भारत सरकार
GOVERNMENT OF INDIA

रेल मंत्रालय
MINISTRY OF RAILWAYS

भारतीय रेल एकीकृत मानक विनिर्देश
(फॉर्मेशन कार्य,पूल कार्य एवं पी वे कार्य)

Indian Railways Unified Standard Specifications
(Formation Works, Bridge Works and P. Way Works)

इंजीनियरिंग विभाग
Engineering Department

2021

IR Unified Standard Specifications – 2021 (IRUSS – 2021)

INDEX

General Instructions

1.0 Indian Railways Unified Specifications – 2021 (IRUSS – 2021) are the revised edition of existing Specifications applicable for items of Railway Formation Works, Bridge Works and P. Way Works.

2.0 IRUSS - 2021 will replace existing IRUSS – 2019. The specifications of many items have been updated. Specifications of items, which have become obsolete over a period of time or are not in use, have been deleted. Many new items have also been added.

3.0 Specifications for "Preparation of foundation for earthwork in embankment/cutting" are incorporated for the first time.

4.0 For steel fabrication work, provision of additional weight on account of Welding/Rivetting, in earlier versions of Specifications has been removed as the same is now part of rates itself. However, HSFG bolts, where used, shall remain separately payable unless it is specifically mentioned otherwise.

5.0 Specifications of items in IRUSS - 2021 are complementary to applicable Indian Railway's codes, manuals, specifications & guidelines including IS codes and other international standards and also includes important extract therefrom to give an overview of standards for execution of work without being exhaustive.

In case of any contradictions between these specifications and latest amended relevant codes, manuals, specification and guidelines, the later shall prevail to that extent of contradictions.

6.0 Any correction/suggestion may be sent to Executive Director/Civil Engineering (G) at e-mail id edceg@rb.railnet.gov.in .

Chapter-1
Earth Work

1.1 EARTHWORK – GENERAL

Earthwork for Railway Formation (Embankment and Cutting) shall be as per RDSO Specifications: "Comprehensive Guidelines and Specifications for Railway Formation": RDSO/2020/GE: IRS-0004 with latest correction slips as applicable for suitability of soil, construction processes, sampling, testing and acceptance. This has been summarized hereunder for general guidelines and for details, aforesaid Guidelines may be referred to.

1.1.1 General Site Clearance: Before work in Embankment / Cutting is started, the whole area between the toes of banks or tops of cuttings plus 1 m on both sides shall be properly and effectively cleared by the contractor of all obstructions require to move men and machinery for execution of the work for which cost of which is deemed to be included in items of earth work.

1.1.2 Preparation of foundation for Earthwork:

a) Top layers of ground surface contain organic impurities and level of natural compaction is generally far from the requirement to sustain heavy structural load imposed over it without causing undue settlement, general or differential. Therefore, the natural ground needs to be prepared suitably to take the load of embankment, track structure and all other moving load. Such preparation may not be required when major soil improvement techniques have been used in the stretches of weak soils along with replacement of top layers of soil.

b) Preparation of foundation for earthwork in embankment shall include Clearing, Grubbing, Stripping, Ploughing & pulverizing and proper compaction with suitable mechanized rollers. In case of cutting, Clearing, Grubbing and Stripping shall not be required. However, natural compaction of soil strata at different depth is generally less than desired even in cutting, foundation preparation shall be done consisting of Ploughing & Pulverizing and proper compaction of naturally available top layers of soil before laying of prepared subgrade and/or blanket layer, as the case may be similar to the earthwork in embankment.

c) When Embankment is constructed on Ground having steep slope, then the ground surface should be suitably benched so that new material of embankment gets well bonded with the existing ground surface. Surface drainage shall be constructed, wherever required, so as to maintain the natural water drainage facilities and limit the introduction of water into the earthworks.

d) The meaning and scope of different parts of work involved in preparation of foundation for earthwork is as under:

1.1.2.1 Clearing: This shall mean clearing of all obstructions viz. vegetation, trees, stumps, bush, shrubs, and other vegetation at a level not more than 150 mm above ground, and the disposal of all cut material, other fallen timber, fallen branches,

building materials released from dismantling of structures and other surface litter including all debris and unwanted material visible on the surface up to a distance of 100m from the periphery of the area under site clearance. The clearing shall be done in the area required for the permanent works. The extent of clearing required for the permanent works shall normally be 1.0 metres on either side of base of embankment or as directed by the Engineer. All materials arising out of the clearing shall be pushed outside the clearing limit and shall remain the property of the Railway.

1.1.2.2 Grubbing: The term “grubbing” shall mean the entire removal of all stumps, roots, and embedded vegetable growth to a required depth below the ground line. The term “grubbing” shall also include the suitable disposal of all material resulting there from. Necessary grubbing of all areas is to be carried out where clearing has been done. The grubbing of such areas shall be carried out by a suitable method and the suitable disposal of all material resulting there from. Cost of clearing and grubbing of Trees up to the girth of 30 cm is deemed to be included in this item.

1.1.2.2.1 Trees of girth over 30 cm, measured at a height of 1m above ground level, shall be considered as large trees. Cutting down of large trees shall be paid extra at the rate specified when stumps are grubbed up in addition. Large trees shall not be cut without specific orders from the Engineer. As few trees shall be cut as is absolutely necessary for the execution of work. All holes or hollows formed due to removal of roots shall be filled up with earth rammed and leveled.

1.1.2.2.2 Trees, shrubs, poles, fences, signs, monuments, pipe lines, cable, etc. adjacent to the area which is not required to be disturbed during site clearance shall be properly protected by the contractor at his own cost. In case any damage to the pipe lines, cables, etc. is done due to negligence on part of the contractor, the necessary cost of damage shall be recovered accordingly.

1.1.2.2.3 The contractor shall have no claim to the trees or other material removed during site clearance and the same shall be the property of the Railway.

1.1.2.3 Stripping: The term “stripping” shall mean the removal of all top soil and organic material to an average depth of approximately 150 mm, and shall include the interim stockpiling of suitable topsoil or organic material for reuse elsewhere, as well as the disposal of the unsuitable and/or surplus material. The term “topsoil” shall mean the top layer of in-situ material which contains organic components, and which is not suitable for embankment construction.

1.1.2.4 Ploughing & pulverizing: The term “Ploughing & pulverizing” shall mean tilling the top surface with suitable mechanized equipment after stripping, to loosen top 150 – 200 mm of soil and crumbling loosened lumps into small sizes to make it amenable for uniform mixing of water or drying, as the case may be, to change the natural moisture content to optimum moisture content for compaction with heavy mechanical vibrators to specified density. Depressions, if any, should be filled with suitable soil to prepare even and leveled surface before starting compaction.

1.1.2.5 Compaction: Once the top loosened soil attains near about OMC, entire foundation surface shall be compacted by suitable heavy duty mechanical roller with sufficient number of passes to get leveled and uniform ground surface. First layer of soil/blanketing material, as the case may be, shall be laid with express written order of Engineer only after prepared foundation passes all the prescribed tests.

1.1.3 Demarcation and Profiles: The contractor, before starting work, shall demarcate with a deep furrow, at least 20 cm wide and 15 cm deep, 90 cm away from the toes of slopes of banks and the outside limits of cuttings on both sides of the centre line, the boundaries of the bottom. This is to be considered as part of the setting out of work, and preliminary to contractor being allowed to start the work; and this dagbelling is to be maintained and renewed by contractor as and when necessary, or when ordered by the Engineer. The cost of this is included in the initial rate for earth-work.

1.1.3.1 The centre line shall be initially set out by the Railway. The contractor shall, at his own expense, provide all building materials such as cement, stone chips, sand, bricks, steel plates, nails, markers, stakes, bamboos, strings, pegs and labour necessary for setting out the centre line and profiles required for the correct execution of work and shall be responsible to ensure that they are maintained in proper order.

1.1.3.2 The contractor before starting any work, shall take charge of all bench marks, centre line, demarcation and other field stones and reference pegs and be responsible for their subsequent preservation, and if they disappear or be destroyed after he has taken them over, he shall pay the cost of their replacement or replace them at his own cost in consultation with the department.

1.1.4 Maintenance: Banks and cuttings are to be correctly dressed and finished in profile with slopes as specified in each case. Where gullies or water-cuts commence to form on the slopes of embankments or cuttings, the erosion is to be checked as early as practicable and made good with suitable material well rammed into place. Where a gully or water-cut has not been checked at its commencement, it may be advisable to cut it out or step it before filling and compacting, and to further protect the place by turfing, pitching or other means as may be ordered by the Engineer. Work, before being finally paid for, is to be checked by the Engineer as having been correctly brought up, or carried down, to the proper level and to be otherwise complete in all respects in accordance with the specifications.

1.1.4.1 As soon as the work has been satisfactorily completed, the Engineer shall issue a certificate of completion in respect of the work as specified in Clause 48 of the General Conditions of Contract. Unless otherwise specified in the Tender conditions, the contractor shall maintain the banks / cuttings for a period of six months or as per conditions of contract and handing over of banks / cuttings to Railway in proper condition and where necessary, for their restoration to such condition, at the end of maintenance period. Until then, contractor is responsible for all losses due to subsidence, wastage or guttering due to rain, wind, wear, wash or from any other

cause whatsoever and for their restoration to correct profile and he shall have no claim for any extra work or payment on this account.

1.1.5 Spoil from Cutting to Bank: Up to the initial lead of 2 km, material from each end of every cutting shall be led forward into the adjoining bank as a matter of course, and the rate to be paid for such material shall be the rate for cutting only. Both bank and cutting shall not be paid for. The Engineer shall specify in each case from what point in each cutting to what point in the adjoining bank, spoil shall be led out, payment being made only for the excess lead over and above the initial lead included in the rate for cutting. The Engineer can modify these limits at any stage of the work and all such changes shall be binding on the contractor without any claim for any extra payment on this account. Compaction of the bank shall, however, be paid for in addition.

1.1.6 Classification of Soils: The classification of soils met with in executing the work shall be made by the Engineer/ Engineers' representative authorized by the Engineer for this purpose subject to the approval and final decision of the Engineer, if not made by him. The rates to be paid to the contractor in his bills shall be based on these classifications. Earth work can be divided under the following heads:

1.1.6.1 Soft / Loose Soil: Generally, any soil which yields to the ordinary application of pick and shovel, or to phawra, rake or other ordinary digging implements; such as vegetable or organic soil, turf, gravel, sand, silt, loam, clay, peat, etc.

1.1.6.2 Hard/Dense Soil: Generally, any soil which requires the close application of picks or jumpers or scarifiers to loosen; such as stiff clay, compact moorum, macadam surfaces of any description, (water bound, grouted, tarmac etc.), kankar soil, shingle and boulder studded soil and soft conglomerate etc.

1.1.6.3 Mud (Soil): A mixture of soil and water in fluid or weak solid state and where inflow of sub soil water is not involved.

1.1.6.4 Soft/Disintegrated Rock (Not Requiring Blasting): Rock or boulders which may be quarried or split with crow bars. This shall also include laterite and hard conglomerate.

1.1.6.5 Hard Rock (Requiring Blasting): Any rock for the excavation of which blasting is required.

1.1.6.6 Hard Rock (Blasting Prohibited): Hard rock requiring blasting as described under Sub Para 1.1.6.5, but where blasting is prohibited for any reason and excavation shall be carried out by chiseling, wedging or any other agreed method.

1.1.7 Measurements: Cutting and banks are to be executed neatly to the profiles shown in the cross section as per approved construction drawing. No payment shall be made for excess work done outside these profiles except when such work is so ordered in writing by the Engineer. However, if any bulges are left in the slopes of cuttings due to practical difficulties and are permitted, deduction as per actual measurements shall be made. Concave surfaces in the slopes of embankments shall not be permitted.

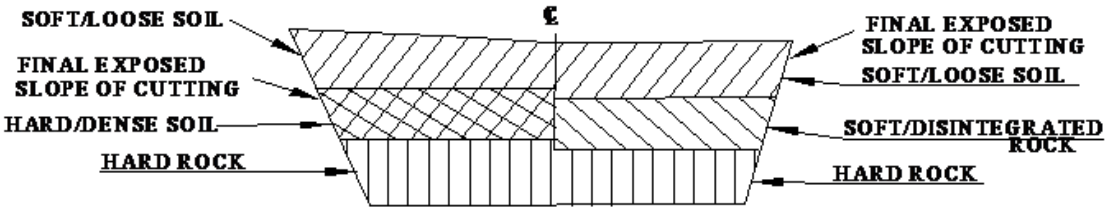
1.1.7.1 Should the Engineer so desires, he may, at any stage of the work, order the Contractor to increase or reduce the slopes of any cutting or bank or alter the formation level, in which case the amount of work actually done shall be paid for in accordance with the specifications and the Schedule of Rates.

1.1.7.2 Lead for the purpose of payment shall be measured from the centre of gravity of excavation to the centre of gravity of the bank or spoil heap and shall be measured along the shortest practicable route and not necessarily the route actually taken.

1.1.7.3 For purpose of payment, cuttings shall be assumed to be composed of such soil / soils only, as stand exposed on both or one side of the finished cuttings, depending upon whether the cutting is box type or one sided on a transversely sloping ground. The content of each type of soil thus assigned to any cross section shall be determined as indicated below. It is to be noted that no portion of cutting shall be payable for any such type of soil as is not exhibited on the finished side slope, where the side slope exists.

a) For box type cutting: The centre line of the alignment shall be marked vertically on the cross section and the content of each type of soil shall be determined by computing the area of the strip, formed by joining the points, which form the extremity of occurrence of the particular soil on the finished side slope of cutting, by straight horizontal lines terminating on the centre line. Figure No.1.1 is illustrative of the manner in which payment is to be made.

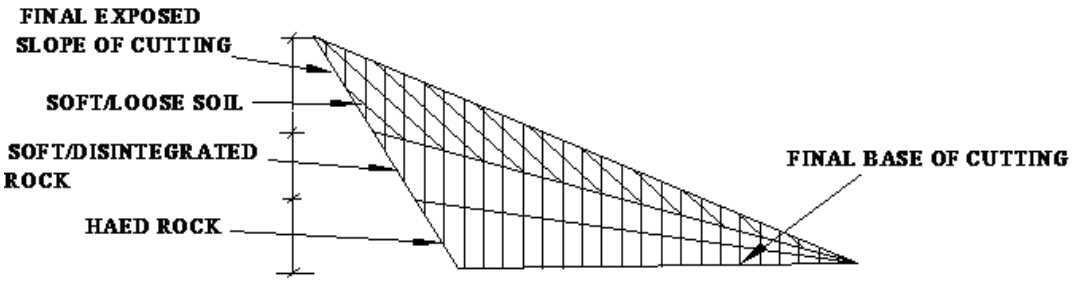
Sketch Showing Manner of Computation of Quantities of various classification of Soils



BOX TYPE CUTTING (Figure No.1.1)

b) For one sided cutting on a transversely sloping ground: Content of each type of soil shall be determined by computing the area of the strip, formed by joining the points, which form the extremity of occurrence of the particular soil on the finished side slope of the cutting, by straight lines to the zero point. Figure No.1.2 is illustrative of the manner in which the payment for the cutting shall be made.

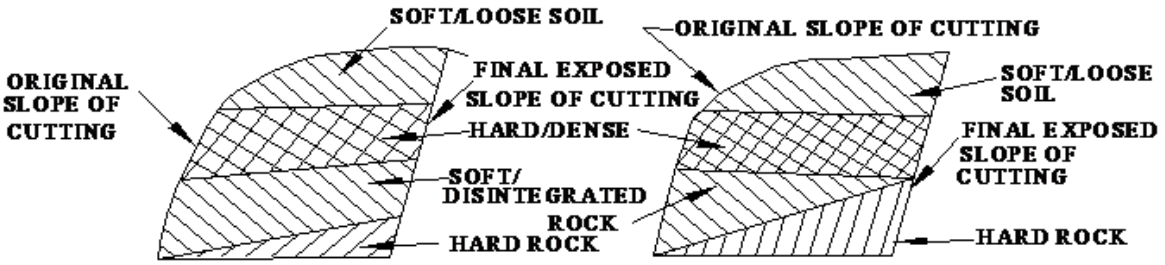
Sketch Showing Manner of Computation of Quantities of various classification of Soils



ONE SIDED CUTTING IN A TRANSVERSE SLOPING GROUND (Figure No.1.2)

c) For widening of existing cuttings for one or more lines where the existing cutting slope disappears and a fresh slope stands: Before undertaking widening of the cutting, pre-classification of the existing cutting slope (which will disappear) should be done after clearing and cleaning the surface and the strata met marked on the cross-section sheets. After completion of the work various strata as stand exposed on the new finished slope of the cutting shall again be marked on the cross-sections. Then the demarcation points of adjacent strata as determined by classification of the existing slope and the final slope should be joined as shown in Figure No. 1.3. The cross-sectional areas for different strata may be worked out and quantities payable classification-wise assessed accordingly.

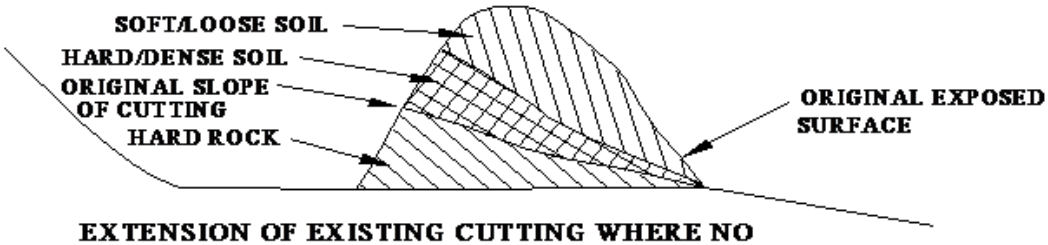
Sketch Showing Manner of Computation of Quantities of various classification of Soils



WIDENING OF CUTTING WHERE THE EXISTING CUTTING SLOPE DISAPPEARS AND A FRESH SLOPE ARISES (Figure No.1.3)

d) For extension to the existing cutting where no fresh cutting slope is available after work: Before execution of the work, pre-classification of the existing cutting slope which will not be finally available, should be done and recorded in the initial cross-section. Figure No. 1.4 is illustrative of the manner in which the payment for the cutting is to be made for soil of different classifications.

Sketch Showing Manner of Computation of Quantities of various classification of Soils



EXTENSION OF EXISTING CUTTING WHERE NO FRESH CUTTING SLOPE IS AVAILABLE AFTER THE WORK (Figure No.1.4)

1.1.7.4 Classification in the above manner shall be made only at such points where the cross sections giving the ground profile have been recorded. The classification as recorded in the above manner in case of cuttings shall be signed by the contractor in token of his acceptance. The classification as recorded by the Authorized representative of the Engineer in the above cases for cuttings is subject to confirmation by the Engineer, whose decision shall be final and binding on the contractor. Where there is disagreement between the Contractor and the Authorized representative of the Engineer on classification of soil, payment shall be effected "on account" as per lower classification as made by the Authorised representative of the Engineer. Payment for extra at the rate for higher classification shall be made after final decision by the Engineer on the admissibility of the Contractor's claim for higher classification.

1.1.7.5 In computing the quantity of earth work in cuttings and side drains, no cognizance shall be taken of the additional excavation, which may be necessitated during the progress of the work due to the presence of boulders or other material, and payment shall only be made for the quantity as per cross sections required to be provided.

1.1.7.6 Where cutting spoil is utilised for making the bank, stones over 15 cm size, which are not to be used in the bank, shall be stacked separately at a site to be indicated by the Engineer. To determine the quantity of cutting spoil led out for making the bank, the sectional quantity of the cutting shall be reduced by the volume of stones and boulders stacked outside, which shall be arrived at by deducting 50% for voids from the stack measurements of these stones and boulders. The stacking of these stones and boulders including lead upto 2 km is covered by the initial rate of Earth work.

1.1.7.7 Stones and boulders over 15 cm size shall not be used in making embankments. In embankments where payment is made on the basis of cross section measurements, the stones and boulders over 15 cm size shall be stacked separately, and their volume, after deducting 50% for voids from the stack measurements of these stones and boulders, shall be included as extra, for payment for earthwork in excavation.

