rock mass.

The dilation of the rock mass is related to the degree of opening of the discontinuities exposed in the mapped area.

Water

Water seepage shall be described by the determination of location, amount (dry, damp, wet, dripping, running [l/sec]) and condition [colour, smell] of the water as well as by the impact of the water on the rock mass [soaking, break down].

Weathering

The description of the degree of weathering shall be based on the terminology shown in the table.

Descriptive term with abbreviation	Field identification test
Fresh (F)	Rock shows no signs of weathering (discoloration, decomposition).
Slightly Weathered (SW)	Rock is locally discoloured (stains of discontinuities, discoloured adjacent to discontinuities).
Moderately Weathered (MW)	Rock is dis-coloured, discontinuities have discoloured surfaces with weathering starting to penetrate inwards.
Highly Weathered (HW)	Rock is discoloured almost throughout. Weathering penetrates deeply inwards, but core stones are still present.
Completely Weathered (CW)	Rock is decomposed to soil but original fabric and structure are still visible, occasionally small core stones are possible.
Residual Soil(RS)	All rock material is converted to soil. The mass structure and material fabric are destroyed, change in volume but no significant transportation.

Rock Strength

The description of the rock strength shall be based on the terminology shown in the table.

Descriptive term with abbreviations	Field estimate of strength
Extremely Strong (ES)	Rock material only chipped under repeated hammer blows
Very Strong (VS)	Requires many blows of a geological hammer to break intact rock specimens
Strong (S)	Hand held specimens broken by single blow of geological hammer
Medium Strong (MS)	Firm blow with geological pick indents rock to 5 mm, knife just scrapes surface
Weak (W)	Knife cuts material but too hard to shape triaxial specimens
Very Weak (VW)	Material crumbles under firm blows of geological pick, can be shaped with knife
Extremely Weak (EW)	Indented by thumbnail

Behaviour of Rock Mass

The behaviour of the rock mass during excavation and at recently excavated faces until support installation shall be described.

Terms which shall be used are stated below.

stable

after breaking

friable

squeezing

loose

Over break

In case overbreak due to geological reasons has been encountered, which exceeds the tolerance location, shape, and reasons of the overbreak shall be recorded where possible.

Execution

General

The documentation of the tunnels shall be based on the mapping of the face and the full periphery mapping method. The full periphery mapping method shall be applied for the permanent walls only.

The frequency shall be adjusted to the variability of the encountered ground conditions. In case ground conditions are frequently changing within one round length each round shall be mapped. Each drive which is under construction shall be checked at least once a day.

Face Mapping Sheet

The form sheet for mapping shall show the area to be mapped in a scale of 1:100 and shall have a grid of 1 x 1 m for easier drafting, marked with "+".

The position of the laser beams on the face as well as the steel rib connections may be marked as drafting guides.

The sketch of the exposed face shall contain:

interfaces of different rock types (e.g. lithology), respectively rock mass types

visual features of rock mass (e.g. weathering)

major structural discontinuities

points of water inflow

position and shape of over break

The different degrees of weathering of the rock mass can be depicted as its independent feature separated from the lithology.

Remarks can be stated directly on the mapping sheet or can be referred to the data sheet.

Data Sheet

The data sheet contains the topics as explained below.

TUNNEL

Name of construction area (e.g. name of tunnel)

LOCATION

Name of the drive and working face (side gallery, top heading, bench etc.)

CHAINAGE

Chainage of the face

EXCAVATION

Excavation method (excavator, hydraulic hammer, bulldozer, road header, blasting).

MAPPED BY

Name of mapper

DATE/TIME

Date and time of recording

ROCK TYPES/ROCK MASS TYPES

Rock types shall be described with standardised names and terms according to the legend. The description shall include

Type of rock

colour

remarks on mineralogy

short remarks on rock strength (for terminology see Clause 0).

Rock mass types shall be described with standardised names and terms.

DISCONTINUITIES

Discontinuities shall be recorded by the determination of type, orientation, shape, roughness, persistence, spacing, filling, thickness of filling and additional remarks if necessary (for terminology see Clause 0).

JOINTING OF ROCK MASS

Jointing of rock mass shall be described by determination of the maximum average spacing of discontinuities and general shape of joint blocks using the prepared chart as well as by the degree of loosening of the rock mass (for terminology see Clause 0).

WATER/WEATHERING

Water seepage shall be described by the determination of location, amount and condition of the water as well as by the impact of the water on the rock mass (for terminology see Clause 0).

Weathering shall be described as its own feature, not combined with the description of the rock types (for terminology see Clause 0).

BEHAVIOUR OF ROCK MASS

The behaviour of the rock mass during excavation and at fresh excavated faces until support installation shall be described (for terminology see Clause 0).