1.1.7.8 Payment: It must be clearly understood that the Contract rates are intended to cover the full cost of finished work. Banks and cuttings are to be carefully dressed

to formation with such slopes as may be specified in each case. The payment for the quantity of earth work in cutting / bank shall normally be made on cross sectional measurements. The existing ground levels / bank profile shall be taken and plotted by the Authorised representative of the Engineer in the presence of contractor or his authorized representative before commencement of the work. The profile of the bank or the cutting required to be provided shall also be plotted on the same sheets. The levels and cross sections shall be signed by both the Authorised representative of the Engineer and the contractor / his authorized agent. (The profiles of the bank or cutting as required to be provided are for the guidance of the contractor and not for the purpose of measurements).

The profiles of the finished bank/ cutting shall like-wise be taken and plotted in the presence of the contractor or his authorised representative and super-imposed on the original ground profile. These profiles are to be taken at locations as directed by the Engineer, at least at 25m intervals on straight and at least at every 15m on Curves with radii sharper than 600m and at extra locations in special cases such as irregular or side long ground etc. The gross volume of earth work shall be calculated from the original and finished profile of the bank/ cutting. The embankment has to be compacted by heavy machinery as stipulated in subsequent Para 1.6 or in accordance with any other special specifications, on the specific instructions of the Engineer in writing, shrinkage allowance shall be deducted at the rate of 5% of the gross quantity of earth work unless specifically mentioned otherwise in the terms of the contract.

As it may, at times, be difficult to measure by means of cross sections the quantity of rock excavated by blasting or chiseling, owing to its irregular configuration or intermixture with other materials, the quantity of rock may be measured after stacking the excavated rock spoil. The same procedure also applies to any other type of soil, which requires to be measured separately from the material constituting the bulk of the spoil. In all such cases, the payable quantity of the stacked material is to be arrived at by making suitable deductions for voids from the measured cubical contents of the stacks as specified below:

Type of soil stacked	**Deduction**
Rock spoil of different sizes	30 per cent
Sandy materials	7 ½ per cent
Black cotton soil	20 per cent
Other soils, including coal ashes	15 per cent

To facilitate measurement, all stacks to be measured shall be made rectangular in plan and of uniform height, on level ground or ground leveled for this purpose. The

stacking of spoil shall be done in a compact manner to the satisfaction of the Engineer. The rates provided shall include all charges on account of such stacking as well as any lead or lift, as also the re-stacking of stacks or portions of stacks which the Engineer considers, in his sole discretion, as not properly stacked.

As far as possible spoils from cuttings fit for embankment shall be used to make up the bank unless this is found uneconomical due to excessive lead in comparison to cost of construction with Contractor's earth. As far as possible each stretch of bank should be made of earth from only one source so as to avoid mix up. If however, this is not possible due to exigencies of work, earth from one source should be utilised first and duly compacted. After measurement of the compacted earthwork from this source, earth from the next source shall be allowed to be used. Initial cross section of bank and cross section after compaction of earth from each of the sources should be taken. Based on the cross-sectional areas, the gross quantity of earth work embankment executed by utilising the earth from different sources shall be determined. The net quantity shall be assessed after deduction of shrinkage allowance.

Final measurements shall be taken only after the bank/ cutting has been completed to the required profile as directed by the Engineer irrespective of the period of completion and number of monsoons that may pass during execution. Shrinkage allowance shall be applied on these final measurements for banks as admissible.

1.1.7.9 Nothing extra shall be paid for:

(i) Excavation for insertion of planking and strutting.

(ii) Removing slips or falls in excavations

(iii) Bailing out water in excavations from rains, ordinary springs requiring pumping etc. except pumping out water caused by powerful springs, tidal or river seepage, broken water mains or drains and the like, if specifically provided for in the Agreement.

(iv) Unauthorized battering or benching of excavations.

(v) Forming steps in sides of deep excavations and their removal after measurements.

(vi) Protective measures for protection against risk of accidents to the public due to open excavation.

(vii) Protective measures / precautions taken to avoid damage to existing Signal / Electrical / Telecom / other Miscellaneous Cables, Pipes, installations etc.

1.2 EARTH WORK IN EMBANKMENTS

1.2.1 Embankment in Water-logged ground etc.: When embankments are to be carried across water-logged or swampy ground or to be made in soil which requires special protective measures, it rests with the Contractor in all such cases to bring these facts to the notice of the Engineer concerned who will direct on the methods to be

adopted and accordingly rates to be paid either as per the items available in the agreement or shall arrange for a special agreement for the same as necessary.

1.2.2 Selection of Earth:

(i) Only soil, suitable for construction of Railway Formation shall be used in Earthwork. Unsuitable Soils, as has been specified in Para 3.7 of RDSO Specification No. RDSO/2020/GE: IRS-0004, shall not be used.

(ii) Soil Quality: Suitable soil has further been categorised based on percentage of fine particles (size less than 75 micron) present in the soil. Soil containing fines more than 50% is classified as SQ1, from 12% to 50% is classified as SQ2 and less than 12% is classified as SQ3,

(iii) All the earthwork in embankment shall preferably be done with earth of soil quality class SQ2/SQ3. In case of non-availability of adequate quantity of SQ2/SQ3. SQ1 class of Soil may be used in top layer of subgrade only with the prior approval of the PCE/CAO.

(iv) The disturbed / undisturbed **soil samp**les along with the test results as per specifications shall be submitted by the contractor for approval of the source from where the earth is proposed to be borrowed before the Earth work in embankment is started or in case of change in location of the source.

(v) Summary of quality control tests in Borrow material/ finished earth work are given in Table 7.2 of RDSO Specification No. RDSO/2020/GE: IRS-0004 and the same shall be followed for evaluation and acceptance.

1.2.3 Top Width of Formation:

(i) It should be adequate enough to accommodate tracks laid with concrete sleepers and standard ballast section (minimum 35cm depth) and have minimum cess width of 90cm on either side.

(ii) Additional Width of formation shall have to be provided to cater for increase in extra widening of ballast shoulder and extra clearances required on curves.

It shall be regulated/provided in accordance with extant instructions as per Indian Railway Schedule of Dimensions (IRSOD) & Indian Railway permanent Way manual (IRPWM).

1.2.4 Cross Slope: Cross slope should be within 1 in 28 to 1 in 30.

1.2.5 Side Slopes: Side Slope of Embankment: Side slopes of Embankments should be 2H: 1V as per design should not be steeper than 2:1 but the Engineer or his Authorised representative may, by order in writing, vary this slope to suit local conditions. The side slopes shall be carried up simultaneously with the rest of the work and not filled in afterwards. This can only be ensured by insisting on the whole width of embankment (along with berms, wherever required and additional width of 500mm on either side required for compaction) as per design, from the toes of the slope coming up simultaneously.

1.2.6 Profiles: Profiles for banks shall be set out where-ever cross section levels have been taken. These profiles shall be set up at least every 25m on the straight and every 15m on curves with radii shorter than 600m. Profiles shall also be set up at any additional places if ordered by the Engineer.

Extra embankment width of 500mm on either side shall be rolled/compacted to ensure proper compaction at the edges. The extra soil should be cut and dressed mechanically to achieve regular side slope and the slope shall be compacted with 6-8 passes of slope compactors (10-20 ton capacity) before turfing.

1.2.7 Borrow Pits: Borrow Pits in railway land is prohibited. In addition to this, the borrow pits should be selected sufficiently away from the alignment, but not less than 3 m plus height of the Embankment.

1.2.8 Clods: All large clods shall be broken up in the borrow areas or bank to 75 mm or lesser size before placing on Embankment by labour specially deputed for this work. This shall be strictly ensu**red.**

1.2.9 Benching: In widening of an existing bank for Gauge conversion / doubling / tripling / rehabilitation projects, benching of existing embankment slopes shall be done manually in steps 30cm in height and approximately 60 cm wide, in the existing banks of running lines before any new earthwork is taken up to form a bond between the new and old earthwork as per profile prescribed in RDSO latest Specifications and guidelines RDSO/2020//GE: IRS-0004. This work includes uprooting and disposing of all the vegetation, all lift, descends, ascends and additional earthwork required for filling due to removal of earth in benching in existing bank.

The work of benching shall normally be done manually in precise manner to avoid any under-cut or over-cut as prescribed. However, mechanical means with specialized attachment, capable to meet precise profile can be used with the prior approval of Engineer on certification after due demonstration of capability of mechanized means in the field.

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.

The benching Work shall be done for a maximum height of 0.90 m at any time based on the progress of earthwork starting from toe of the embankment. Benching work shall be certified and recorded before starting the earthwork.

Cut soil from bank shall not be used in embankment construction and disposed off away from bank as per the direction of Engineer-in-charge.

1.2.10 Backing to Bridges: In carrying embankments over a bridge or a culvert intended to be covered by the work, the earth work shall be brought up evenly on both sides of the structure so that the pressure may be equalised. In filling in the approaches of a bridge, or the spandrels between small arches, the earth filling shall

be raised simultaneously with the wing walls in the former case and with the face walls in the latter. Filling for the backing of bridges or culverts shall conform to specifications under Para 1.5 of these specifications and subsequent sub-Paras, or as ordered by the Engineer. Suitable vibratory plate compactor shall be used for compaction.

1.2.11 Dressing: After completion of earth work, the side slopes shall be neatly dressed to the correct profiles, and shall be made up where required during the maintenance period. The top of formation should be neatly dressed off sloping at an inclination of 1 in 30 either side from the centre line unless otherwise specified in the drawings.

1.2.12 Turfing: Turfing of banks shall be done during the monsoon season, preferably after a heavy shower, when it can be ensured that the bank slopes shall remain wet for a long time after planting the grass. Turfing shall be paid for separately. Turfing shall not be commenced without the prior written permission of the Engineer. The stretch of embankment where turfing is to be done should be completed in all respects and should be so recorded in the level books. Contractor should be given permission in writing to this effect before starting the Turfing.

1.2.12.1 Before turfing is commenced, the side slopes are to be dressed to the specified section. This dressing is included in the initial rate for earth work, and should a contractor stop work before dressing the bank, he shall be debited with the estimated cost of the dressing to be done by another contractor or departmental labour, as decided by the Engineer. Where the slope is already consolidated, it should be loosened for a depth of about 4 cms before the sods are laid.

1.2.12.2 Turfing shall consist of sods, not less than 10 cm thick and 20 cm square well beaten into the bank till they get a proper hold and form a level and compact mat. The contractor shall be responsible for watering where necessary to ensure that the turf grows properly; and in the event of not doing so, he shall re-turf such parts as have not grown, at his own cost. The turfing shall be measured and taken over only after the grass has rooted well and has formed a sufficiently dense growth over the earth slopes. Turing with sarkanda or other varieties of locally available grass may also be permitted by the Engineer In-charge depending upon the local conditions.

1.2.12.3 Turfing of side slopes of cuttings if ordered by the Engineer shall be carried out in a manner similar to Turfing of bank.

1.2.13 Sarkanda or similar type of planting on bank slopes: Where Sarkanda is planted on bank slopes, the minimum distance centre to centre in rows shall be 40 cm in either direction. The plantation in adjacent rows shall be staggered for proper coverage of the area. For other types of plantations, the local practice shall be followed as directed by the Engineer.

1.3 EARTH WORK IN CUTTINGS

1.3.1 Formation width: The formation widths, exclusive of side drains, are to be as shown in the drawings given in Annexure -2/2A & 2/2C under para 212 of IRPWM 2020.

The formation width and other details are covered in RDSO's "Comprehensive Guidelines and Specifications for Railway Formation" Specification No. RDSO/2020/GE: IRS-0004. Side drain width is generally standard 1.2 m wide on top, 0.6 m at bottom. The depth is min 0.3 m, with deeper drains as per longitudinal slope depending upon length of cutting. Sub-surface longitudinal drains may be required where blanket layer has been provided, unless shown otherwise in the drawing. For longer drains specially designed sections shall be adopted depending upon the catchment area, length and slope of the drain which should be finalized before starting the work in cuttings. Blanket material is to be placed like fill/embankment and top of side drains has to remain below the bottom of blanket material.

1.3.2 Side Slopes: In cutting slope, softening of soil occurs with the passage of time, and therefore, long term stability is the most critical, and should be taken into consideration while designing the cuttings. The side slopes shall ordinarily be 1:1 unless otherwise ordered by the Engineer depending upon the type of soil and depth of cutting.

1.3.3 Excavation:

1.3.3.1 When so ordered, the centre portion of gullet of the cutting shall be first taken out to the full width of formation to enable the Engineer to determine the slopes suitable to the full length of the particular cutting or to different lengths of it. When the gullet is cut out to its full depth in shallow cuttings, or to the depth of the first cut in deep cuttings, the side portions or triangular sections up to the slopes may be excavated. In deep cuttings, the, second cut shall not be started until the top portion is thus completed as per designed cross section of the cutting at that level to maintain safe working.

1.3.3.2 All cuttings shall be taken down carefully to the precise level and section as delineated in the drawings or as ordered by the Engineer. In case the bottom of the cutting is taken down deeper than is necessary by over sight or neglect of the contractor or due to blasting operations, the hollow must be filled up to true depth with selected material and rammed, at contractor's expense. Cuttings with the formation in rock shall be excavated up to the designed depth below the true formation and blanketing layer should be provided over it to true level of formation with specified camber.

1.3.3.3 In soft soil the excavation of cuttings shall be carried out to the additional depth required below formation level for laying prepared subgrade, followed by blanket layer as per design. In case only blanketing layer is to be provided as per design, the additional depth shall be the same as depth of blanketing layer. In both the cases, foundation preparation shall be done as aforesaid before prepared subgrade or blanketing layer is laid over it, as the case may be.

1.3.4 Drainage in cuttings:

1.3.4.1 In excavating cuttings, special precautions are to be taken to ensure that the excavations drain themselves automatically. To ensure this, the central block of

earth or gullet is to be excavated first. This shall be done in such a manner that the bottom of the excavation shall, where possible, slope downwards from the centre of the cutting towards the ends. It shall be made in such cuts or steps as may be directed from time to time. Generally, in deep cuttings, the first cut or step shall approximately follow the surface of the ground, where this will secure the necessary slope for drainage, and shall be excavated to such depth not exceeding 3m as may be ordered, with perpendicular sides leaving pathways for workmen along the sides of the cut parallel to the central line about every 15 m. In shallow cuttings, not exceeding 2m in the deepest part, the gullet may be cut out at once to formation level.

1.3.4.2 Side drains according to the cross section shown in the drawing shall be provided at the toe of the slope in all cuttings to ensure proper drainage. 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.

1.3.5 Catch-water drains: Surface water flowing from top of hill slope towards the track in huge quantities needs to be controlled. 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 to 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.

The spoil from the catch water drain shall be deposited to make a uniform slope from the edge of the cutting towards the drain. The material derived from the catch water drain shall be used to the extent required to provide the slope and the surplus earth should be deposited in the spoil bank of the cuttings.

Unless ordered to the contrary by the Engineer, the Catch water drain must be excavated before the cutting is started.

1.3.6 Berms and spoil banks: No spoil shall be deposited within a distance of 10 m from the top edge of the slope of any cutting duly taking into account the location of the catch water drain, if any. While doing so, the Engineer may bear in mind the side on which the doubling may eventually be done and may be suitably increased.

1.3.6.1 The spoil heap shall be roughly but neatly dressed off to a slope of 1½:1, and shall form a continuous bund along the top of the cutting. In country where there is any cross fall, sufficient spoil shall be thrown on the uphill side of the cutting to

supplement the catch water drain and assist in keeping drainage out. This work must be done first.

1.3.6.2 **a)** All material excavated from cuttings suitable for pitching, ballast, masonry or any other purpose whatever, shall be the property of the Railway, and shall be stacked, or disposed off, as directed by the Engineer, within the limits of lead specified for stacking of spoil. This is included in the rate for cutting.

b) Any object of archaeological interest such as relics of antiquity, coins, fossils or other articles of value discovered shall be handed over to the Engineer and shall be the property of the Railways.

1.3.7 **Springs or Inflow:** Should springs or inflow of water appear in cuttings, or should they be flooded, the contractor must arrange for bailing, pumping or drainage of water, without obstruction to adjacent works. Payment for the same shall not be made unless otherwise provided for in the Agreement.

1.3.8 **Protections**: Excavation, where directed by the Engineer, shall be securely fenced and provided with proper caution signs, conspicuously displayed during the day and properly illuminated with red lights during the night, to avoid accidents. The Contractor shall take adequate protective measures to see that the excavation operations do not damage the adjoining structures or dislocate the services. Water supply pipes, sluice valve chambers, sewerage pipes, manholes, drainage pipes & chambers, communication cables, power supply cables etc. met within the course of excavation shall be properly supported and adequately protected, so that these services remain functional. No extra payment shall be made for taking such measures unless otherwise specifically provided for in the Contract. In case, shifting of these utilities are required to complete the work, the same should be informed to the Engineer who shall arrange expeditious shifting away from work areas.

Excavation shall not be carried out below the foundation level of adjacent buildings until underpinning, shoring etc. are done as per the directions of the Engineer for which payment shall be made separately. The temporary arrangement drawings should be submitted by the contractor and got approved before undertaking such excavation.

1.3.9 **Blasting**: If any blasting operations are necessary, they shall be carried out in accordance with the Explosives Act and the Rules as amended up to date.

1.3.9.1 Where hard rock is met with and blasting operations are considered necessary, the contractor shall obtain the approval of the Engineer in writing for resorting to blasting operation.

Note: In ordinary rock, not requiring blasting, blasting operations shall not be generally adopted. However, the contractor may resort to blasting with the permission of the Engineer, but nothing extra shall be paid for such blasting operations.

The contractor shall obtain license from the competent authority for undertaking blasting work as well as for containing and storing the explosive as per the Explosive Act, 1884 as amended up to date and the Explosive Rules, 2008. The contractor shall

purchase the explosives fuses, detonators etc. only from a licensed dealer. Transportation and storage of explosive at site shall conform to the aforesaid Explosive Act and Explosive Rules. The contractor shall be responsible for the safe custody and proper accounting of the explosive materials. Fuses and detonators shall be stored separately and away from the explosives. The Engineer or his authorised representative shall have the right to check the contractor's store and account of explosives. The contractor shall provide necessary facilities for this.

The contractor shall be responsible for any damage arising out of accident to workmen, public or property due to storage, transportation and use of explosive during blasting operation.

1.3.9.2 Blasting operations shall be carried out under the supervision of a responsible authorized representative of the contractor (referred subsequently as representative on duty), during specified hours as approved in writing by the Engineer. The agent shall be a licensed blaster. In case of blasting with dynamite or any other high explosive, the position of all the bore holes to be drilled shall be marked in circles with white paint. These shall be inspected by the Contractor's agent. Bore holes shall be of a size that the cartridge can easily pass down. After the drilling operation, the agent shall inspect the holes to ensure that drilling has been done only at the marked locations and no extra hole has been drilled. The agent shall then prepare the necessary charge separately for each bore hole. The bore holes shall be thoroughly cleaned before a cartridge is inserted. Only cylindrical wooden tamping rods shall be used for tamping. Metal rods or rods having pointed ends shall never be used for tamping. One cartridge shall be placed in the bore hole and gently pressed but not rammed down. Other cartridges shall then be added as may be required to make up the necessary charge for the bore hole. The top most cartridge shall be connected to the detonator which shall in turn be connected to the safety fuses of required length. All fuses shall be cut to the length required before being inserted into the holes. Joints in fuses shall be avoided. Where joints are unavoidable, a semi-circular ditch shall be cut in one piece of fuse about 2 cm deep from the end and the end of other piece inserted into the ditch. The two pieces shall then be wrapped together with string. All joints exposed to dampness shall be wrapped with rubber tape.

The charges shall be fired successively and not simultaneously. Immediately before firing, warning shall be given and the agent shall see that all persons have retired to a place of safety. The safety fuses of the charged holes shall be ignited in the presence of the agent, who shall see that all the fuses are properly ignited.

Careful count shall be kept by the agent and others of each blast as it explodes. In case all the charged bore holes have exploded, the agent shall inspect the site soon after the blast but in case of misfire, the agent shall inspect the site after half an hour and mark red crosses (X) over the holes which have not exploded. During this interval of half an hour, nobody shall approach the misfired holes. No driller shall work near such bore until either of the following operations have been done by the agent for the misfired boreholes.

a) The contractor's agent shall very carefully (when the tamping is of damp clay) extract the tamping with a wooden scraper and withdraw the fuse, primer and detonator.

b) The holes shall be cleaned for 30 cm of tamping and its direction ascertained by placing a stick in the hole. Another hole shall then be drilled 15cm away and parallel to it. This hole shall be charged and fired. The misfired holes shall also explode along with the new one.

Before leaving the site of work, the agent of one shift shall inform the agent relieving him for the next shift, of any case of misfire and each such location shall be jointly inspected and the action to be taken in the matter shall be explained to the relieving agent.

The Engineer shall also be informed by the agent of all cases of misfires, their causes and steps taken in that connection.

1.3.9.3 General Precautions: For safety of persons, red flags shall be prominently displayed around the area where blasting operations are to be carried out. All the workers at site, except those who actually ignite the fuse, shall withdraw to a safe distance of at least 150 metres from the blasting site. Audio warning by blowing whistle shall be given before igniting the fuse.

Blasting work shall be done under careful supervision of licensed blaster and trained personnel shall be employed. Blasting shall not be done within 100 metres of an existing structure, unless specifically permitted by the Engineer in writing. In such cases, the Authorised representative of the Engineer must be present to ensure that special precautions as may be prescribed by the Engineer and those stipulated by the licensing authority are taken and that necessary warning is given to the inhabitants.

All procedures and safety precautions for the use of explosives drilling and loading of explosives before and after shot firing and disposal of explosives shall be taken by the contractor as detailed in IS:4081, Code of Safety for blasting and related drilling operation.

1.3.9.4 Precautions against misfire: The safety fuse shall be cut in an oblique direction with a knife. All saw dust shall be cleared from inside of the detonator. This can be done by blowing down the detonator and tapping the open end. No tools shall be inserted into the detonator for this purpose.

If there is water present or if the bore hole is damp, the junction of the fuse and detonator shall be made water tight by means of tough grease or any other suitable material.

The detonator shall be inserted into the cartridge so that about one-third of the copper tube is left exposed outside the explosive. The safety fuse just above the detonator shall be securely tied in position in the cartridge. Water proof fuse only shall be used in the damp bore hole or when water is present in the bore hole.

If a misfire has been found to be due to defective fuse, detonator or dynamite, the entire consignment from which the fuse, detonator or dynamite was taken shall be got inspected by the Engineer or his authorised representative before resuming the blasting or returning the consignment.

1.4 EARTH FILLING IN FOUNDATION TRENCHES & BEHIND ABUTMENTS ETC.

1.4.1 Foundation Trenches: The space between the sides of the foundation trenches and the concrete/masonry is to be filled with sound impervious material such as moorum, chips, spalls, gravel or other sandy material well rammed in layers not exceeding 15 cm, each layer being watered, rammed and consolidated before the succeeding one is laid. Earth shall be rammed with iron rammers where feasible, and with the butt ends of crow bars / wooden ballies where rammers cannot be used. Earth used for filling shall be free from salts, organic or other foreign matter. All clods of earth shall be broken or removed.

1.4.1.1 Where concrete foundations are brought up in reducing off-sets, it shall be necessary to bring the earth filling up with the form walls but in such cases special care shall be taken that no earth is allowed to fall on the concrete surface, on which further concrete is to be laid.

1.4.1.2 In all fillings sufficient allowance shall be made for settlement of all materials and restoration of the surface to the required level.

1.4.1.3 The filling shall not be commenced until the recording of levels, measurements etc. as may be necessary in respect of the existing ground or of any work to be filled over or likely to be hidden by the filling has been completed and permission in writing has been given to the contractor by the Engineer to start the filling.

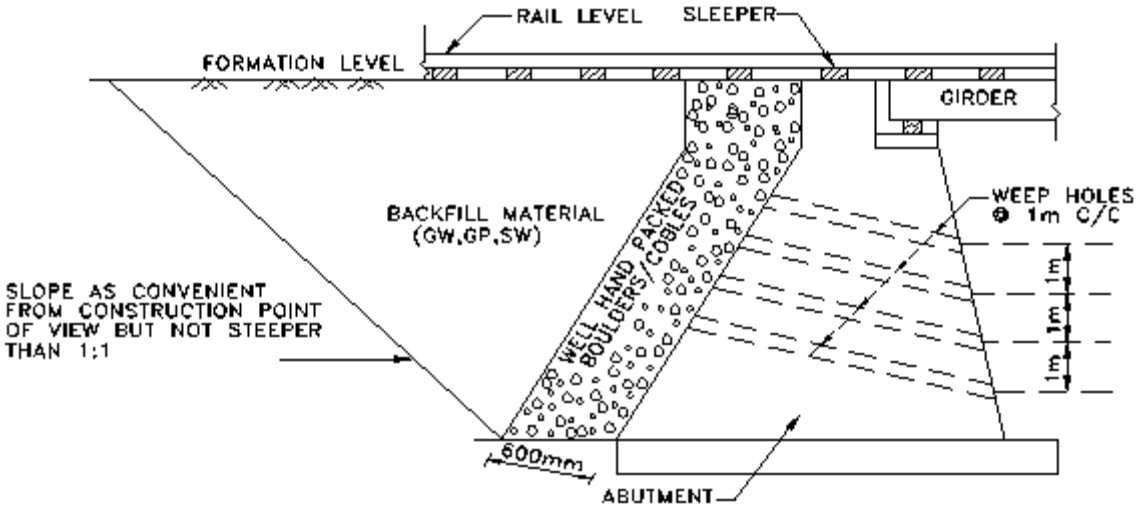
1.4.1.4 The finished level of the filling shall be kept to slope intended to be given to the floor.

1.5 PLACEMENT OF BACK-FILLS ON BRIDGE APPROACHES AND SIMILAR LOCATIONS

1.5.1 Back-Fills on Bridge Approaches

(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 bases. To avoid such differential settlements, while on one hand it is essential to compact the back fill in the properly laid layers of soil for Settlements within tolerable limits so that 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 7.5 of Bridge Substructure code (including latest correction slips). Sketch for details given in **Fig.** below.



NOTE:– 1. BEHIND ABUTMENTS, WING WALLS AND RETURN WALLS, BOULDER FILLING AND BACKFILL MATERIALS SHALL BE PROVIDED UPTO FULL HEIGHT.
2. THE BOULDER FILLING SHALL CONSIST OF WELL HAND PACKED BOULDERS & COBBLES TO THICKNESS NOT LESS THAN 600mm WITH SMALLER SIZE TOWARDS THE BACK. BEHIND THE BOULDER FILLING, BACKFILL MATERIALS, SHALL CONSIST OF GRANULAR MATERIALS OF GW, GP, SW GROUPS AS PER IS: 1498–Latest Edition

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

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

(v) Compactions of the layers shall be done by vibratory plate compactors or as directed by the Engineer.

(vi) Geo-composite drain (vertical) can replace the natural graded filters (consisting of 600mm thick boulders/cobbles etc. as shown in above Fig.), provided behind bridge abutment and/or retaining walls for drainage in places where availability of graded filters is matter of concern. Detailed elaboration is given in Appendix-C of RDSO Specification No.: RDSO/2020/GE:IRS-0004.

1.5.2 Use of earth from excavation: If the excavated earth from the foundations of a bridge is thrown up to form part of the guide bund, embankment or backing of a bridge, it is to be understood that the only items (over and above the rate for the excavation) to be paid for are any extra “Lift”, “Lead” “Dressing” and “Compaction” which may be thus necessitated.

1.5.3 Filling of Trenches for Pipes etc.: The filling back of pipe-line trenches shall not be commenced until any testing as required to be done has been carried out and the pipe-line passed. The filling shall generally be done using the material excavated from the same trench. But any excavated rock used for filling back shall be mixed with finer material so as to fill up all the voids. In refilling, care shall be exercised to avoid damaging or disturbing the pipe line or other work being covered up. The manner in which filling and consolidation are to be done shall, in other respects, be the same as laid down for foundation trenches. Where the trench carries a pipe-line or an arch barrel, sand or other stable soil approved by the Engineer shall be used up to a height of 15 cm above the top of the pipe or barrel. This height shall be increased to 30 cm in the case of trenches cut in rock. In case of sand filling as per drawing additional payment as per relevant item shall be made.

1.5.4 Measurement: The measurement shall in all cases be of the space filled and all the hidden details required for the same shall be measured up before being filled over and deductions made accordingly. No deduction shall be made for shrinkage or subsidence, provided the Engineer is satisfied that the consolidation has been done properly, as specified in each case. In the filling for foundations and other trenches, any extra work done on account of over cuts, slips, etc. shall not be paid for.

1.6 MECHANICAL COMPACTION OF EARTHWORK

Earthwork for Railway Formation (Embankment and Cutting) shall be as per "Comprehensive Guidelines and Specifications for Railway Formation", RDSO Specification No.: RDSO Specification No.: RDSO/2020/GE: IRS-0004.

1.6.1 Advantages of Compaction:

1.6.1.1 Compaction is the process of increasing the density of soil by mechanical means by packing the soil particles closer together with reduction of air voids and to obtain a homogeneous soil mass having improved soil properties. Compaction brings many desirable changes in the soil properties as follows:

a) Helps soils to acquire increase in strength in both bearing resistance and shear strength.

b) Reduces compressibility, thus minimizing uneven settlement during services.

c) Increased density and reduces permeability, thereby reducing susceptibility to change in moisture content.

d) Reduction in erosion

e) Results in homogeneous uniform soil mass of known properties.

f) Reduction in frost susceptibility in cold regions.

1.6.2 Factors affecting Compaction in the field:

Compaction of a particular soil is affected by moisture content, compacting effort, type of roller etc. as explained below:

(a) Compacting Effort: In modern construction projects, heavy compaction machinery is deployed to provide compaction energy. Types of machinery required are decided based on type of soil to be compacted. The method of compaction is primarily of four types viz kneading compaction, static compaction, dynamic or impact compaction and vibratory compaction. Different type of action is effective in different type of soils such as for cohesive soils; Sheep's foot rollers or pneumatic rollers provide the kneading action. Silty soil can be effectively compacted by Sheep's-foot roller / pneumatic roller or smooth wheel roller. For compacting sandy and gravelly soil, vibratory rollers are most effective. If granular soil has some fines both smooth wheeled and pneumatic rollers can be used.

(b) Moisture Control: Proper control of moisture content in soil is necessary for achieving desired density. Maximum density with minimum compacting effort can be achieved by compaction of soil near its OMC (Optimum Moisture Content). If natural moisture content of the soil is less than the OMC, calculated amount of water should be added with sprinkler attached to water tanker and mixed with soil by motor grader for uniform moisture content. When soil is too wet it is required to be dried by aeration to reach up to OMC.

(c) Soil Type: Type of soil has a great influence on its compaction characteristics. Normally, heavy clays, clays and silts offer higher resistance to compaction, whereas, sandy soils and coarse grained or gravelly soils are amenable for easy compaction. Coarse-grained soils yield higher densities in comparison to clay. A well-graded soil can be compacted to higher density.

(d) Thickness of Layer: Suitable thickness of soil of each layer is necessary to achieve uniform compaction. Layer thickness depends upon type of soil involved and type of roller, its weight and contact pressure of its drums. Normally, 200-300mm layer thickness is optimum in the field for achieving homogeneous compaction.

(e) Number of Passes: Density of soil will increase with the number of passes of roller but after optimum number of passes, further increase in density is insignificant for additional number of passes. For determination of optimum number of passes for given type or roller and optimum thickness of layer at a predetermined moisture content, a field trial for compaction is necessary for which contractor's shall make all arrangement of test/tests at his own cost as per procedure prescribed in Sub-Para 6.2.3.C of "Comprehensive Guidelines and Specifications for Railway Formation", RDSO Specification No.: RDSO Specification No.: RDSO/2020/GE: IRS-0004.

1.6.3 Compaction procedure for Different soils:

The embankments are constructed with locally available soil provided it fulfills the specified requirements. Procedure of compaction to be adopted will depend on the type of soil being used in construction. General guidelines to deal with compaction of various types of soils for attaining optimum dry density/relative density at minimum effort have been briefly given as under. The procedure to be adopted shall be decided by the Engineer for strict adherence by the Contractor.

1.6.3.1 Compaction of Cohesion less gravely and Sandy soil:

Sandy & gravely soils should be compacted with vibratory rollers. If fines are less in these types of soils, it can be compacted with minimum number of passes of vibratory rollers without strict control of moisture to achieve desired Relative Density. With higher percentage of fines, sandy and gravely soils need to be brought to OMC level to get effective compaction. Uniformly graded sand and gravel are difficult to be compacted. Top layer of sand and gravel remains loose in vibratory compaction. Therefore, in final pass the roller should move smoothly without vibration. Dry densities attained in field trials normally should be around MDD/ specified Relative Density as obtained from laboratory tests and should form the basis for specification and quality control.

1.6.3.2 Compaction of Silty- Clayey Soils

Silty soil is a fine-grained soil. These can be plastic or non-plastic depending upon the clay content in it. Silts and fine sands with high water content have a tendency to undergo liquefaction under vibrating rolling due to the pore water pressure generated by mechanical work. Silty soils can be compacted satisfactorily near about OMC either with smooth rollers or vibratory rollers. Vibratory roller will give high degree of compaction and higher lift. Compaction of silty clays will have to be handled in a manner similar to clays.

1.6.3.3 Compaction of Clays

(i) Water content plays very important role in compaction of clays. Main objective of compacting predominantly clays is to achieve uniform mass of soil with no voids between the lumps of clays. If moisture content is too high, roller tends to sink into the soil and if too low the chunks would not yield to rolling by rollers. Appropriate water content i.e. OMC of the soil is in the range of about plastic limit plus two percent. Sheep's-foot rollers are most effective in breaking the clods and filling large spaces.

(ii) Thickness of layer should not be more than depth of feet of roller plus 50mm.

1.6.3.4 In case of such soils, the MDD and OMC as determined in the Laboratory may not be very relevant and therefore achievable MDD and practicable moisture content at which such soils can be compacted should be determined by conducting field trials.

1.6.4 Selection of Compacting Equipment:

The performance of roller is dependent mainly on type of soil used in construction. Typical Compaction Characteristics for natural soils and rocks are given in **Appendix – F** of "Comprehensive Guidelines and Specifications for Railway Formation", RDSO Specification No.: RDSO/2020/GE: IRS-0004 and the same may be used for selection of suitable type of compacting equipment. Accordingly, the Contractor should get the Engineer's approval for the type of equipment to be deployed for compaction.

1.6.5 General aspects of Mechanical Compaction.

(a) The spreading of material in layers of desired thickness over the entire width i.e. designed width plus additional 50cm on either side, of embankment should be done by mechanical means and finished by a motor grader for each layer of soil or blanketing. The motor grader blade shall have hydraulic control suitable for initial adjustment and maintain the same so as to achieve the slope and grade.

(b) Thickness of layer is decided based on field compaction trials. However, thickness of each layer should not be more than 300mm for fill material and 250mm for blanket material in loose state before compaction.

(c) If natural moisture content (NMC) of the soil is less than the OMC, calculated amount of water based on the difference between OMC and NMC and quantity of earthwork being done at a time, should be added with sprinkler attached to water tanker and mixed with soil by motor grader or by other means for obtaining uniform moisture content. When soil is too wet, it is required to be dried by aeration to reduce moisture content near to OMC. Efforts should be made to keep moisture content level of the soil in the range of OMC ± 2% at the time of compaction.

(d) Fill shall be placed and compacted in layers of specified thickness. The rate of progress should be, as far as possible, uniform so that the work is completed to final level almost at the same time.

(e) The rolling for compaction of fill material should commence from edges towards center with minimum overlap of 200mm between each run of the roller. In final pass, roller should simply move over the surface without vibration so that top surface is properly finished.

(f) Extra bank width of 500mm on either side shall be rolled to ensure proper compaction at the edges. The extra soil would be cut and dressed to avoid any loose earth at the slopes. This should preferably be done with help of grade cutter. After cutting, the slop should be properly compacted by Slope Vibratory Roller/Compactor. The earth so cut in final stages shall not be paid.

(g) At the end of the working day, fill material should not be left uncompacted. Care should be taken during rolling to provide suitable slope towards toe of the bank to facilitate quick shedding of water and avoid ponding on formation.

(h) During construction of formation, there may be rainfall to the extent that rain cuts may develop on the surface of formation due to erosion of soil. Care should be taken that these rain cuts are not allowed to develop wide and deep otherwise these locations will remain weak spots.

(i) 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 center of formation to both sides in single line.

(j) Once the top surface of the formation has been finished to proper slope and level, movement of material vehicle for transportation of ballast, sleepers etc. should be

avoided since these movements will cause development of unevenness, ruts on the surface which will accumulate water and weaken the formation.

(k) In conversion / doubling / rehabilitation projects, suitable benching of existing slope shall be done as provided for in the contract before new earthwork is taken up to provide proper bonding between old and new earthworks. 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.

(l) At locations where the water table is high and the fill soil is fine-grained, it may be desirable to provide a granular layer of about 30 cm thickness at the base, above subsoil across the full width of formation. This work shall be carried out if directed by the Engineer for which extra payment shall be made.

1.6.6 Quality Control of Compacted Earth / Blanket layer

1.6.6.1 Compacted Earth: Degree of compaction of each layer of compacted soil should be ascertained by measurement of dry density / Relative Density of soil at locations selected in specified pattern. The method of sampling, frequency of tests, method of tests to be conducted and acceptance criteria to be adopted are as under.

a) Method of Sampling:

(i) Various methods of selection of sample points for checking the fields dry density are shown in Fig.7.1 of "Comprehensive Guidelines and Specifications for Railway Formation", RDSO Specification No.: RDSO/2020/GE: IRS-0004.The sampling adopted shall be such that effectiveness of compaction for the entire area of compacted earth can be judged properly. The Engineer-in-Charge should specify the sampling method depending on the site conditions.

(ii) For each layer, a minimum of one sample at a predetermined interval along the centre line of the alignment would be taken in a staggered pattern so as to attain a minimum frequency of tests as given in the note below Table 7.2 of RDSO Specifications. For subsequent layer, the stagger should be such that the point of sampling does not fall vertically on the earlier sampling points of the layer immediately below. The process of sampling is explained in Fig 7.1 of RDSO Specifications for guidance. Additional sampling points can be taken, as considered necessary.

(iii) In case of embankment widening, sampling should be done at an interval of minimum 200 metres on widened side(s) of embankment.

b) Method of In-situ Dry Density Measurements

Any of the following methods could be adopted as per the requirements at site.

(**Table 7.1 of RDSO Specification No.: RDSO/2020/GE: IRS-0004)**

Method of measurement	Procedure of test	Parameters to be measured	Remarks

i) Sand Replacement Method	As per IS:2720 (Part 28) - latest version	In-situ Dry Density Moisture Content	May be adopted for all type of soils
ii) Core Cutter Method	As per IS:2720 (Part 29) - latest version	-do-	In some of the coarse-grained soils (with little fines) taking core cutter samples is difficult. In such cases, a sand replacement method may be used for density measurement.
iii) Nuclear Moisture Density Gauge	As per Appendix-H	a) Bulk density b) Moisture Content c) Dry density d) Degree of compaction	It is a faster Method and should be widely used for large construction projects.

c) Acceptance Criteria:

(i) Coarse grained soils which contain fines passing 75 micron IS Sieve, up to 5 percent should have the Density Index (Relative Density) a minimum of 70% as obtained in accordance with IS:2720 (Part-14).

(ii) In field compaction trial, the maximum attainable dry density should not be less than 98% of MDD value as obtained by Heavy Compaction Test (IS:2720 (Part 8) in the laboratory. In case, there are difficulties in achieving 98% of the MDD values as obtained by Laboratory test, in the field trials, the same may be relaxed up to 95% of MDD with the specific approval of Chief Engineer/Construction, recording reasons for such relaxation. The level of compaction to be achieved in field, as a percentage of MDD value achieved in field compaction trial, for various layers shall be as per Table 3.3 to 3.6 of Chapter 3 of "Comprehensive Guidelines and Specifications for Railway Formation", RDSO Specification No.: RDSO/2020/GE: IRS-0004.