In case over break due to geological reasons has been encountered, which exceeds the tolerance location, shape and reasons of the over break shall be recorded where possible.

GENERAL REMARKS

Additional remarks concerning the encountered conditions shall be noted.

Photos shall be taken of areas of special interest as well as to complete the geological documentation. Motive and number of photos shall be recorded. A scale shall be shown on the photos.

Samples shall be taken of representative rock types or in case specific geological and hydro geological conditions are encountered (e.g. fault zones, coloured or smelling water). Location, kind and purpose of samples which have been taken shall be recorded.

TAXES AND DUTIES, ROYALTIES ETC

1. Subsequent to the enactment of GST Act, the following paras are applicable:-

(i) Tenderers will examine the various provisions of The Central Goods and Services Tax Act, 2017(CGST)/Integrated Goods and Services Tax Act, 2017(IGST)/Union Territory Goods and Services Tax Act, 2017(UTGST)/ respective state's State Goods and Services Tax Act(SGST) also, as notified by Central/State Govt & as amended from time to time and applicable taxes before bidding. Tenderers will ensure that full benefit of Input Tax Credit (ITC) likely to be availed by them is duly considered while quoting rates.

(ii) The successful tenderer who is liable to be registered under CGST/IGST/UTGST/SGST Act shall submit GSTIN along with other details required under CGST/IGST/UTGST/SGST Act to railway immediately after the award of contract, without which no payment shall be released to the contractor. The contractor shall be responsible for deposition of applicable GST to the concerned authority.

(iii) In case the successful tenderer is not liable to be registered under CGST/IGST/UTGST/ SGST Act, the railway shall deduct the applicable GST from his/their bills under reverse charge mechanism (RCM) and deposit the same to the concerned authority.

2. i) The tenderer shall quote the rate by taking into account all the statutory duties/GST/taxes/cess/(royalty, EMF,DMF, additional charges on minerals) etc. applicable to the work up to the date of opening of tender.

ii) Any new impost or revision in the duties/GST/taxes/cess/(royalty, EMF,DMF, additional charges on minerals) etc. during the original currency of the contract will be to the Railway's account subject to production of Govt. Notification and documentary evidence. This will also be applicable for the work done during the extended period, if such extension is on Railway's account.

iii) Any benefit on account of downward revision of duty/GST/taxes/cess/(royalty, EMF, DMF, additional charges on minerals) etc. either in original contract period or during the extended contract period shall be passed on by the contractor to the Railways.

3. Income Tax @2.3% or at the rate as specified/proposed by the Income Tax Deptt, Govt. of India from time to time is deductible from all the bills of the contractor.

4. The present rates of royalty, EMF,DMF and additional charges for minerals etc. are to be collected from Mining Officer of that particular area or from concerned Govt. sources.

5. The tenderers for carrying out any construction work must get themselves registered from the Registering Officer under Section-7 of the Building and Other Construction Workers' Welfare Cess Act, 1996 and rules made thereto by the concerned State Govt. and submit certificate of Registration issued from the Registering Officer of the concerned State Govt. (Labour Dept.). Cess shall be deducted from the contractor's bills as per provisions of the Act.

6. In case the contractor fails to produce transit pass and money receipt in support of payment of Royalty, EMF, DMF, additional charges etc. then Railway shall deduct Royalty, EMF, DMF, additional charges from the contractor's bill as per prevailing rates at the time of opening of tender.