(iii) During widening of embankment in case of gauge conversion and rehabilitation of unstable formation, compaction of earthwork should be minimum 95% of MDD as obtained by Laboratory test as per Heavy Compaction Test (IS:2720 (part 8) \or 70% Relative Density for Coarse grained soils which contains fines (Passing 75 micron IS Sieve up to 5% (IS:2720 (Part 14).

1.6.6.2 Deformation Modulus (Ev_2) measurement: It is a parameter expressing the deformation characteristics of a soil. It is calculated taking values from the load settlement curve obtained from the second cycle of loading in the Plate Load Test (Details given in **Appendix-H of** "Comprehensive Guidelines and Specifications for Railway Formation", RDSO Specification No.: RDSO/2020/GE: IRS-0004.). It is to be determined in the field on top of each formation layer i.e. at top of compacted Blanket layer/Prepared sub-grade/Sub-grade - Top & Lower layer in accordance with DIN: 18134-2012 at frequency given in Table 7.2 of "Comprehensive Guidelines and Specifications for Railway Formation", RDSO Specification No.: RDSO/2020/GE: IRS-0004.

1.6.6.3 Frequency of Tests: The frequency of testing at finished earthwork should be as specified in Table 7.2 of "Comprehensive Guidelines and Specifications for Railway Formation", RDSO Specification No.: RDSO/2020/GE: IRS-0004 for **Deformation Modulus (Ev_2), Compaction and Relative Density**

1.6.6.4 Qualifying and Quality assurance Tests: Qualifying tests as part of pre-selection of good earth for Blanket, Prepared sub-grade, Subgrade is required to be carried out. Also, quality of execution of formation earthwork shall be controlled through exercise of checks on the borrow material, blanket material, compaction process to ensure good quality construction. The quality control procedures are summarized in **Table-7.2** below**.**

Summary of quality control tests in Borrow material/ finished earth work

(Table 7.2 of RDSO Specification No.: RDSO/2020/GE: IRS-0004.)

Item/ Material	Parameters to be determined	Location of sampling for quality control	IS Code Ref. (Latest version)	Frequency of test	Acceptance Criteria
(i) Borrow material					
(a)Subgrade/ Prepared Subgrade	**(i)** Soil classification	At site before laying	IS:1498	At least one test at every change of subgrade/ prepared-subgrade material subject to minimum of one test for every 5000 cum.	Soil should not be "unsuitable type" as given in 3.7 and should conform to specification given in Para 3.10 for 25T/32.5T Axle load of Chapter 3
	(ii)CBR		IS:2720-Part-16		
	(iii) Plasticity Index (Prepared Subgrade)		IS:2720- Part-5		
	(iv) OMC & MDD		IS:2720 – Part-8		
(b)Blanket material	(i) Gradation	At site before laying	IS:2720- Part-4	Minimum one	
	(ii) Cc & Cu				
	(iii)Fines (passing 75 μ)				

	(iv)Abrasion value		IS:2386 – Part-4	test for every 500 cum or part thereof	
	(v)CBR		IS:2720-Part-16		
	(vi)Filter criteria		IS:2720 – Part-4		
	(vii) OMC & MDD		IS:2720 – Part-8		
	(viii)γ_{max} & γ_{min} (Determined in Relative Density test If fines are up to 5%)		IS:2720-Part-14		
(ii) Finished earthwork					
(Subgrade/ Prepared Subgrade/Blanket)	(i) Ev_2	Top of final finished surface of Blanket/ Prepared subgrade & Subgrade	DIN 18134 –2012	One test per Km (*)	Acceptance Criteria as specified in Para 3.10 of Chapter 3
	(ii) Compaction	Every compacted layer	IS:2720(Part-28/29) or NMDG(as per Procedure issued by RDSO)	As per note given below	
	(iii) Density Index (Relative Density if fines are upto 5%)	Every compacted layer	IS:2720 – Part-14		Minimum 70%

Additionally, this test can also be done by third party (i.e. IIT, NIT, Govt. Labs or any NABL approved Lab) having testing facilities, to cross check the results achieved at site. Frequency of testing in this case shall be decided/approved at the level of Chief Engineer (Con). In PSUs, frequency of such tests shall be decided as per existing delegations for testing.

Note: Frequency of Tests: Density check would be done for every layer of compacted fill/blanket material as per following minimum frequency:

(i) At least one density checks for every 30 m length for blanket layers and top one metre of prepared subgrade/subgrade along the alignment in a staggered pattern of each compacted layer.

(ii) At least one density checks for layers other than as specified in(i) above, every 500 m^2 or 75 m c/c whichever occurs earlier along the alignment in a staggered pattern of each compacted layer.

(iii) In case of important bridge approaches (100 m length on either side), at least one density check for every 25 m length shall be adopted.

1.6.7 Formation Level: Finished top of sub-grade level may have variation from design level by ± 25mm and finished top of blanket layer may also be permitted to have variation from design level by plus 25mm only. The ballast should be placed only on finished formation after ensuring that there are no ruts or low pockets on the top surface i.e. top surface is in one plane without any undulations, duly certified by Engineer-in-Charge.

1.6.8 Cross Slope: Cross slope should be within 1 in 28 to 1 in 30.

1.6.9 Side Slopes: Side slope should be 2H: 1V or flatter as per design.

1.6.10 Formation Width: Formation width should not be less than the specified width.

1.7 QUALITY CONTROL RECORDS: Following records of quality control as prescribed in "Comprehensive Guidelines and Specifications for Railway Formation", RDSO Specification No.: RDSO/2020/GE: IRS-0004 needs to be maintained.

(i) Characteristics of borrow materials as per Proforma **No. G-1.**

(ii) Quality of blanket materials as per Proforma **No. G-2.**

(iii) Field compaction trial computation sheet details as per **Table D-4** of **Appendix-D.**

(iv) Quality of compaction of earthwork including blanket material as per Proforma no. **G-3** for core cutter method & Proforma no**. G-4** for sand replacement method.

(v) Quality of material and its compaction for backfill behind bridge approaches etc. as per Proforma no. **G1, G2, G3 & G4.**

(vi) Details of machineries engaged in execution of earth work including its output as per Proforma decided by field engineers.

1.8 SETTING UP OF GE LAB AT CONSTRUCTION/REHABILITATION SITE:

A well-equipped Geo-technical Engineering (GE) Field Laboratory shall be set up at all construction projects connected with new lines, doubling and gauge conversion works as well as, where rehabilitation of failing formation is being undertaken as prescribed in RDSO Specification No.: RDSO/2020/GE: IRS-0004.

1.9 CERTIFICATION FOR QUALITY OF EARTHWORK: Certification for quality of earthwork in formation in respect of new lines, Gauge Conversion and Doubling projects etc. shall be done by Executive authority at SAG level (i.e. CE/Con of respective projects) as per checklist in Appendix – M of RDSO Specification No.: RDSO/2020/GE: IRS-0004.

1.10 BLANKETING MATERIAL:

1.10.1 General: Where the drawings provide for a Blanket of coarse and granular material of thickness as shown therein over the full width of formation, the contractor shall arrange for the supply of the materials at site, spreading over the top layer of

subgrade in layers, consolidation to specified density and true to designed top profile of embankment.

Blanket material, to be used, shall generally be produced mechanically by crushing the hard stones to specified gradation or by mixing, naturally available materials using suitable equipment/plants like pug mill, wet mix plant, crusher etc. if there is a specific provision in the agreement for use of naturally available material conforming to the specifications.

1.10.2 Specifications of Blanket Material: Blanket material, whether mechanically manufactured or produced by mixing of naturally available materials, shall conform to specifications prescribed in Table 3.3 to Table 3.6 of RDSO Specification No.: RDSO/2020/GE: IRS-0004 for different axle load and number of layer.

1.10.2.1 Key parameters of specification of material to be used and quality of finished work is reproduced as under:

(i) $C_U > 7$ and C_C between 1 and 3.

(ii) Fines (passing 75 microns) : 3% to 10%

(iii) Los Angeles Abrasion value < 40%

(iv) Minimum soaked CBR value ≥ 25, (soil compacted at 100% of MDD in lab)

(v) Field compaction: 100% of MDD in field trial

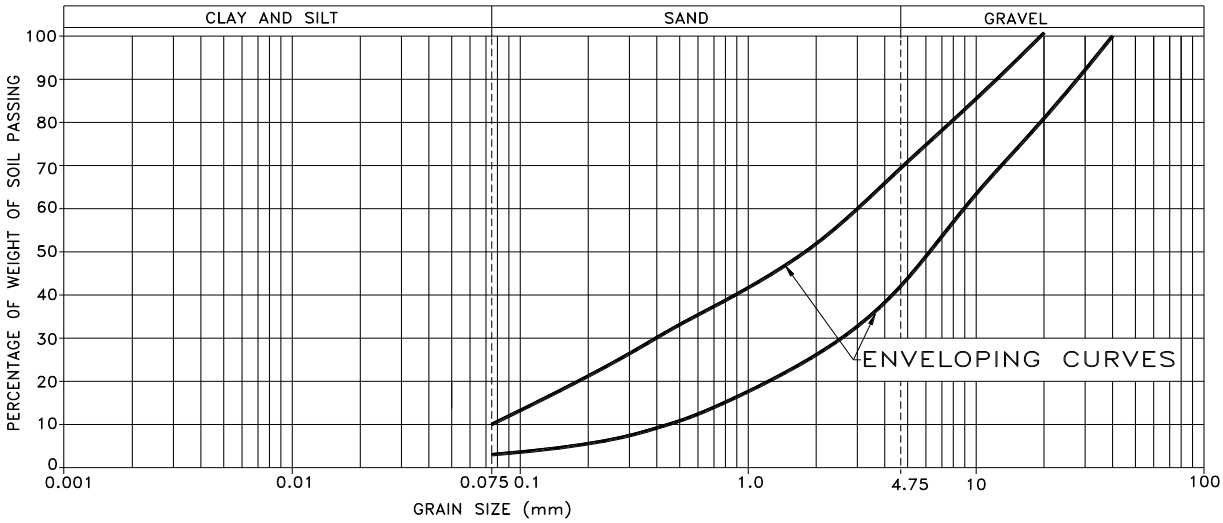
(vi) Minimum Ev_2 = 100 MPa / 120MPa for 25T /32.5 T Axle Load respectively

1.10.2.2 Size gradation:

a) Gradation of blanket material shall in the specified range as given in the table below:

SL	**IS Sieve Size**	**Percent Passing** (by weight)
1.	40 mm	100
2.	20 mm	80 – 100
3.	10 mm	63 – 85
4.	4.75 mm	42 – 68
5.	2 mm	27 – 52
6.	600 micron	13 – 35
7.	425 micron	10 – 32
8.	212 micron	6 – 22
9.	75 micron	3 – 10

b) Once the size gradation is plotted, it should lie within the enveloping curve as under:



Enveloping Curves for Blanket Material

c) Filter criteria should be satisfied with prepared sub-grade layer in case of double layer system or subgrade in case of single layer system as given below:

Criteria-1: D_{15} (blanket) <5xD_{85} (prepared sub-grade/sub-grade)
Criteria-2: D_{15} (blanket) > 4 to 5xD_{15} (prepared sub-grade/sub-grade)
Criteria-3: D_{50} (blanket) < 25xD_{50} (prepared sub-grade/sub-grade)

Filter criteria of blanket material is not required or mandatory with the application of Non-woven Geotextile as a separator layer below the blanket.

1.10.3 Quality Control:

(a) Method of Test: Blanket material should be tested as per IS:2720 (Part -4) to plot particle size distribution curve, so as to assess its suitability. It would be necessary to carry out wet analysis to assess the actual percentage of fines.

(b) Frequency of Tests and Acceptance Criteria: The frequency of testing at site before laying for blanket material and finished work should be as detailed in **Table 7.2** RDSO Specification No.: RDSO/2020/GE: IRS-0004.

(c) Following tests/checks are to be conducted

(i) Sieve analysis and hydrometer analysis to determine C_C, C_U & percentage fines
(ii) CBR test
(iii) Los Angeles Abrasion value,
(iv) Filter criteria, as required
(v) Gradation Analysis,
(vi) Check for conformity with enveloping curves

1.10.4 Quality Control on Blanket Material at Production site

1.10.4.1 The source of blanket material needs to be identified based on tests & studies conducted and conformity of the material to the Specification.

1.10.4.2 It is desirable to have a check on quality of material at source/manufacturing point so that major deviation in quality of the material being sent to site does not exist. It would be in the interest of the supplier to have such tests conducted on his own to avoid any rejection at a later stage.

1.10.4.3 The supplier/ Engineer may also lay down Proforma for 'Incoming Material Register' to be maintained at manufacturing point for having a control on utilization of different grades of material, especially where blending is done using crushed as well as local material.

1.10.4.4 Test for Quality: Blanket material should be tested as per IS:2720 (Part -4) of a minimum of one test per 500 cum. or part thereof to plot particle size distribution curve, so as to assess its suitability. It would be necessary to carry out wet analysis to assess actual percentage of fines. To expedite testing work, dry sieve analysis may be carried out if variation between results of dry and wet analysis is not significant and adequate margin exists with respect to acceptance criteria. However, in such cases also, wet analysis has to be carried out at frequent interval to verify the extent of variation. In any situation, acceptance of blanket material would be based on wet analysis only. The sample for wet analysis should be prepared as per Para 4.3 of IS:2720 (Part -4).

1.10.5 Transportation: The blanket material should be transported wet after mixing water in order to achieve OMC, in tippers for direct unloading on formation.

1.10.6 Laying, Spreading and Compacting

1.10.6.1 The blanket material must be spread with a hydraulically operated Motor Grader or a paver-finisher in layers of uniform thickness, before allowing compaction.

1.10.6.2 Compaction to specified levels of RD or percentage of MDD shall be carried out through a number of passes of vibratory rollers. A combination of vibrating rolling initially and static finishing rolling may be established through trials to be followed for specified compaction. Speed of roller shall not exceed 5 km/hr.

1.10.6.3 Proper control of moisture is required to optimize the compaction effort. Optimum moisture content may be established through Modified Proctor Apparatus (IS:2720, Part -8) and moisture may be added at the plant and deficit if any should be compensated by sprinkling at site as per the requirement.

1.10.6.4 Rolling is to be carried out in layers of not more than 300 mm each (in loose condition), following the same camber profile as provided in the subgrade layer and to be maintained up to the top layer.

1.10.6.5 Extra width of 500mm on either side of embankment shall be rolled to ensure proper compaction at the edges. The extra blanket material would be cut and dressed to avoid any loose mass at the slopes. This should preferably be done with

help of grade cutter. After cutting, the slope should be properly compacted by Slope Vibratory Roller/Compactor. The quantity of blanketing material for additional width of 500 mm on either side shall not be paid.

1.10.7 Measurement:

1.10.7.1 Measurement of blanket material shall be done on the basis of finished cross section limited to theoretical profile after the material and workmanship have been accepted as per the above acceptance criteria.

1.10.7.2 In very rare cases, where it is not possible to take blanket material on finished subgrade, measurement may be done on the basis of stack measurement with the permission of Chief Engineer in-charge. It may be necessary to frame different schedule items for different methods of measurement. There should be no occasion to change the method of measurement unless specifically provided for in the tender documents duly approved by competent authority.

1.10.7.3 Method of measurement in case of stack measurement required in formation rehabilitation work may be the same as in case of track ballast.

1.11 NON-WOVEN NEEDLE PUNCHED AND MECHANICALLY OR THERMALLY BONDED TYPE GEOTEXTILE

1.11.1 Specifications are given in Appendix - C of RDSO Specifications: "Comprehensive Guidelines and Specifications for Railway Formation": RDSO/2020/GE: IRS-0004 for providing Non-woven Needle Punched and Mechanically or Thermally bonded type Geotextile for use as Separator/Filtration for Railway formation made of Polypropylene / Polyethylene / Polyamide or combination thereof having apparent opening size of ≤ 85 microns and elongation at failure > 50% in both directions

1.11.2 On top of subgrade or prepared subgrade before laying blanketing layer with minimum strengths in Grab test, Trapezoidal Tear test and Puncture test of 700N, 250 N and 1800 N respectively.

1.11.3 Below the ballast and above blanket layer with minimum strengths in Grab test, Trapezoidal Tear test and Puncture test of 1750N, 800 N and 5800 N respectively.

1.12 DRAINAGE BEHIND BRIDGE ABUTMENT/RETAINING WALL

1.12.1 Geo-composite drain (Vertical)

1.12.2 Laying of drainage composite for use behind abutments, wing walls, return walls and Retaining walls Geo-composite drain (Vertical) as per the Appendix - C of RDSO "Comprehensive Guidelines and Specifications for Railway Formation" Specification No. RDSO/2020/GE: IRS-0004, September 2020 with latest correction slips & latest revision with all material, labour, equipment, tools and plants, lead, lift etc. complete in all respects as per the direction of Engineer-in-Charge.

Chapter- 2
Bridge Works - Substructure

2.1 GENERAL

2.1.1 Scope

The Specifications given in this chapter deal with works pertaining to all types of foundations for bridges and bridge superstructure viz., Piers, abutments, wing walls, bed blocks and ballast walls / dirt walls.

2.1.2 Types of Foundations

Bridge foundations can be of:

i) Open or Shallow Foundations including footings, blocks and raft foundations.

ii) Pile Foundations

iii) Well Foundations

2.1.3 Types of sub-structures:

a) Abutment:

i) Wall Type abutment

ii) Spill through abutment

b) Pier:

i) Wall type

ii) Columns - Solid or hollow

iii) Trestle type

c) Wing Walls:

i) Splayed Wing walls

ii) Box Type Wing walls

2.1.4 Design and inspection aspects of Bridges

Design and inspection aspects of bridges are not covered in these Specifications. User may refer to the relevant Codes and Specifications and Indian Railways Bridge Manual and departmental instructions issued and amended from time to time for same. Provisions made in other chapters of the specifications are applicable to the extent they are relevant.

2.2 SETTING OUT FOR FOUNDATIONS

2.2.1 Setting out for Minor Bridges and Culverts

Setting out shall be carried out by a competent / qualified engineer, employed by the Contractor and checked by the Engineer’s representative for all bridges and culverts. Contractor shall provide necessary instruments, linear tapes, pegs etc.

The setting out for foundations and sub-structure shall be carried out with a Theodolite /latest measuring instruments with higher precision like Total Station and steel tapes / Invar tapes in case of works not involving standing water. All levels shall be measured using a precise levelling instrument. Errors in location of piers / abutments and fixing levels shall be within following limits.

Linear Measurements $\pm$ 5 mm

Levels $\pm$ 3 mm

2.2.2 Setting out for Major Bridges

a) Locations of piers and abutments along the centre line of the bridge should be accurately laid out by establishing one or more base lines as directed and a system of pegs and posts. Also sufficient reference pegs and pillars should be established for checking the positions with ease during progress of work. Reference Bench Marks for levelling should be established nearby on a permanent structure or on a pillar built in vicinity for this purpose.

b) The principal reference lines and level pegs should be established at easily accessible locations. They include-

i) Longitudinal Centre line

ii) Transverse Centre lines of abutments and piers

iii) Tangent points of the curve at either end, if alignment is on a curve.

c) For Bridge Works involving deep excavations, pile driving or well sinking and / or where there is standing water, use of base line is obligatory. They should be preferably at right angle to centre line of bridge, with one on either end on high bank in case of long bridges or on one side bank of bridge for shorter ones.

d) In case of bridges of length exceeding 1000 Metres, base lines and reference towers shall have to be established. Provision of all assistance in form of measuring instruments, linear tapes as may be required by the surveyor, technical and skilled staff and labour required to assist them, fixing pegs, pillars and towers including all building materials including supply of all materials, tools and plant shall be done by the Contractor at his cost and maintaining and guarding them safely. Nothing extra shall be payable to them on this account. Important points to be observed in this activity are:

1. Linear Measurement shall be carried out with electronic distance measuring instruments like Total Station and other latest measuring instruments with higher precision or

2. Spring balances shall be used for giving specified tension to the invar tape, if used for short linear measurement. Tape readings shall be corrected for tension, temperature and slope.

3. Concrete pillars with steel plates fixed over them shall be located at intermediate points as required and at ends.

4. Reference pillars at pier and abutment position along centre lines and reference pillars on base lines shall be to standards to be prescribed by the Engineer. During construction, since centre line pillars at abutment / pier locations will be disturbed, reference pillars and lines shall be fixed around each structure by the Contractor under Site Engineer's supervision. Reference diagrams at Annexures 4/1 and 4/2 and Clause 401 of IRBM shall be referred to for more details.

2.3 SOIL EXPLORATION

2.3.1 Shallow Foundations

a) Shallow Foundations are provided where sufficiently hard soil is available at shallow depths. They shall be taken down at least 1.75 m below anticipated scour level except in case of pipe and Box culverts. The bearing capacity of soil and nature of soil should be ascertained by making trial pits at location of culvert/ bridge.

b) The depths of such pits shall extend for sufficient depth below the proposed founding level. If the soil in the pit by observation is found hard and stable, Plate load test shall be conducted at a level to be decided by the Engineer but not less than 0.60m below proposed foundation level for determining safe bearing capacity of soil and the characteristics of the strata in accordance with provisions of IS:1888 (Plate Load Test).

c) In addition, at the discretion of the Engineer, exploratory bores or sounding shall be done for depth of about 1.5 times the proposed width of foundation below proposed founding level. In case of exploratory bores, sample shall be collected and laboratory tests conducted as detailed in Para 2.3.4.

d) The results of laboratory tests and of plate load tests and Standard Penetration Tests shall be compared for conformity. It shall be ensured that no layer of soft soil is met with upto 1.5 times of depth below the founding level.

2.3.2 Soil Exploration for Deep Foundations

a) At least one exploratory bore shall be drilled at the location of each pier / Abutment. The bore shall be taken down to a minimum depth of 1.5 times the proposed width of foundation below design founding level. If rock is met with in the bore, the bore should be taken down at least 5m into the rock.

b) In case the rock layer is suspected to be sloping or dipping or fissures are noticed, more than one bore per foundation will be required to be done. Additional bores should be done as instructed by the Engineer.

c) Only rotary drills shall be used for drilling bore holes and collection of samples. Use of percussion or wash boring equipment may be permitted by the Engineer in certain types of soils, based on his judgement.

d) SPT tests and collection of undistributed samples shall be done at intervals of 1.5 m depth unless otherwise specified in contract or directed by the Engineer, and in accordance with IS: 2131 and IS:1892 respectively. Samples collected shall be properly protected, packed and sent for tests. Tests shall be conducted as per provisions in relevant part of IS:2720.

2.3.3 Tests: - In-situ and laboratory tests listed below shall be carried out according to soil type and site requirement.

Cohesion less soils:

a) Classification tests, density etc.

Standard Penetration Test or Dynamic Penetration Test (as per IS:2131) when considered appropriate.

b) Laboratory Tests:

Triaxial or shear or box shear test on collected samples and saturated samples where sub soil water level is likely to reach that level.

Cohesive soils

a) Classification tests, density etc.

b) Field Tests

i) Plate Load Tests (IS: 1888)

ii) Unconfined compression Test (IS:2720-Part -10)

iii) Vane Shear Test (IS:4434)

iv) SPT (IS:2131)

c) Laboratory Tests

i) Shearing strength Test -Triaxial Tests (IS:2720-Part -11)

ii) Consolidation Test (IS:2720-Part -15)

d) Special Tests

i) Permeability tests should be conducted on samples in case need for dewatering is expected for / during excavation / or well sinking.

ii) Chemical tests of soils and sub-soil water where considered necessary

iii) Look out should be maintained for presence of any gas, in case peaty soils are met with or otherwise suspected, especially when well foundations are proposed.

2.3.4 Coverage

a) The exploration shall cover the entire length of the bridge and also extend at either side for a distance of about twice the depth below bed of the lowest main foundations.

b) The depth of exploration should be at least 1 ½ times the minimum width of foundation below the proposed foundation level. Where such investigation ends in

any unsuitable or questionable foundation material, the exploration shall be extended to a sufficient depth into firm and stable soils or rock but not less than four times the minimum depth of foundation below the earlier contemplated foundation level. In case of good sound rock the stipulation of minimum depth may be decreased based on difficulty to conduct core drilling and the minimum depth may then be restricted to 3 metres.

c) **Locations of Boring** - Where the data made available by detailed exploration indicates appreciable variation or where variations in a particular foundation are likely to appreciably affect the construction (specially in case of bridge foundations resting on rock), it will be necessary to resort to additional bores / soundings to establish complete profile of the underlying strata. The additional borings / soundings shall be decided by the Engineer depending upon the extent of variation at a particular foundation location and should cover the entire area of the particular foundation.

2.3.5 Construction Stage Exploration

Whenever a change in the sub-soil strata / rock profile is encountered during construction, detailed explorations shall be resorted to establish the correct data for further decisions.

2.3.6 Logging of bore holes: - Logging of bore holes by radioactive methods shall be done for detailed investigations as specified in the contract or in special provisions.

2.4 EXPLORATION FOR BRIDGE FOUNDATIONS RESTING ON ROCK

2.4.1 Scope of Work

To arrive at the characteristic strength of rock mass, reliance shall be placed more on in situ tests in comparison to laboratory tests.

2.4.2 Identification and classification

Identification and classification of rock types for engineering purposes may in general be limited to broad, basic geological classes in accordance with accepted practice. Apart from strength of parent rock, investigation should cover study of spacing and distribution of discontinuities of the rock mass, such as the joints, bedding planes, faults and weathered seams. A major factor affecting the behaviour is the weathered zone at top.

2.4.3 Basic Information Required from Exploration in rock

i) Depth or rock strata and its variation over the site,

ii) Whether isolated boulder or massive rock formation.

iii) Extent and character of weathered zone,

iv) Structure of rock – including bedding planes, faults, fissures, solution cavities etc.

v) Properties of rock material-strength, geological formation, etc.

vi) Erodibility or rock to the extent possible

vii) Colour of water.

2.4.4 Extent of Exploration

The extent of exploration shall be adequate enough to give a complete picture of the rock profile both in depth and across the channel width to assess the constructional difficulties in reaching the foundation levels.

2.4.5 Depth of Boring

The depth of boring in rock should be such that it shall pass through the upper weathered or otherwise weak zone, well into the sound rock. Minimum depth of boring in sound rock shall be 3 metres.

2.4.6 Special Features in Drilling through Rock

During drilling through rock, every care shall be taken to notice and record any small change during drilling. The time required to drill through a certain depth, amount of core recovery, physical condition, length of pieces of core, joints, colour of water residue, weathering and evidence of disturbance and other effects shall be carefully noticed and entered in the drilling log. For guidance, IS:5313 may be referred to. The data shall be presented in accordance with IS:4464. The cores shall be stored properly in accordance with IS:4078.

Laboratory Tests

The rock cores obtained shall be subjected to following laboratory tests:

i. Visual identification for texture, structure, composition, colour and grain size.

ii. Laboratory tests shall be done for specific gravity, porosity and moisture content and compressive and shear strength.

2.4.7 In-situ Tests

(a) In-situ tests shall be made in accordance with relevant IS Codes or any other International Codes acceptable; IS:7317 (Uniaxial Jacking Test for Deformation Modulus of Rock Mass): and IS:7746 (In-Situ Shear Test on Rock Mass). In addition, laboratory tests can also be made on samples. Use of in-situ tests for measuring strength and deformation characteristics shall be made. If required, bore-hole photography may be done to evaluate the presence of faults, fissures or cavities, etc.

(b) In some cases, the foundation behaviour will be dominated by a possible mode of failure involving movement along some joint surface, fissures or weak layer within a generally strong rock system and also by possible weathering. In situ shear tests may be conducted wherever feasible, as, such tests are likely to give more representative data than the shear tests conducted on core samples.

2.4.8 Special Cases

a) Investigation for conglomerate:

A drill hole shall be made same as for rock. The samples collected shall be subjected to suitable tests depending upon the material. Special care shall be taken to ascertain

erodibility of the matrix. Where possible, especially for shallow foundation, Plate load Test shall be conducted.

b) Investigation for laterites:

The investigation shall be similar to that required for cohesive soils. Use of penetration tests shall be preferred, if suitable correlation charts are available. These may be static or dynamic penetration tests or vane shear tests. In the case of hard laterite, recourse will have to be made to core drilling as for soft rocks.

2.4.9 Presentation of Data

The data shall be given in diagrammatic form in 3 sheets giving the following details:

Sheet 1: Plan to scale (Site Plan) showing the position of bore-holes clearly marked so as to fix the position at a future date.

Sheet 2: This shall contain the bore-log chart and test results of the samples separately for each bore-hole / pit etc.

Sheet 3: This shall contain pictorial representation of the bore log data to get an overall picture of the soil profile at the cross section of the river.

2.5 RECORDS OF BORINGS AND TRIAL PITS AND SAMPLING

2.5.1 Field records

The field records for the preliminary and detailed exploration shall contain the date when the boring was made, the location of the boring with reference to a permanent system of coordinates and the elevation of the ground surface with respect to a permanent bench mark. They shall include elevation at which the water table and the upper boundary of each of the successive soil strata were encountered, the investigator's classification of the layer on the basis of general information obtained from field examination and the Standard Penetration Test values at different depths. The type of tools used for borings shall be recorded. If the tools were changed, the depth at which the change was made and the reason thereof shall also be noted. Incomplete and abandoned borings shall be described with same care as for completed bores including information on any part of pipe or tool left behind in the bore. It should contain details of the job such as the elevation at which wash water was lost from the hole and any other significant information.

2.5.2 Contents of Report

For all borings and trial pits, necessary information as detailed below shall be given in the Reports. It shall include all drawings including site plan.

a) Agency

b) Location with reference map

c) Pit/ Bore-hole number

d) Reduced level (R.L) of ground surface or other reference point

e) Dates of starting and completion

f) Name of supervisor

g) Scales of Plans and Sections

h) Dimensions, methods of advancing exploration such as by hand tools, blasting, boring etc.

i) General description of strata met with and RLs at which they were met

j) Position and altitude of contacts, faults, strong joints, slickenside, etc.

k) Inflow of water, methods of controlling the water, required capacity of pumps for de-watering

l) The level at which the sub-soil water was met with

m) Dip and strike of bedding and of cleavage

n) Visual description of strata

o) Results of field tests e.g. SPT, in-situ vane shear test etc.

p) Any other information and remarks

2.5.3 Record of Measurement

Upon removal of sampling tube, the length of the sample in the tube and the length between the top of the tube and the top of the sample in the tube shall be measured and recorded.

2.5.4 Methods of Sampling

a) The usual methods for sampling conforming to IS:1892 and IS:2132 are given below:

Nature of Ground	Type of Sample	Method of Sampling
Soil	Disturbed	Hand Samples
		Auger Samples
		Shell Samples
	Undisturbed	Hand Samples
		Tube Samples
Rock	Disturbed	Wash samples from percussion or rotary drilling
	Undisturbed	Cores

b) For proper identification of sub-surface material, sample should be recovered containing all the constituents of the materials in their proper proportion. In clayey deposits such samples could be collected by split spoon samplers. In the case of sandy deposits, sampling spoons shall be fitted with suitable devices for retaining samples. All data required for soil identification should be collected from the samples so extracted when undisturbed samples, which are more desirable for collection of some of the data, are not available. Penetration test should be carried out with the standard split spoon sampler or Penetrometers, if the soil is coarse grained. When it

is known in advance that the soil profile is fairly regular, preliminary and detailed investigation may be combined. Tube samplers can be used in place of split spoon samplers for collecting samples in clayey strata.

c) Disturbed **Soil Samples**

i) Disturbed samples of soil shall be obtained in the course of excavation and boring. For procuring samples from below the ground water level, where possible, special type of sampler shall be used. Where Standard Penetration Test is conducted, representative samples shall be obtained from the split spoon.

ii) The size of sample generally required shall be as given in **Table 2.1**

TABLE 2.1: SIZE OF SOIL SAMPLE REQUIRED

Sl. No.	PURPOSE OF SAMPLE	SOIL TYPE	WEIGHT OF SAMPLE REQUIRED (Kg)
1.	Soil identification, natural moisture content tests, mechanical analysis and index properties, chemical tests	Cohesive soils Sands and Gravels	1 3
2.	Compression tests	Cohesive soils and sand	12.5
3.	Comprehensive examination of construction material and borrow area soil including soil stabilization	Cohesive soils and sand Gravelly soil	25-50 50-100

iii) While taking out disturbed soil samples, Standard Penetration Test shall also be conducted to find out the bearing capacity of the sub-soils at specified levels.

d) Undisturbed Soil Samples

i) Samples shall be obtained in such a manner that their moisture content and structure do not get altered. This may be ensured by use of correctly designed sampler and by careful protection and packing.

ii) Standard Penetration Test may have to be conducted in each case to obtain additional data as directed by the Engineer. In soft clay, in-situ vane shear test as per IS:4434 may have to be conducted. Where all the three operations have to be carried out in one layer, the sequence shall be undisturbed soil sampling followed by in-situ vane shear test, followed by Standard Penetration Test.

iii) For compression test samples, a core of 40mm diameter and about 150 to 200mm length may be sufficient, but for other laboratory tests, a core of 100mm diameter and 300mm length shall be taken as far as possible, unless otherwise specified by the Engineer.

iv) The upper few millimeters of both types of sample shall be rejected as the soil at the bottom of the bore hole usually gets disturbed by the boring tools.

e) Rock Samples

i) Disturbed Samples:

The sludge from percussion borings or from rotary borings which have failed to yield a core, shall be collected for a disturbed sample. It may be recovered from circulating water by settlement in a trough.

ii) Undisturbed Samples:

Block samples taken from the rock formation shall be dressed to a size of about 90 x 75 x 50mm.

For core samples, undisturbed cores of rock shall be taken by means of rotary drills fitted with a coring bit with core retainer, if warranted.

2.6 EXCAVATION FOR OPEN FOUNDATIONS

2.6.1 Depth of Foundation

Depth of foundation shall be as shown in Drawing. If it is in erodible soil, the depth should be such that it has grip of not less than 1/3 depth of scour. The ground at final level should be inspected by the Engineer or his representative and approved before construction of pier or abutment is started.

2.6.2 Setting Out

The plan dimensions of the foundation shall be set out at the bottom of foundation trench and checked with respect to original reference line and axis. It shall be ensured that at no point the bearing surface is higher than the founding level shown on the drawing or as directed by the Engineer.

2.6.3 Preparation of Foundations

The last 300mm of excavation shall be done just before laying of lean concrete below foundation. In the event of excavation having been made deeper than that shown on the drawing or as ordered by the Engineer, the extra depth shall be made up with M15 concrete as specified in case of foundation resting on soil and foundation grade concrete for foundations in rock, at the cost of the Contractor and shall be considered as incidental work. Special care shall be taken not to disturb the bearing surface. Open foundations shall be constructed in dry conditions and the Contractor shall provide for adequate dewatering arrangements to the satisfaction of the Engineer.

2.6.4 Laying of Lean Concrete base

The base of the pit should be tamped and compacted and kept dry before laying a base concrete or levelling course. A layer of minimum 10 cm thick lean concrete (1:3:6) or equivalent should be laid on the prepared base. After the concrete sets and hardens, the bottom profile of the base of footing shall be accurately marked and got checked by the Engineer before the formwork for footing is laid. Before laying of lean

concrete layer, the earth surface shall be cleaned of all loose material and wetted. Care shall be taken to avoid muddy surface. Concrete M15 or as shown in the drawing shall be laid to the thickness as required. No construction joint shall be provided in the lean concrete.

Before laying foundation concrete, the lean concrete or hard rock surface shall be cleaned of all loose material and lightly moistened. Foundation concrete of required dimensions and shape shall be laid continuously upto the location of construction joint shown on the drawing or as directed by the Engineer. No form work is necessary for the lean concrete layer.

2.6.5 Special Provisions for Rocky strata

In rocky strata, foundation should be keyed in the rock for depths mentioned below unless otherwise specified in drawings or approved by competent authority. In case of sloping rock, benching should be done so that the size of concrete is in level planes suitably stepped. Keying depths should be

i) Hard rock's like igneous granites or gneissic rocks with crushing strength of 100 Kg/sq.cm or more - 0.6m

ii) Other type of rocks with crushing strength of 20 kg/sq.cm. or more – 1.5m

iii) Other cases to be decided by Engineer / Designer after considering presence of fissures, cavities, bedding planes and ultimate crushing strength.

iv) Well foundation on rock shall be taken to adequate depth and seated evenly all around the periphery on sound rock and provided adequate embedment.

2.6.6 Formwork

Form work shall conform to relevant specifications, true to the designed dimensions. It shall be watertight with inner surface without any undulations and should sustain the fresh concrete without showing any distortion in shape or size. Only steel shuttering shall be used for concrete work. In case petty works of non-structural type, other impermeable material of desirable strength may be used with the prior approval of Engineer. Form work for top of the foundation concrete shall also be provided, if its top has slopes steeper than 1 (vertical) to 3 (horizontal). When concrete is laid in slope without top form work, the slump of the concrete shall be maintained so as to ensure that compaction is possible without slippage of freshly placed concrete down the slope. In certain cases, it may be necessary to build the top form work progressively as the concreting proceeds up the slope.

2.6.7 Concreting

Providing concrete and steel reinforcement shall conform to relevant sections of Chapters of Concrete work & RCC of specification. Minimum grade of concrete shall be M 20 unless otherwise specified or directed. The concrete shall be produced only by using automatic weigh batching and mixing plant, stationery or mobile as per the requirement for all structural works. RMC may also be used with the approval of Engineer after due verification and satisfaction of consistent quality control system of

producing plant. Concrete surface shall be finished smooth with a trowel. The location of construction joint and its treatment shall be done as per specification. Form work shall not be removed prior to specified time for the specific work. Where form work has been provided for top surface, the same shall be removed as soon as concrete has hardened. Uninterrupted curing of concrete shall be carried out by approved method for the prescribed duration without any exception. Sides shall be kept wet for the same period by spraying water or covering with wet gunny bag etc., and top surface shall be cured by ponding continuously. Alternatively, Curing Compounds may be applied on the exposed surfaces instead of direct curing by water.

2.6.8 Backfilling

Before back filling around the foundation and structure is commenced, loose sand laid on foundation shall be removed and dispersed as directed by the Engineer. All spaces excavated and not occupied by the foundation or other permanent works shall be refilled with earth up to surface of surrounding ground in 150mm layers wetted and compacted by rammers, light rollers and as directed by Engineer. In case of excavation in rock, the annular space around foundation shall be filled with M 15 concrete or as specified upto the top of rock. Protection works, where provided, shall be completed before the floods so that the foundation does not get undermined.

No point of the surface of the lean concrete in the case of foundation on soil or the surface of hard rock in the case of foundation of hard rock, shall be higher than the founding level shown on the drawings or as ordered by the Engineer.

2.6.9 Tests and Standards of Acceptance

The materials shall be tested in accordance with stipulated Specifications and shall meet the prescribed criteria. The work shall conform to these Specifications and shall meet the prescribed standards of acceptance. All tests prescribed shall be done at specified frequency either in site lab or other approved labs and test results shall be considered while acceptance of any concrete work.

Quality Assurance Plan (QAP)for all structural works shall be prepared in advance and submitted for approval of the competent authority. The approved QAP shall be followed religiously. Record of the same shall be preserved, for verification of compliance subsequently, in electronic format or any other acceptable format.

The system of Tests for concrete cubes shall be approved before start of concreting for establishing correlation of test specimen with concrete batches, part of structure where the same have been used, schedule of tests and should be followed duly recording results in prescribed Proforma. These records shall be preserved in such a manner that it can be verified without any ambiguities while acceptance or subsequent check, as required.

2.6.10 Measurement for Payment

Measurement shall be made for different items of work in the stipulated unit based on the actual quantity executed subject to the maximum as shown in the drawings unless

it has specifically been ordered otherwise, in writing. All linear measurements shall be made correct to nearest 0.01m except for the thickness of slab which shall be measured to nearest 0.005m (IS:1200 Part -2). Other measurement shall be computed to nearest 0.01 sqm for area, 0.01 cum for volume and 0.001 MT for weight of steel.