SAFETY RULES

- 1.1 Suitable scaffolds should be provided for workmen for all works that cannot be safely done from the ground or from solid construction except for such short periods work as can be done safely from ladders. When a ladder is used an extra labour shall be engaged for holding the ladder and if the ladder is used for carrying materials as well, suitable foot holds and hand holds shall be given an inclination not steeper than 1 to 4 (1 Horizontal to 4 Vertical).
- 1.2 Scaffolding or staging more than 3.5 metres above the ground or floor, swung or suspended from an overhead support or erected with stationery support shall have a guard rail properly attached, bolted, bracketed and otherwise secured at least 1 metre high above the floor or platform of such scaffolding or staging and extending along the entire length thereof with only such opening as may be necessary for the delivery of materials. Such scaffolding or staging shall be fastened as to prevent it from swaying from the building or structure.
- 1.3 Working platform gangways and stairways should be so constructed that they should not sway unduly or unequally and where the height of the platform or the gangway or the stairway is more than 3.5 metres above ground level or floor level they should be closely boarded, should have adequate width and should be suitably fastened as described in the Para above.
- 1.4 Safe means of access shall be provided to all working platform and other working places. Every ladder shall be securely fixed. No portable single ladder shall be over 10 metres in length while the width between side rails in swung ladder shall in no case be less than 300 mm. for ladder upto and including 3.5 metres in length.
 - 1.4.1 For longer ladders this width should be increased by at least 20 mm. each additional metre of length. Uniform steps spacing shall not exceed 300 mm. Adequate precautions shall be taken to prevent danger from electrical equipment. No materials on any of the sites of work shall be so stacked or placed so as to cause danger or inconvenience to any persons or the public. The Contractor shall provide all necessary fencing and lights to protect the public from accident and shall be bound to bear the expenses of defences of every suit, action or other proceedings at law that may be brought by any persons for injury sustained owing to neglect of the above precautions and to pay any damages and cost which may be awarded in any such suit, action or proceedings to any such person shall be paid by the Contractor to compromise any claim by any such person. In case the Contractor fails to settle such problems, the Railway Administration will make payments arising on account of the conditions given above to the concerned parties and recover the same from Contractor's dues without any delay. Contractor will not have any claim on this account at any stage.
- 1.5 Demolition: Before any demolition work is commenced and also during the process of work.
 - a) All roads and open area adjacent to the work site shall either be closed or suitably protected.
 - b) No electric cable or apparatus which is liable to be a source of danger over a cable or apparatus used by the operator shall remain electrically charged.
 - c) All practical steps shall be taken to prevent danger to persons employed from risk of fire or explosives or flooding. No floor, roof or other part of the building

shall be so over loaded with debris or materials as to render it unsafe.

- 1.6 All necessary personal safety equipment as considered adequate by the Authority Engineer should be kept available for the use of the persons employed in the site and maintained in a condition suitable for immediate use and the contractor should take adequate steps to ensure proper use of equipment by these concerned.
 - a) Workers employed on mixing asphaltic materials cement and mortar shall be provided with protective goggles.
 - b) Those engaged in white washing and mixing or stacking of cement bags or any materials which are injurious to the eye shall be provided with protective goggles.
 - c) Those engaged in welding works shall be provided with welder's protective eye sight lids.
 - d) Stone breakers shall be provided with protective goggles and protective clothing and seated at sufficiently safe intervals.
- 1.7 When the work is done near any place where there is risk of drowning, all necessary equipment should be provided and kept ready for use and all necessary steps taken for prompt rescue of any persons in danger and adequate provision should be made for prompt first aid treatment of all injuries like to be sustained during the course of the work.
- 1.8 Use of hoisting machines and tackles including their attachment anchorage and supports shall conform to the following standards of condition.
 - a) (i) These shall be of good mechanical construction, sound materials and adequate strength and free from patent defects and shall be kept in good repair and in good working order.
(ii) Every rope used in hoisting or lowering materials or as a means of suspension shall be of durable quality and adequate strength and free from patent defects.
 - b) Every crane driver or hoisting appliances operator shall be properly qualified and no person under the age of 21 years should be in-charge of any hoisting machine including any scaffolding.
 - c) In case of every hoisting machine and every cable ring, hook, shackle, swivel and pulley block used in hoisting or as means of suspension safe working load shall be ascertained by adequate means. Every hoisting machine and all gear referred to above shall be plainly marked with the safe working load. In case of hoisting machine having a variable safe working load of the conditions under which it is applicable shall be clearly indicated. No part of any machinery or any gear referred to above in this paragraph shall be loaded beyond the safe working load except for the purpose of testing.
 - d) In case of departmental machine, the safe working load shall be notified by the Technological Authority Engineer. As regards Contractor's machines, the contractors shall notify the safe working load of machine to the Authority Engineer whenever he brings any machinery to site of work, get it verified by the Authority Engineer concerned.
- 1.9 Motors, gearing, transmission, electric wiring and other dangerous parts of hoisting appliances should be provided with efficient safe guards. Hoisting appliances should be provided with such means as will reduce to the minimum the risk of accidental decent of the load; adequate precautions should be taken to reduce the minimum the risk of any part of a suspended load becoming accidentally displaced. When

workers are employed on Electrical installations which are already energized, insulating mats wearing apparel, such as gloves, sleeves and both as may be necessary should be provided. The workers should not wear any rings, watches and carry keys or other materials which are good conductors of electricity.

- 1.10 All scaffolds, ladders and other safety devices mentioned or described herein shall be maintained in safe condition and no scaffold, ladder or equipment shall be altered or removed while it is in use. Adequate warning facilities should be provided at or near places of work.
- 1.11 These safety provisions should be brought to the notice of all concerned by display on a notice board, at a prominent place at the work spot. The persons responsible for compliance of the safety code shall be named therein by the Contractor.
- 1.12 To ensure effective endorsement of the rules and regulations relating to safety precautions, the arrangements made by the contractor shall be open to inspection by the Labour Officer, Authority Engineer of the Department or their representative.
- 1.13 Notwithstanding the above clause from 1 to 12, there is nothing in these to exempt the contractor from the operations of any other act or rule in force in the Republic of India.
- 1.14 PRECAUTION TO BE TAKEN WHILE PLYING OF VEHICLES ADJACENT TO RUNNING LINES/STRUCTURES.