2.7 PILE FOUNDATIONS

2.7.1 General:

2.7.1.1 Work shall be done in accordance with IS:2911 (Parts - 1 to 4) unless otherwise specified herein or in Drawings and Contract specifications. Under reamed piles shall not be used for Railway bridges. The Construction of pile foundations requires a careful choice of the piling system depending upon sub-soil conditions and loading characteristics and type of structure. The permissible limits of total and differential settlements, unsupported length of pile under scour, impact / entanglement of floating bodies and any other special requirements of project are other important criteria for selection of the piling system. The method of installing the piles, including details of the equipment shall be submitted by the Contractor and got approved by the Engineer before start of work.

2.7.1.2 Sub-Surface Investigations

Borings should be carried up to sufficient depths so as to ascertain the nature of strata around the pile shaft and below the pile tip. However, unless otherwise specified or agreed to, depth of boring shall not be less than:

i) 1.5 times estimated length of pile in soil but not less than 15m beyond the probable length of pile

ii) 15 times diameter of pile in weak / jointed rock but minimum 15m in such rock

iii) 4 times diameter of pile in sound, hard rock but minimum 3 m in such rock.

iv) The investigation shall be adequate for the purpose of selection of appropriate piling system and for estimating design capacities for different diameters and lengths of piles.

v) For piles socketed into rocks, it is necessary to determine the uniaxial compressive strength of the rock and its quality.

vi) The investigation shall also include location of ground water table and other parameters including results of chemical tests showing Sulphate and chloride content and any other deleterious chemical content in soil and / or ground water, likely to affect durability.

2.7.2 Materials

The specifications for steel reinforcement, structural concrete, Prestressed concrete and structural steel to be used in pile foundations shall be similar to provisions given in the relevant sections of the specifications.

2.7.2.1 Concrete in Piles

Minimum Grade of concrete to be used in cast-in-situ piles shall be M25, unless specified otherwise in the agreement. The Cement content shall normally not be less than 400 kg per cubic metre of concrete. However, with proper mix design and use of proper admixture the cement content may be reduced but in no case the cement content shall be less than 350 kg/m^3.Grades of concrete for precast reinforced and Prestressed concrete piles shall not be less than M 25 and M 35 respectively. Maximum water cement ratio shall be 0.5 for cast-in-situ piles and 0.45 for precast piles. The minimum slump of concrete for driven cast-in-situ piles shall be 100mm to 150mm and that of bored cast-in-situ piles 150mm to 200mm. The slump should not exceed 200mm in any case.

Suitable and approved admixtures may be used in concrete mix where necessary. The minimum clear cover for piles shall be 40mm over all reinforcement including binding wire. Where piles are to be located in corrosive environment, the cover shall be 50mm. Where piles are exposed to action of harmful chemicals or severe conditions of exposure due to presence of sulphate, chloride etc., higher grades of concrete, restricting water cement ratio to 0.45 shall be used. Special types of cement, such as sulphate resistant cement may be used where considered appropriate by Engineer-in-Charge.

2.7.3 Test Piles

2.7.3.1 The piles shall be load tested in accordance with provisions laid down in IS:2911(Part -4). Integrity tests must be done prior to load test, to satisfy that pile has no inherent defects due to poor workmanship during installation and casting. Load test shall be conducted only on those installed test piles passing the integrity test(s) as per IS:14893 or any other codes prescribed by the Engineer. Videography of load testing shall be done additionally showing all procedures and measurements in a clear and vivid manner for record without any editing.

2.7.3.2 Test piles which are shown on the drawings or specified in the contract or installed by the Contractor on his own to determine the lengths of piles to be furnished shall conform to the requirements for piling as indicated in these specifications.

2.7.3.3 In case test pile installed fails integrity test(s), a detail investigation shall be done to find out the reasons of failure. Next test Only after proposal covering action to obviate reasons causing poor quality for approval of the Engineer. Only after with investigation shall be done to pin point reasons and

2.7.3.4 Test piles which are to become a part of the completed structure shall be installed with the same type of equipment that is proposed to be used for piling in the actual structure. Test piles which are not to be incorporated in the completed structure shall be cut off at atleast 600mm below the proposed soffit level of pile cap and head finished properly with cover concrete and the remaining hole shall be back filled with earth or other suitable material. If any test pile in a cluster fails, an additional pile shall be provided and incorporated in the Cluster at the position approved by the Engineer.

2.7.4 CAST-IN-SITU CONCRETE PILES

2.7.4.1 Cast-in-situ concrete piles may be either installed by making a bore into the ground by removal of material or by driving a metal casing with a shoe at the tip and displacing the material laterally. The two types of piles are termed as “bored piles” and “driven piles” respectively. Cast-in-situ concrete piles may be cast in metal shells which may remain permanently in place. However, other types of cast-in-situ concrete piles, plain or reinforced, cased or uncased, may be used if in the opinion of the Engineer the soil conditions permit their use and if their design and the methods of placing are satisfactory. The metal casing shall be of sufficient thickness and strength to hold its original form and show no harmful distortion after it and adjacent casings have been driven and the driving core, if any, has been withdrawn.

2.7.4.2 Concreting and reinforcement work shall be done in accordance with relevant Specifications supplemented by these specifications.

2.7.4.3 Cast-in-situ concrete driven piles shall be installed using a properly designed detachable shoe at the bottom of the casing.

2.7.4.4 Any liner or bore-hole which is improperly located or shows partial collapse that would affect the load carrying capacity of the pile, shall be rejected or repaired as directed by the Engineer at the cost of the Contractor.

2.7.4.5 Bored cast-in-situ piles in soils which are stable may often be installed with only a small casing length at the top. A minimum of 2.0m length of top of bore shall invariably be provided with casing to prevent any loose soil falling into the bore. In cases in which the side soil lower down can fall into the hole, it is necessary to stabilise the side of the bore hole with drilling mud, or a suitable steel casing. The casing may be left in position permanently specially in cases where the aggressive action of the ground water is to be avoided, or in the cases of piles built in water or in cases where significant length of piles could be exposed due to scour.

2.7.4.6 For bored cast-in-situ piles, casing / liner shall be driven open ended with a pile driving hammer capable of achieving penetration of the liner to the length shown on the drawing or as approved by the Engineer. Materials inside the casing shall be removed progressively by air lift, grab or percussion equipment or other approved means. Boring shall be carried out using rotary or percussion type equipment. Unless otherwise approved by the Engineer, the diameter of the bore-holes shall be not more than the inside diameter of the liner.

2.7.4.7 Where bored cast-in-situ piles are used in soils liable to flow, the bottom of the casing shall be kept enough in advance of the boring tool to prevent the entry of soil into the casing, thus preventing the formation of cavities and settlements in the adjoining ground. The water level in the casing should generally be maintained at the natural ground water level for the same reasons. The joints of the casing shall be made as tight as possible to minimise inflow of water or leakage of slurry during concreting. Where mud flow conditions exist, the casing of cast-in-situ piles shall not be allowed to be withdrawn. Prior to the lowering of the reinforcement cage into the pile shaft, the

shaft shall be cleaned of all loose materials. Cover to reinforcing steel shall be maintained by suitable spacers, tied in advance to the reinforcement.

2.7.4.8 Wherever practicable, concrete should be placed in a clean dry hole. Where concrete is placed in dry condition and there is casing present, the top 3m of the pile shall be compacted using internal vibrators.

2.7.4.9 Before concreting under water, the bottom of the hole shall be cleaned of drilling mud and all soft or loose material very carefully. In case a hole is bored with use of drilling mud, concreting should not be taken up when the specific gravity of bottom slurry is more than 1.2. The drilling mud should be maintained at 1.5m above the ground water level.

2.7.4.10 Where the casing is withdrawn from cohesive soils for the formation of cast-in-situ pile, the concreting should be done with necessary precautions to minimise the softening of the soil by excess water. Care shall be taken during concreting to prevent as far as possible the segregation of the ingredients. The displacement or distortion of reinforcement during concreting and also while extracting the tube shall be avoided.

2.7.4.11 The concrete shall be properly graded, shall be self-compacting and shall not get mixed with soil, excess water, or other extraneous matter. Special care shall be taken in silty clays and other soils with the tendency to squeeze into the newly deposited concrete and cause necking. Sufficient head of green concrete shall be maintained to prevent inflow of soil or water into the concrete.

2.7.4.12 The placing of concrete shall be a continuous process from the toe level to the top of the pile. To prevent segregation, a tube or tremie pipe as appropriate shall be used to place concrete in all piles.

2.7.4.13 To ensure compaction by hydraulic static heads, rate of placing concrete in the pile shaft shall not be less than 6m (length of pile) per hour. Under water concreting should be done with tremie.

2.7.4.14 Concreting under water: General requirements and precautions for concreting under water shall be as given in concreting chapter supplemented by following instructions:

a) The concreting of a pile must be completed in one continuous operation. Also, for bored holes, the finishing of the bore, cleaning of the bore, lowering of reinforcement cage and concreting of pile for full height must be accomplished in one continuous operation without any stoppage.

b) The concrete should be coherent, rich in cement with high slump and restricted water cement ratio.

c) The tremie pipe shall have to be large enough with due regard to the size of aggregate. For 20mm aggregate the tremie pipe should be of diameter not less than 150mm and for larger aggregate, larger diameter tremie pipes may be necessary.

d) The first charge of concrete should be placed with a sliding plug pushed down the tube ahead of it to prevent mixing of water and concrete.

e) The tremie pipe should always penetrate well into the concrete with an adequate margin of safety against accidental withdrawal if the pipe is surged to discharge the concrete.

f) The pile should be concreted wholly by tremie and the method of deposition should not be changed part way up the pile to prevent the laitance from being entrapped within the pile.

g) All tremie tubes should be scrupulously cleaned after use.

h) In special circumstances, the Engineer may permit use of any other proved method of concrete placement designed for under water concrete. In such cases, a detailed method statement should be prepared and got approved by the Engineer.

2.7.4.15 The diameter of the finished pile shall not be less than that specified and a continuous record shall be kept by the Engineer as to the volume of concrete placed in relation to the pile length cast.

2.7.5 Pile Cap

i) The minimum embedment of cast-in-situ concrete piles into pile cap shall be 150mm. Any defective concrete at the head of the completed pile shall be cut away and made good with new concrete. The clear cover between the bottom reinforcement in pile cap from the top of the pile shall be not less than 25mm. The reinforcement in the pile shall be exposed for full anchorage length to permit it to be adequately boned into the pile cap. Exposing such length shall be done carefully so as to avoid damaging the rest of the pile. In cases where the pile cap is to be laid on ground, a levelling course of M 15 or as stipulated nominal mix concrete 100mm thick shall be provided. Defective piles shall be removed or left in place as judged convenient without affecting the performance of adjacent piles or pile cap. Additional piles shall be provided to replace the defective piles.

ii) Pile caps shall be of reinforced concrete of minimum grade of M 25 unless otherwise stated in drawings or work specifications or directed by the Engineer. A minimum offset of 150mm shall be provided beyond the outer faces of the outer most piles in the group. If the pile cap is in contact with earth at the bottom, a levelling course of minimum 100mm thickness of M 15 or as specified nominal mix concrete shall be provided.

iii) The attachment of the pile head to the cap shall be adequate for loads and forces. The top of concrete in a pile shall be brought above cut-off level to permit removal of all laitance and weak concrete before pile cap is laid. This will ensure good concrete at the cut-off level.

iv) Concreting of the pile cap shall be carried out in dry conditions. The bottom of the pile cap shall be laid preferably as low as possible taking into account the water level

prevalent at the time of casting. Suitable leak-proof floating form work shall be used for casting caps over piles in water.

2.7.5.1 Driving Equipment

Piles or their casings may be driven with any type of drop hammer, diesel hammer or single acting or double acting steam or compressed air hammer, provided they penetrate to the prescribed depth or attain the designed resistance without being damaged. The weight or power of the hammer should be sufficient to ensure a penetration of at least 5mm per blow, unless rock has been reached. It is always preferable to employ the heaviest hammer practicable and to limit the stroke, so as not to damage the pile. The minimum weight of the hammer shall be 2.5t. In the case of precast concrete piles the mass of the hammer shall be not less than 30 times the mass of 300mm length of pile.

Steam or air hammers shall be operated with a boiler or air compressor of capacity not less than the capacity that is specified by the manufacturer of the hammer. The boiler or air compressor shall be equipped with an accurate pressure gauge and safety valves at all times. The valve mechanism and other parts of steam, air or diesel hammers shall be maintained in first class condition so that the length of stroke and number of blows per minute, for which the hammer is designed, will be obtained. The boiler shall be inspected by statutory authorities at prescribed intervals. Inefficient steam, air or diesel hammers shall be removed from the work.

2.7.6 Driving

2.7.6.1 General Procedure

Piles shall be installed from cranes or derricks standing on firm ground or from temporary supports or from fixed platform. Piles in water shall be installed from cranes erected on pontoons/ barges properly anchored and held in position. The arrangement shall provide sufficient rigidity to ensure accuracy of pile driving under all conditions of tide, stream flow or hammer drop. During driving, the top of pile shall be protected by a suitable helmet of substantial and well fitted steel construction. The helmet shall provide uniform bearing across the top of the pile and shall hold the pile centrally under the hammer.

No pile shall be driven unless inspected and approved by the Engineer. Forces producing undue bending or torsional stresses in piles shall not be applied during driving. The force of the hammer shall be directed centrally and axially during driving. The stroke of a single acting or drop hammer shall be limited to 1.2m unless otherwise permitted by the Engineer. A shorter stroke may be specified when there is danger of damaging the pile.

Piles shall not be bent or sprung into position but shall be effectively guided and held on-line during the initial stages of driving. Attempts to correct any tendency for the pile to run off-line by the application of significant horizontal restraint shall not be permitted. Shortly after the commencement of driving and at regular intervals throughout the

driving operation, checks shall be made to ensure that the pile frame does not exert any undue lateral force on the pile due to restraint within the helmet.

To avoid the possibility of premature “set up” pile driving shall be continuous in the later stages, without any deliberate stops. Delays of an hour or less may lead to significant “set-up” in piles i.e. resistance to further driving increases after driving is stopped.

If any pile is damaged in any way during driving, it shall be repaired or replaced as directed by the Engineer, at no extra cost. If during driving, the head of a pile is damaged to the extent that further driving is not possible, the head shall be cut off and helmet replaced and driving continued. The cost of cutting of the head shall be borne by the Contractor and where, as a result of such cutting of the head, the pile is too short, the Contractor, shall, at his own cost, provide extension or splicing of sufficient length of pile to restore the pile to its correct length.

2.7.6.2 Piles should be driven to the minimum acceptable penetration shown on the drawings. This may require pre-boring and / or jetting as detailed in the relevant Clause of IS:2911 (Part 1/ Section 3).

Piles shall be driven to nominal refusal or the required ultimate dynamic capacity specified on the drawings or until the top of the pile is at the level required and specified on the drawing whichever gives the lowest toe elevation. The Engineer’s decision in these matters shall be final. Nominal refusal shall be taken as equivalent to 25mm total penetration for the final 20 blows using a hammer of driving energy as specified and shall be used as the criterion for acceptance for piles founded on rock. Severe driving which results in an average set per blow of less than 0.5mm shall not be permitted.

Where hard drilling is encountered because of dense strata or obstructions located above the predetermined pile tip level, nominal refusal shall not be considered to have been achieved unless the Engineer is satisfied that the total number of blows, required for achieving the average driving resistance specified for nominal refusal, indicates that further driving will not advance the pile through the dense strata or obstructions.

2.7.6.3 The pile shall be driven as accurately as possible to the vertical or to specified batter. Straining the pile into position can damage it and the driving equipment should be adjusted as much as possible to follow the position of the pile. Any deviation from the proper alignment shall be noted and promptly reported to the Engineer. If the deviation is to such an extent that the resulting eccentricity cannot be taken care of by strengthening the pile cap or pile ties, such a pile shall, at the discretion of the Engineer, be replaced or supplemented by an additional pile. If the indications are that a pile will finish outside the specified tolerances, driving operations on that pile shall cease. The pile shall be withdrawn, the hole filled and the pile re-driven at no extra cost.

2.7.6.4 When employing a liner which is subsequently withdrawn for the formation of cast-in-situ pile, consideration shall be given to the possibility of doing harm to a pile

recently formed by driving the liner nearby before the concrete has sufficiently set. The danger of doing harm is greater in compact soils than loose soils. No pile shall be bored or driven within 3 m of a newly cast pile until at least 24 hours after completion of its installation.

2.7.6.5 Driving piles in loose sand tends to compact the sand which in turn increases the skin friction. Therefore, driving a number of friction piles in a group shall proceed outward from the centre as otherwise it will be difficult to drive the inner piles to the same depth as the others. In the case of stiff clay also, the driving for a group of piles shall proceed outward from the centre. However, in case of very soft soil, the driving may proceed from outside to inside, so that the soil is restrained from flowing out during driving operations.

2.7.6.6 If there is a major variation between the depth at which adjacent foundation piles in a group meet refusal, a boring shall be made nearby to ascertain the cause of this difference. If the boring shows that the soil contains pockets of highly compressive material below the level of the shorter pile, it will be necessary to enforce penetration of all the piles to a level below the bottom of the zone which shows such pockets.

2.7.7 Pile Tests

a) The bearing capacity of a single pile may be determined from test loading a pile. The load test on a concrete pile may not be carried out earlier than 28 days from the time of casting of the pile. The methodology of carrying out load tests and of arriving at safe load on piles shall conform to IS:2911 (Part IV).

b) There shall be two categories of tests on piles, namely, initial tests and routine tests. Initial tests should be carried out on test piles which are not to be incorporated in the work. Routine tests shall be carried out as a check on working piles. The number of initial and routine tests on piles shall be as determined by the Engineer depending upon the number of foundations span length, type of superstructure and uncertainties of founding strata. In any case, the initial load tests shall not be less than 2 in number, while the routine load tests shall not be less than 2 per cent of the total number of piles in the structure and nor less than 2 in number.

c) The above stipulations hold good for both vertical as well as lateral load tests on pile foundations. However, both initial and routine tests may be suitably increased for important structures or cases with large variation in the sub-surface strata.

d) In case of any doubt of workmanship or load carrying capacity of working piles not subjected to routine tests, or when ordered by the Engineer, or when provided in the Contract, load tests on working piles may be supplemented by non-destructive testing. Such tests may include “Integrity Testing” of concrete in the installed pile and utilisation of “Pile Driving Analyser” which gives an indication of pile capacity in end bearing and side friction.

2.7.8 Important Considerations, Inspection / Precautions Bored Cast-In-Situ Piles

i) While concreting uncased piles, voids in concrete shall be avoided and sufficient head of concrete shall be maintained to prevent inflow of soil or water into the concrete. It is also necessary to take precautions during concreting to minimise the softening of the soil by excess water. Uncased cast-in-situ piles shall not be permitted where mudflow conditions exist.

ii) The drilling mud such as bentonite suspension shall be maintained at a level sufficiently above the surrounding ground water level to ensure the stability of the strata which is being penetrated all through the boring operation and until the pile has been concreted.

iii) Where bentonite suspension is used to maintain the stability of the bore-hole, it is essential that the properties of the material be carefully controlled at stages of mixing, circulating through the bore-hole and immediately before concrete is placed. It is advisable to limit:

a) The density of bentonite suspension to 1.05 g/cc and maintain it.

b) The marsh cone viscosity between 30 and 40

c) The pH value between 9.5 and 12

d) The silt content less than 1 per cent

e) The liquid limit of bentonite not less than 400 per cent

These aspects shall act as controlling factors for preventing contamination of bentonite slurry by clay and silt.

iv) The bores shall be washed by bentonite flushing to ensure clean bottom at two stages viz. (a) after completion of boring and (b) prior to concreting after placing of reinforcement cage. Flushing of bentonite shall be done continuously with fresh bentonite slurry till the consistency of inflowing and outflowing slurry is similar.

v) Tremie of 150mm to 200mm diameter shall be used for concreting. The tremie should have uniform and smooth cross-section inside, and shall be withdrawn slowly ensuring adequate height of concrete outside the tremie pipe at all stages of withdrawal. Other precautions to be taken while tremie concreting are:

a) The sides of the bore-hole have to be stable throughout

b) The tremie shall be water tight throughout its length and have a hopper attached at its head by a water tight connection.

c) The tremie pipe shall be large enough in relation to the size of aggregates. For 20mm aggregate the tremie pipe shall be of diameter not less than 150mm and for larger size aggregate tremie pipe of larger diameter is required.

d) The tremie pipe shall always be kept full of concrete and shall penetrate well into the concrete in the bore-hole with adequate margin of safety against accidental withdrawal if the pipe is surged to discharge the concrete.

e) For very long or large diameter piles, use of retarding plasticiser in concrete is desirable.

2.7.9 Tolerances for Installation of Piles

a) Permissible Tolerances for Pile

i) Bored Piles

a) Variation in cross-sectional dimensions : + 50mm, - 10mm

b) Variation from vertical or specified rake : 1 in 50

c) Variation in the final position of the head in plan: 50 mm

d) Variation of level of top of piles : $\pm$ 25 mm

ii) Permissible Tolerances for Pile Caps

a) Variation in dimensions : + 50mm – 10mm

b) Misplacement from specified position in plan: 15mm

c) Surface irregularities measured with 3m straight edge : 5mm

d) Variation of levels at the top : $\pm$ 25mm

2.7.10 Measurements for Payment

i) The Engineer shall decide on what depth of excavation is to be made and the level at which the top of pile is to be placed before driving or boring is started. Such excavation shall be paid for at rate specified for excavations for foundations. Rates applicable to driving / casting pile shall be paid for the depth below that level only.

(For supply of precast concrete, timber or steel piles of specified cross section, the measurement shall be in metres of the length of piles ordered in writing by the Engineer measured from the head to the butt of the shoe or the tapered point.) Reinforcement in precast concrete piles shall be paid for separately unless otherwise specified in work contract.

ii) For driven cast-in-situ and bored concrete piles of specified cross-section, the measurement shall be the length in metres of the accepted pile that remains in the finished structure complete in place. Reinforcement in cast-in-situ driven and bored concrete piles shall be measured for payment as per RCC Chapter.

iii) Routine and Initial Pile Load Tests shall not be measured for payment, unless otherwise specified in the Contract schedule.

iv) For installation of the pile, i.e. by driving in the case of precast concrete, timber, steel and cast-in-situ driven piles, and by boring in the case of cast-in-situ bored piles the measurement shall be the length in metres that remains in the finished structure complete in place, limited to that shown on drawings or as ordered by the Engineer. No distinction shall be made for penetration through hard strata or rock and socketing into rock.

v) For steel liners / casing shown on the drawings to be permanently left in place, the measurement shall be by weight in ones (or in metre lengths of specified thickness as specified in the schedule) that remains in the finished structure complete in place, limited to that shown on drawings or ordered by the Engineer.

vi) For the pile cap, the quantity of concrete shall be measured in cubic metres while reinforcement in pile cap shall be measured in tonnes unless specified otherwise.

vii) The contract unit rate for concrete in pile cap shall cover all costs of labour, materials, tools, plant and equipment, form work and staging including placing in position, sampling and testing and supervision, all as per provisions in Concrete work. Reinforcement in the pile cap shall be paid for separately in accordance with payment clause mentioned in chapter of RCC.

2.8 WELL FOUNDATIONS

2.8.1 General

2.8.1.1 In case of larger than 12m in diameter and for wells to be sunk by using special equipment, supplemental instructions / specifications will be necessary.

2.8.1.2 To facilitate sinking of well, steel cutting edge is fabricated and connected to a concrete well curb of required shape. Minimum grade of concrete for well curb shall be M 20 unless otherwise specified in Drawing or directed by Engineer. On top of the well curb, adequate height of well steining is cast and the process of sinking is carried out. After a portion of the well has been sunk, another height of well staining is cast on top of the previous section and further sinking carried out. This process is continued till the bottom level of the well reaches the founding level.

2.8.1.3 At the top of the well staining, an adequately designed “well cap” is laid which transmits the loads and forces from the sub-structure (piers or abutments) to the foundations.

2.8.1.4 The plan dimensions of sand islands, used for forming the well in water, shall be such as to have a working space of at least 2 metres all around the staining. The dimension of the sand islands shall however be not less than twice the dimension in plan of the well or caisson. Sand islands shall be maintained to perform their functions, until the well is sunk to a depth below the bed level at least equal to the depth of water. Sand island shall be protected against scour and the top level shall be sufficiently above the prevailing water level to be decided by the Engineer so that it is safe against waves and induced afflux Island should be adequately protected against force of water current and wave action.

2.8.1.5 Where depth of water is more than 5 to 6 metres and in fast flowing water, caissons shall be used. Floating caissons are generally fabricated or cast near the banks on dry land or in dry docks. Floating caissons are towed into position in floating condition.

Floating caissons maybe of steel, reinforced concrete or a combination of the two.

2.8.2 Equipment for sinking wells

Equipment shall be deployed for construction of well foundation as required and as directed by the Engineer in quality, performance and quantity. Generally, the following equipments may be required for the work:

a) Crane with grab buckets capacity 0.5 to 2.0 cum.

b) Submersible pumps

c) Air compressors, air locks and other accessories where pneumatic sinking of well is anticipated.

d) Chisels of appropriate sizes

e) Aqua header for cutting rocky strata

f) Driving helmets and accessories

g) Concrete Mixer or Batching Plant; Pumps or skips and hoists; vibrators etc.

h) Pre arrangements for blasting equipment in case of unforeseen circumstances.

2.8.3 Well Steining

2.8.3.1 The dimensions, shape, concrete strength and reinforcement of the well `steining shall strictly conform to those shown on the drawings. The form work shall preferably be of MS sheets shaped and stiffened suitably. In case timber forms are used, they shall be lined with plywood or M.S. sheets.

2.8.3.2 Steining built in the first lift above the well curb shall not be more than 1.5 metres high and in subsequent lifts it shall not exceed the diameter of the well or the depth of well sunk below the adjoining bed level at any time. For stability, the first lift of steining shall be cast only after sinking the curb at least partially for stability. Concreting of steining may be carried out in subsequent lifts of about 1.2, or 2 to 2.5 metres. Attempts should be made to minimise the number of construction joints. The concreting layers shall be limited to about 450 mm restricting the free fall of concrete to not more than 1.5m. Laitance formed at the top surface of a lift shall be removed to expose coarse aggregates before setting of concrete at the proposed construction joint. As far as possible, construction joints shall not be kept at the location of laps in the vertical steining bars.

2.8.3.3 The steining of the well shall be built in one straight line from bottom to top such that if the well is tilted, the next lift of steining shall be aligned in the direction of the tilt. The work shall be checked carefully with the aid of straight edges of lengths approved by the Engineer. Plumb bob or spirit level shall not be used for checking verticality alignment. After sinking of a stage is complete, damaged portions if any, of steining at top of the previous stage shall be properly repaired before constructing the next stage.

2.8.3.4 The height of steining shall be calibrated by making atleast 4 gauges (two in traffic direction and two in a direction normal to traffic direction) distributed equally on the outer periphery of the well. Each gauge should be in the form of a 100mm wide

strip painted on the well, with every metre mark shown in black paint and sub-mark at 10 cm intervals. The gauges shall start with zero at the bottom of the cutting edge. It shall be in black or a white background. Marking of the gauges shall be done carefully with a steel tape. Cost of providing the gauges shall be presumed to be included in the rate for sinking.

2.8.3.5 After reaching the founding level, the well steining shall be inspected to check for any damage or cracks. The Contractor shall execute the remedial measures as directed by the Engineer before acceptance of the well steining. In case the well cannot be accepted even with any remedial measures, then the well shall stand rejected.

2.8.3.6 Blasting may have to be resorted to in order to facilitate sinking through difficult strata, such as boulders and rocks etc. In case blasting is anticipated, protective / strengthening measures specified in clause 710.6 (IV) of IRC: 78 shall be taken. The grade of concrete and / or Bridge Sub-structure in bottom 3 metres of steining shall not be leaner than M 20 or as shown on the drawings.

2.8.3.7 In case the bore hole data shows the presence of steeply dipping rock, chiselling may have to be resorted to so as to obtain proper seating of the foundation. For this purpose, the well may require to be dewatered completely under high air pressure inside the well. This process is known as pneumatic sinking. Pneumatic sinking may also have to be resorted to in cases where obstacles such as tree trunks, large sized boulders or hard strata etc. cannot be removed by open dredging. The necessity of adopting pneumatic sinking shall be decided by the Engineer.

2.8.3.8 The curb and steining have to be specifically designed for special loadings when pneumatic sinking is adopted. Minimum grade of Concrete should, preferably be M 25.

2.8.3.9 The specifications given in this chapter deal only with such items of work as are peculiar to the construction of wells. For the basic items of work such as concrete (pain and reinforced), brickwork, stone masonry, earthwork, etc. which are also incidental to the construction of wells, the relevant specifications as given in the respective chapters shall be followed.

2.8.4 Sinking Wells for Foundations

2.8.4.1 This specification pertains to the actual operation of sinking the well through various kinds of strata to the reduced level shown on the drawing, or to any other level as ordered by the Engineer, to enable it to be founded on a suitable foundation stratum.

2.8.4.2 Programme

The programme for sinking shall be so arranged that every well started during a working season is completed, plugged and sealed at top, and the pier or abutment over it built to a suitable height, within the same season, so as to be safe during the floods. In the event of the Contractor’s failure to ensure this, any protective measure

or other extra work involved in completing the unfinished portion in the next working season shall be done by the Contractor at his own cost.

2.8.4.3 Strata Variation

a) The Contractor may, at his own expense, make trial bores to ascertain the exact depth to which each well may have to be sunk. If any boring data are indicated by the Railway at the tender stage, these may be taken as a general guide only, and the Contractor shall not be entitled to any compensation on account of variations in the strata as actually met with during sinking.

b) The Contractor shall, during the course of the work, collect and hand over to the Engineer's representative samples of all the different strata passed through, including undisturbed samples, where so required by the Engineer. The cost of collection of these samples shall be included in the rate for sinking.

c) Unless otherwise stipulated, the sinking of wells through (a) Hard Rock, and (b) Soft rock & all soils shall be measured and paid for separately.

2.8.4.4 Level of commencement: Excavation and Island

(a) The sinking of the well shall start from a level not more than 30 cm. above the water level or the spring level (subsoil water level), as the case may be unless any higher level is specially approved by the Engineer, based on local conditions such as tidal or other anticipated variations in water level, stability of existing works etc. The water level, for the purpose of this Para, shall be taken as on the date of laying the cutting edge for the well curb.

(b) Where the existing ground level is higher than the level of commencement as specified above, open excavation shall be carried out to that level. Payment for such excavation shall be made as for ordinary cutting unless any special rate has been agreed upon. Notwithstanding the quantity of work actually done, the quantity payable shall be restricted to the actual area of the capping slab, multiplied by the average depth of excavation upto the level from which sinking starts as per Sub-Para (a) above.

(c) Where it is necessary to sink the well in water, an island shall be formed. The dimensions of the island shall be as approved by the Engineer, and its top finished to the level from which the sinking is to be commenced. The formation of the island shall be paid for separately at rates specially agreed upon, unless otherwise stipulated in the contract.

(d) If, for his own convenience, the Contractor commences sinking of a well from any level higher than that specified in Sub-Para (a) above, no payment shall be made to him for the extra depth of sinking resulting therefrom.

2.8.4.5 When the well curb is ready for sinking, it shall be "pitched" by careful removal of the blocking timbers on which the cutting edge was so long supported. The timbers shall be removed after loosening the sand around each, and the removal shall be so phased as to maintain equality of pressure and thereby avoid tilting of the curb.

2.8.4.6 After all the blocking timbers are removed, the soil from within the curb shall be excavated evenly over the whole internal area, excavating first in the centre and then working towards the circumference. In the case of double-D wells or twin octagonal wells, the excavation in both dredge holes shall progress simultaneously. The sinking shall be stopped when the top of the curb is about 15 cm above the ground, after which the building up of the initial lift (of say 1.5m height) of the steining shall be taken up.

2.8.4.7 Methods of Sinking:

a) All possible care shall be taken to ensure perfect verticality of sinking of the well curb and the first two lifts (or say 3m.) of the steining, since by doing so, the subsequent sinking to plumb becomes easier. The manner of sinking shall continue to be as followed for the well curb. The operation of sinking will, naturally, alternate with that of adding further lifts of steining, which may be done for two lifts in a sequence, except for the first two lifts which shall be done in two stages, with sinking done in between.

The maximum depth of excavation below the level of the bottom of cutting edge of the well at any stage shall not generally exceed the internal diameter of the well.

Where dewatering is resorted to and it gives rise, at any stage, to “blowing” of the surrounding soil into the bottom of the well, the dewatering shall be stopped forthwith and the water levels balanced to prevent further blowing, before attempting to remove the blown material from inside the well.

b) In deep water, excavation shall be carried out with the use of grabs operated by winches, or preferably by cranes. Harder strata upto soft rock may be loosened by the use of heavy chisels, slung at a suitable angle. Removal of obstructions such as boulders and logs shall be done by employing divers.

c) Small charges of approved explosive may be used, with the written permission of the Engineer in the following circumstances: (1) To blast through rock or to break boulders, which cannot be done by any alternative method; and (2) To effect sinking, especially in the final stages, when the usual formation of a sump at the bottom of the dredge hole does not result in sinking. In the latter case, the charge of explosive shall be placed at the centre of the dredge hole and exploded to set up a tremor which will serve to help sinking of the well. Any damage caused to the well or to adjoining structure by the use of explosives shall be made good by the Contractor at his own expense.

d) Where a considerable depth of rock is to be pierced through, and dry sinking i.e. without much water except what can be pumped out is not possible, it will be necessary to resort to pneumatic sinking. This requires the use of proper air locks and ancillary equipment, with special precaution observed for safety and certain modifications to the structure of the well to fit the air locks. Sinking of wells by such method shall be a matter of special agreement and covered by special specifications.

e) Where two or more separate wells in a group are to be sunk, and the clear distance between any two wells is less than the diameter of the well, such wells shall be sunk alternately, each not having a lead of more than half the diameter over the other at any stage.

2.8.4.8 Use of Kentledge as Sinking Load

Kentledge shall be placed in an orderly and safe manner on the loading platform and in such a way that it does not interfere with the excavation of the material from inside the dredge hole and also does not in any way damage the steining of the well. Where tilts are present or there is a danger of well developing a tilt, the position of the kentledge load shall be regulated in such a manner as to provide greater sinking effort on the higher side of the well.

2.8.4.9 Use of Water Jetting

Water jetting, on the outside of the well may be employed for well sinking wherever necessary. Where stiff clayey strata is anticipated, small diameter water pipes are encased in the well with jet ends on periphery during casting of steining for this purpose.

2.8.4.10 Use of Explosives

Mild explosive charges may be used as an aid for sinking of the well only with prior permission of the Engineer. Blasting of any sort shall only be done in the presence of the Engineer and not before the concrete in the steining has hardened sufficiently and is more than 7 days old. When likelihood of blasting is predicted in advance, protection of the curb and the bottom portion of the well shall be done as per these specifications. After blasting operations are completed, the well curb and steining should be examined for any cracks and remedial measures taken.

a) The charges shall be exploded well below the cutting edge by making a sump so as to avoid chances of any damage to the curb or to the steining of the well. A minimum sump of 1 metre depth should be made before resorting to blasting. Use of large charges, 0.7 kg or above, may not be allowed except under expert direction and with the permission from the Engineer. Suitable pattern of charges may be arranged with delay detonators to reduce the number of charges fired at a time. The burden of the charge may be limited to 1 metre and the spacing of holes may normally be kept as 0.5 to 0.6 metre. All prevalent laws concerning handling, storing and using of explosives as per latest “Indian Explosives Act” shall be strictly followed.

b) All safety precautions shall be taken as per IS:4081 “Safety Code for Blasting and related Drilling Operations”, to the extent applicable, whenever blasting is resorted to. There should be no equipment inside the well nor there any labour in the close vicinity of the well at the time of exploding the charges.

c) If rock blasting is to be done for seating of the well, the damage caused by flying debris should be minimised by covering blasting holes by rubber mats before blasting.

If blasting has been used after the well has reached the design foundation level, normally 24 hours shall be allowed to lapse before the bottom plug is laid.

2.8.4.11 Daily records of tilt and shift, with reference to the principal axes of the well, shall be maintained at the site, separately for each well, on the Proforma prescribed by the Engineer. Tilts shall be measured along the two axis of the bridge and RL (Reduced Levels) of the marks painted on surface of steining shall be taken. For determination of shift, locations of the ends of the two diameters shall be precisely measured along the two axes, with respect to the fixed reference points. A pair of wells close to each other will have a tendency to come closer during sinking (Tilting towards each other). Timber struts may be introduced in between the steining of these walls to prevent tilting. Record shall also be kept of the daily water levels, commencing from the time of formation of islands or excavation of the site of the well, as the case may be. The Contractor shall further be responsible for maintaining a continuous record of the depth sunk in each working shift and of the types of strata passed through at the various depths, as well as any obstruction met with.

2.8.4.12 It shall be the Contractor's responsibility to sink the wells to the correct alignment, spacing and levels, based on the reference pillars and bench mark provided by the Railway. Unless otherwise specified the completed well shall not have a tilt of more than 1 in 80 in any direction or a shift of more than 5 per cent of the overall diameter or width of the well, as measured in either of the principal directions or 150mm in resultant direction, whichever is less. Where these tolerances are exceeded, the orders of the Engineer shall be sought. These tolerances shall be further subject to the condition that the stability of the foundation is not affected and that any modification thereby necessitated in the design of the substructure or superstructure shall be done at the cost of the Contractor.

Such acceptance shall be subject to:

i) Calculations for foundation pressures and steining stresses after accounting for the tilt and shift and consequent relocation of superstructure on top being safe;
ii) Remedial measures required for bringing stresses within permissible limits such as increasing dimension of well cap, providing dummy weights on well cap as well as redesign of structure above shall be carried out by the Contractor at no extra cost to Railway; and
iii) The Contractor shall agree to any reduction in rate for such defective work.

2.8.4.13 Tilt observed may, during the sinking, be corrected by one or more of the following methods, as approved by the Engineer:

1) Loading kentledge eccentrically
2) Carrying excavation at the bottom of the well deeper on the side which is higher.
3) Providing heavy inclined struts bearing against the face of the well steining on the side towards which it leans.
4) Jetting to reduce skin friction on the higher side, on the well periphery.
5) Pulling or pushing the well by approved methods.

If the well is rejected, the Contractor shall dismantle the defective well to the extent desired by the Engineer, at his cost. Further, the Contractor, at his risk and cost, shall complete the bridge with modified span arrangements.

2.8.4.14 Seating of Well

When the well approaches the final depth of sinking, the exact height to which the last lift of steining is to be made up shall be decided before it is completed and sunk. When the well has reached the required level and stratum, it shall be properly seated by levelling, the area under the cutting edge. In the case of rock also, every effort shall be made to ensure even seating of the cutting edge, with the use of divers for cutting or benching the rock, as required. No extra payment shall be admissible for the bedding of wells in this manner. Any portion of the rock stratum where the cutting edge cannot be bedded shall be got cleared of the overlying material and filled subsequently with the concrete of the bottom plug.

On completion of the bedding of the well, the bottom of the dredge hole shall be got cleared of all spoil and left in a fit condition for laying of the bottom plug.

2.8.5 Islands For Well Sinking

2.8.5.1 Islands shall be formed where it is necessary to sink wells in water of reasonable depth. The dimensions, method of construction, top level and side-slopes, if any, shall be as specified or got approved by the Engineer, depending on the local conditions.

2.8.5.2 Construction of Island

The island shall be made up of sand, earth or other approved material, deposited in uniform layers. The material shall be free from clods, stones or other hard materials which may obstruct the sinking of the well or deviate it from the correct location or plumb.

Where the water is shallow, the filling may be done within a ring of sand bags laid all round for protection. Alternatively, side-slopes may be formed and protected by pitching of stones or sand bags.