Whenever a Lorry or any other Form of Road transport is required to ply along or in the vicinity of a running line or any other Rly track where Rly Engines or Trains are liable to move, the Contractor shall inform the Authority Engineer in writing, of such requirement specify in the locations and duration of time over which such specified Road Vehicles have to operate in the area (for loading, leading or unloading of earth, ballast or any other materials, or plants or equipments) without any obstruction or dislocation to the running Trains.

- 1.14.1 The Contractor shall also furnish the particulars of Vehicles and the names and Photographs of Driver and attendant retained for each Vehicle to enable the Engineer to issue necessary permits allowing the holder to operate the Vehicles, with such restrictions regarding duration and /or location as are considered necessary. Such permit shall be returned to the Authority Engineer as soon as the work for which it is issued is over.
- 1.14.2 The Authority Engineer or his Authorized Representative will personally counsel, examine and certify the road Vehicle Drivers, Contractor's Flag Man and Supervisor and will give written permission giving names of Road Vehicle Drivers, Contractor's Flag Man and Supervisor to be deployed on the work , location, period and timing of the work. This permission will be subject to the following obligatory conditions:
 - (a) The Road Vehicles will ply only between sunrise and sunset.
 - (b) Nominated Vehicles and Drivers will be utilized for the work in presence of at least one Flag Man and on Supervisor certified for such work.
 - (c) The Vehicle shall ply 6 mtr Clear of track. Any movement / work at less than 6 mtr and up to minimum 3.5 mtrs clear of track centre shall be done only in presence of Authority Engineer or their representative. No part of the Road Vehicle will be allowed at less than 3.5 mtrs from track centre. Cost of such Rly Employee shall be the Rly.
 - (d) The Contractor shall remain fully responsible for ensuring safety and in case of

any accident shall bear the cost of all damages to this equipment and crew and also damages to Rly and its Passengers. Authority Engineer may impose any other condition necessary for a particular work of site. Such permit shall be returned to the Engineer, as soon as the work for which it is issued is over.

- 1.14.3 The Contractor shall execute a Bond undertaking to ply the Road Vehicles in a safe and satisfactory manner and strictly in accordance with the stipulation and other conditions specified by the Authority Engineer and to engage and retain only the permit Holder to be the Contractor's Agent In-Charge of the Vehicle and the attendance shall at all time, be vigilant and on the look-out for signals from the Look Out Man, Flag Man or other personnel available at Site with a view to stop or late the road movement so as to ensure adequate margin of safety for the timely passage of an approaching Train or a Rly Engine, without any delay or detention.
- 1.14.4 The Contractor shall also be bound by the provisions of this Agreement to ply the Road Vehicles only with adequate margin of safety, well clear of the fixed structure profile of infringement, as stipulated in the rules laid under the Indian Rly.'s Act and to seek and be guided by the signals and other directions of any Look Out Man or other personnel retained for the purpose of ensuring safety, and to ensure extra care and vigilance while turning, reversing or moving the Road Vehicles in any other manner at an inclination to the running Rly track or the siding as the case may be. The Contractor shall employ necessary Look-out Man also at his own cost, irrespective of any other arrangements that Rly may make in this regard.
- 1.14.5 The Contractor also undertakes to make good at his cost, any inconvenience, loss, damage or other expenses, costs incurred by the Rly. Administration and to pay such amount as are determined by the Engineer to be recoverable from Contractor as penalty or damages from any omission, negligence, carelessness, over sight or accident on the part of any Contractor's Agent, Drivers or Attendant or any other person to whom the services of the Holder of the permit (issued by the Engineer) has been lent or otherwise made accessible available.
- 1.14.6 Any breach of these conditions by the Contractor and his Agents affecting the safety of movement of Trains, Engines, or other rolling stock of the Rly, shall constitute a breach of contract by the Contractor entitling liability termination of contract for the fault on the part of the contract.
- 1.14.7 In exceptionally vulnerable locations, physical barrier in the form of barricades a height of 1.5 mtr of trenches on ground shall be provided so as to indicate the limit up to which the Vehicle can be approached the running line. The locations or circumstances under which such barriers have to be put will be decided personally by the Authority Engineer.
- 1.14.8 Suitable gates/barriers should be installed across the new embankment, preferably adjoining the manned/unmanned level crossings. The entry for the vehicles shall be regulated by an Authority Engineer during the working hours.

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