Where the depth of water is such that the above methods are rendered unsuitable, two rows of piling, with bamboos or casuarina piles or any other material as approved by the Engineer, shall be driven all round. The piles shall be of such dimensions and driven to such spacing and depths as considered by the Engineer to be sufficient to withstand any possible scour and at the same time retain the earth fill of the island in a stable manner. Each row shall be lashed round with wire rope or bound together with horizontal bamboos or bullies at top. Two rows of bamboo matting shall be placed on the inside of the piling and the inter space filled up with earth. Alternatively, sand bags may be used for the filling. The inside space i.e., within the inner row of piling, shall thereafter be filled up with the approved material for forming the island.

2.8.5.3 The island shall be maintained throughout the sinking operation and for any further period as may be necessary for completion of other items of the bridge work.

If any of these works gets carried over to the next working season, the Contractor shall not be entitled for any compensation on account of repairs to damages caused to the island during the floods.

2.8.5.4 If so directed by the Engineer in writing, the Contractor shall remove the whole or part of the island when it is no longer required and / or when such removal is necessary to clear the obstruction to the water-way.

2.8.5.5 The rate for forming an island shall, unless otherwise stipulated, include the cost of its construction, its maintenance for the period of utility and its removal to the extent ordered in terms of Sub Para 2.8.5.4 above.

2.8.6 Cutting Edges For Well Curbs

2.8.6.1 Unless otherwise specified, the cutting edges shall be fabricated out of new structural steel. The fabrication shall be done strictly in accordance with the detailed drawings and shall conform to the specifications.

2.8.6.2 Before being taken to the site, the cutting edge shall be assembled on level ground and verified for the accuracy of its shape and size. If in sections, the individual sections shall be match marked before being dismantled.

At the place for laying, necessary reference points to site the well accurately shall be fixed in advance, based on the permanent reference pillars on either bank or the base line provided on either or both banks. The ground shall be prepared by leveling to an even surface at the level from which sinking of the well is to be commenced.

2.8.6.3 On the prepared bed the cutting edge shall be placed and positioned accurately with respect to the reference points fixed. It shall be supported evenly and to true level on a series of blocking timbers, spaced sufficiently close together to withstand and distribute to the soil below the full weight of the cutting edge plus the weight of shuttering and concrete, without any unequal settlement. Where the cutting edge is in sections, any welding or riveting required shall be done after the cutting edge has thus been assembled to the correct lay out and level.

2.8.6.4 The rate for the cutting edge shall, unless otherwise specified, include the cost of supply, fabrication, transporting and placing the cutting edge as specified above, to its correct lay out and level including site joining by welding or bolting / riveting with cover/ fish plates.

2.8.7 Well Curbs and Steining

2.8.7.1 The basic items of work shall conform to one or more of the following and relevant specifications as applicable:

i) Cement Concrete

ii) RCC

Concrete steining shall generally be cast in “lifts” not exceeding 2.0m in height, for the convenience of placing and consolidation without segregation. Sinking shall not be started till the depth of masonry or concrete to be sunk has set properly. In the case

of concrete steining and RCC well curbs, the minimum periods as specified below shall be observed, unless any different period is prescribed by the Engineer, taking into account the local conditions or in the Contract.

For well curbs Minimum period

(a) Removal of outer shuttering	24 to 48 hours depending on the temperature
(b) Removal of inside shuttering	72 hors
(c) Commencement of sinking	7 days

For Steining

(a) Removal of outer or inside shuttering	24 hours
(b) Resumption of sinking	48 hours

In any case, the sinking shall not commence until the work that has been added on has been passed by the Engineer's representative and the commencement of sinking approved.

2.8.7.2 Bond Bars, bond flats, bottle nuts etc. which are built into the steining shall be paid for separately, but no extra payment shall be made for keeping these in the concrete or masonry work nor shall any deduction be made for their volume from the total volume of the concrete or masonry unless specified otherwise.

2.8.8 Plugging And Finishing Of Wells

2.8.8.1 Bottom Plug

a) The concrete used for the bottom and top plugs of foundation wells shall be of the specified mix, conforming to Specification for Cement Concrete

Where the bottom plugging is to be done under water, the special provisions of "Under Water Concreting" shall be observed carefully; and it shall further be ensured that the water inside the well has first been brought to a steady level, and there is no flow of water into the well.

b) Before the concrete is placed, the bottom of the well shall be inspected carefully and cleaned of any debris etc. The concreting shall be done in such a manner as to ensure thorough and even filling to the desired level. In under-water work, divers shall be engaged for the purpose, as may be required.

2.8.8.2 After the concrete has set fully, water shall be pumped out completely or partially, as directed by the Engineer, to test whether the plugging has been satisfactory. If complete dewatering is done, any kentledge required to counteract buoyancy shall be provided before pumping out. In case appreciable leakage of water into the well is observed, the Contractor shall, at his own cost, arrange for its rectification by grouting etc.

2.8.8.3 Sand Filing

Sand filling shall commence after a period of 3 days of laying of bottom plug. Also, the height of the bottom plug shall be verified before starting sand filling.

Sand shall be clean and free from earth, clay clods, roots, boulders, shingles etc and shall be compacted as directed. Sand filling shall be carried out upto the level shown on the drawing, or as directed by the Engineer.

2.8.8.4 Top Plug

After filling sand upto the required level a plug of concrete of specified mix shall be provided over it as shown on the drawing, or as directed by the Engineer.

2.8.8.5 Well Cap

1. A reinforced cement concrete well cap shall be provided over the top of the steining in accordance with the drawing. Form work shall be prepared conforming to the shape of well cap. Concreting shall be carried out in dry condition.

2. The bottom of the well cap shall be laid preferably as low as possible, taking into account the water level prevalent at the time of casting. Bond rods of steining shall be anchored into the well cap.

2.8.9 Tolerances

The permissible tilt and shift shall not exceed 1 (horizontal) in 80 (vertical) and the shift at the well base shall not be more than 150mm in any resultant direction or 5% of the overall diameter or width as measured in the principal directions, whichever is less.

For the well steining and well cap the permissible tolerances shall be as follows:

a) Variation in dimension : +50mm–10mm

b) Misplacement from specified position in plan: 15mm

c) Surface irregularities measured with 3m straight edge: 5mm

d) Variation of levels at the top :± 25mm

2.8.10 Tests and Standards of Acceptance

The materials shall be tested in accordance with specified Specifications and shall meet the prescribed criteria.

The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

2.8.11 Measurements for payment

All quantities shall be measured from the drawing, or as ordered by the Engineer, excepting those required to be provided by the Contractor at his cost.

a) The cutting edge shall be measured in tonnes based on the net weight of metal used in it, nearest to one kilogram. However, no deduction for the holes drilled shall be done.

b) The concrete in curb, well steining and well cap shall be measured in cubic metres separately for each item. The reinforcement shall be measured in tonnes and no deduction for the bottle nuts shall be done.

c) The measurement for well sinking shall be made in running metres for different depths and in different types of strata (Hard rock/ other rock &soils) unless otherwise specified in the Contract. The depth of sinking shall be measured from the reduced level specified in the Contract. If no level has been specified in the Contract, sinking shall be measured from the low water level or from the level at which the cutting edge was laid whichever is higher.

d) The quantity of concrete in bottom and top plug shall be measured in cubic metres.

e) The quantity of sand filling shall be measured in cubic metres.

f) Pneumatic sinking, where required shall be paid as a separate item and shall be measured in cubic metres of material to be excavated unless otherwise specified in Contract.

2.8.11.1 Reduction in Rate

Tilt and / or shift exceeding beyond permissible values shall not be acceptable. However, in exceptional circumstances, if it is accepted by the Engineer recording reasons of doing so, rates shall be reduced and amount of reduction shall be decided by the Engineer whose decision shall be final and binding. However, the minimum amount of reduction shall be as under:

Sl. No.	Amount of Tilt and / or shift	Per cent deduction on the rate (s) for sinking of whole well
1	Tilt exceeding the specified permissible value but equal to or within 1 in 60	10 per cent
2	Tilt exceeding 1 in 60 but equal to or within 1 in 50	15 per cent
3	Shift exceeding the specified permissible value but equal to or within 200mm	5 per cent
4	Shift exceeding 200mm but equal to or within 300 mm	10 per cent

Acceptance of Tilt and / or shift exceeding beyond permissible values but within prescribed limit in the above table is purely the discretion of the Engineer and the Engineer is at liberty to accept it with reduced rate or reject it altogether. The additional cost incurred on account of design and construction in this circumstance, if any, shall be borne by the contractor, over and above the reduction in rates stated as above.

2.9 SUB STRUCTURE - The term substructure covers:

a) Piers

b) Abutments and

c) Wing walls

d) Bed Blocks

e) Ballast retainers or dirt walls

f) Arches which form integral part of the pier / abutment in Arch bridges and

g) Face walls or spandrels of Arches.

They can be made of:

i) Brick Masonry

ii) Stone Masonry

iii) Plain Concrete or Reinforced Concrete

Some special requirements as provision of temperature or nominal reinforcements with respect to form work are covered in this chapter. Brick work and stone work specification covered in relevant chapters are applicable.

2.10 FORM WORK

2.10.1 General

This section covers requirement of form work for bridge foundations, sub structure and superstructures. Form works as per IS:3696, IS:4014 shall include all temporary or permanent forms required for forming the concrete of the shape, dimensions and surface finish as shown on the drawing or as directed by the Engineer, together with all props, staging, centering, scaffolding and temporary construction required for their support.

2.10.2 Material and Design

The Contractor shall furnish the design and drawing of complete form work (i.e. the forms as well as their supports) for approval of the Engineer before any erection is taken up. Materials used for form work shall be steel or timber. All bolts shall be counter sunk. Approved internal steel ties, struts and plastic spacers may be used if approved. Steel plate shall be of adequate thickness and thickness of walls of steel tubes used for supporting shall be at least 4mm. If proprietary system of form work is used, the Contractor shall furnish detailed information to the Engineer for approval.

Notwithstanding any approval or review of drawing and design by the Engineer, the Contractor shall be entirely responsible for the adequacy and safety of form work.

The design of the form work shall be such that it shall ensure that the forms can be conveniently removed without disturbing the concrete. The design shall facilitate proper and safe access to all parts of form work for inspection. In the case of prestressed concrete superstructure, careful consideration shall be given to redistribution of loads on props due to prestressing.

2.10.3 Workmanship

i) The form work shall be robust and strong and the joints shall be leak-proof. Balli shall not be used as staging. Staging must have cross bracings and diagonal bracings in both directions. Staging shall be provided with an appropriately designed base plate resting on firm strata. Approved steel or trestles or cribs or standard pipe scaffolding shall be used.

ii) The number of joints in the form work shall be kept to a minimum by using large size panels. The design shall provide for proper "soldiers" to facilitate alignment. All joints shall be leak proof and must be properly sealed. Use of PVC Joint sealing tapes, foam rubber or PVC T-Section is essential to prevent leakage of grout.

iii) As far as practicable, clamps shall be used to hold the forms together. Where use of nails is unavoidable, minimum number of nails shall be used and these shall be left projecting so that they can be withdrawn easily.

iv) Use of ties shall be restricted, as far as practicable. Wherever ties are used they shall be used with HDPE sheathing so that the ties can easily be removed. No parts prone to corrosion shall be left projecting or near the surface. The sheathing holes if permitted shall be grouted with cement mortar of the same strength as that of the structure.

v) Unless otherwise specified, or directed, chamfers or fillets of sizes 25mm x 25mm shall be provided at all angles of the form work to avoid sharp corners. The chamfers, beveled edges and mouldings shall be made in the form work itself. Opening for fixtures and other fittings shall be provided in the shuttering as directed by the Engineer.

vi) Shuttering for walls, sloping members and thin sections of considerable height shall be provided with temporary openings to permit inspection and cleaning out before placing of concrete.

vii) The form work shall be constructed with pre-camber to the soffit to allow for deflection of the form work. Pre-camber to allow for deflection of form work shall be in addition to that indicated for the permanent structure in the drawings.

viii) Where metal forms are used, all bolts and rivets shall be countersunk and well ground to provide a smooth, plane surface. Where timber is used it shall be well seasoned, free from loose knots, projecting nails, splits or other defects that may mar the surface of concrete.

ix) Forms shall be made sufficiently rigid by the use of ties and bracings to prevent any displacement or sagging between supports. They shall be strong enough to withstand all pressure, ramming and vibration during and after placing the concrete. Screw jacks or hard wood wedges where required shall be provided to make up any settlement in the form work either before or during the placing of concrete.

x) Where centering trusses or launching trusses are adopted for casting of superstructure, the joints of the centering trusses, whether welded, riveted or bolted should be thoroughly checked periodically. Also, various members of the centering trusses should be periodically examined for proper alignment and unintended

deformation before proceeding with the concreting. They shall also be periodically checked for any deterioration in quality due to steel corrosion.

xi) The formwork shall take due account of the calculated amount of positive or negative camber so as to ensure the correct final shape of the structures, having regard to the deformation of false work, scaffolding or propping and the instantaneous or deferred deformation due to various causes affecting Prestressed structures. Suitable camber shall be provided to horizontal members of structure, especially in long spans to counteract the effects of deflection. The form work shall be so fixed as to provide for such camber.

xii) The form work shall be coated with an approved release agent that will effectively prevent sticking and will not stain the concrete surface. Lubricating (machine oils) shall be prohibited for use as coating. The inside surfaces of forms shall, except in the case of permanent form work or where otherwise agreed to by the Engineer be coated with a release agent supplied by approved manufacturer or of an approved material to prevent adhesion of concrete to the form work. Release agents shall be applied strictly in accordance with the manufacturer's instructions and shall not be allowed to come into contact with any reinforcement or Prestressing tendons and anchorages. Different release agents shall not be used in form work for exposed concrete.

2.10.4 Formed Surface and Finish

The form work shall be lined with material approved by the Engineer so as to provide a smooth finish of uniform texture and appearance. This material shall leave no stain on the concrete and so fixed to its backing as not to impart any blemishes. It shall be of the same type and obtained from only one source throughout for the construction of any one structure. The contractor shall make good any imperfections in the resulting finish as required by the Engineer. Internal ties and embedded metal parts shall be carefully detailed and their use shall be subject to the approval of the Engineer.

2.10.4.1 Precautions in Bridge Works

i) Special measures in the design of form work shall be taken to ensure that it does not hinder the shrinkage of concrete. The soffit of the form work shall be so designed as to ensure that the formwork does not restrain the shortening and / or hogging of beams during Prestressing. The forms may be removed at the earliest opportunity subject to the minimum time for removal of forms with props retained in position.

ii) Where necessary, form work shall be so arranged that the soffit form, properly supported on props only can be retained in position for such period as may be required by maturing conditions of concrete.

iii) Any cut-outs or openings provided in any structural member to facilitate erection of form work shall be closed with the same grade of concrete as the adjoining structure immediately after removal of form work ensuring water tight joints.

iv) Provision shall be made for safe access on, to and about the form work at the levels as required.

v) Close watch shall be maintained to check for settlement of form work during concreting. Any settlement of form work during concreting shall be promptly rectified.

vi) Water used for curing should not be allowed to stagnate near the base plates supporting the staging and should be properly drained.

2.10.5 Removal of Form work for Reuse

i) The scheme for removal of form work (i.e. de-shuttering and decentering) shall be planned in advance and furnished to the Engineer for scrutiny and approval. The form work shall be so removed as not to cause any damage to concrete. Centering shall be gradually and uniformly lowered in such a manner as to permit the concrete to take stresses due to its own weight uniformly and gradually and any shock or vibration to structure is avoided.

ii) Where not specifically approved, the time of removal of form work (when ordinary Portland Cement is used without any admixtures at ambient temperatures exceeding 10 degrees Celsius) shall be as under:

a) Walls, piers, abutments, columns and Vertical faces of structural members:12 to 48 hours as may be decided by the Engineer

b) Soffits of Slabs (with props left under):3 days

c) Props (left under slabs):14 days

d) Soffit of Girders (with props left under):7 days

e) Props (left under girders):21 days

iii) Where there are re-entrant angles in the concrete sections, the form work should be removed at these sections as soon as possible after the concrete has set, in order to avoid cracking due to shrinkage of concrete.

iv) When form work is dismantled, its individual components shall be examined for damage and damaged pieces shall be removed for rectification. Such examination and rectification shall always be carried out before being used again. Before re-use all components shall be cleaned of deposits of soil, concrete or other unwanted materials. Threaded parts shall be oiled after cleaning. All bent steel props shall be straightened before re-use. The maximum deviation from straightness is 1/ 600 of the length. The maximum permissible axial loads in used props shall be suitably reduced depending upon their condition. The condition of the timber components, plywood and steel shuttering plates shall be examined closely for distortion and defects before re-use.

2.10.6 Re-use of Form work:

Before re-use of forms, the following actions shall be taken:

i) The contact surfaces of the forms shall be cleaned carefully thoroughly and dried before applying a release agent.

ii) It should be ensured that the release agent is appropriate to the surface to be coated. The same type and make of release agent shall be used throughout on similar form work materials and different types should not be mixed.

iii) The form surfaces shall be evenly and thinly coated with release agent. The vertical surface shall be treated before horizontal surface and any excess wiped out.

iv) The release agent shall not come in contact with reinforcement or the hardened concrete. All forms shall be thoroughly cleaned immediately before concreting.

2.10.6.1 Specialized Form work

Specialised form work may be required in the case of slip form work, underwater concreting, segmental construction etc. Such specialised form work shall be designed and detailed by competent agencies and a set of complete working drawings and installation instructions shall be supplied to the Engineer. The site personnel shall be trained in the erection and dismantling as well as operation of such specialised form work. In case proprietary equipment is used, the supplier shall supply drawings, details, installation instructions etc. in the form of manuals along with the form work. Where specialized form work is used, close coordination with the design of permanent structure is necessary.

2.11 SUB STRUCTURE

2.11.1 Piers and Abutments

a) Masonry, form work, concrete and reinforcement for piers and abutments shall conform to relevant sections of these specifications and drawings. In case of concrete piers, minimum grade shall be M20 unless otherwise specified / approved. The number of horizontal construction joints shall be kept to minimum. Construction joints shall be avoided in splash zones unless specifically permitted by the Engineer and provided they are treated in accordance with special provisions. No vertical construction joint shall be provided. Shear connectors in the form of vertical plumbs, dowels, bond bars or rail cut pieces shall be provided at all horizontal joints as directed by Engineer. The work shall conform strictly to the drawings or as directed by the Engineer.

b) In case of tall piers and abutments, use of slipform shall be preferred. The design, erection and raising of slip form shall be subject to special specifications which shall be furnished by the Contractor. The concrete shall also be of higher grade and subject to additional specifications as necessary. All specifications and arrangements shall be subject to the approval of the Engineer.

c) The surface of foundation / well cap / pile cap shall be scraped with wire brush and all loose materials removed. In case reinforcing bars projecting from foundations are coated with cement slurry, the same shall be removed by tapping, hammering or wire brushing. Care shall be taken to remove all loose materials around reinforcements. Just before commencing masonry or concrete work, the surface shall be thoroughly wetted.

d) In case of solid (non-spill through type) abutments, weep holes as shown on the drawings or as directed by the Engineer, shall be provided.

e) The surface finish shall be smooth, except the earth face of abutments which shall be rough finished or left as form finished.

f) In case of abutments likely to experience considerable movement on account of backfill of approaches and settlement of foundations, the construction of the abutment shall be followed by filling up of embankment in layers simultaneously with filter backing behind to the full height to allow for the anticipated movement during construction period before casting of superstructures.

2.11.2 Pier Cap and Abutment Cap (Bed Blocks)

a) Form work, Concrete and reinforcement shall conform to relevant paras of Concrete work & RCC of these specifications and the Drawings. Unless otherwise specified, minimum grade of concrete mix shall be M_{25}.

b) The locations and levels of pier cap / abutment cap / pedestals and bolts for fixing bearings shall be checked carefully to ensure alignment in accordance with the drawings of the bridge.

c) The surface of cap shall be finished smooth and shall have a slope for draining of water as shown on the drawings or as directed by the Engineer. For short span slab bridges with continuous support on pier caps, the surface shall be cast horizontal. The top surface of the pedestal on which bearings are to be placed shall also be cast horizontal.

d) The surface on which elastomeric bearings are to be placed shall be wood float finished to a level plane which shall not vary more than 1.5mm from straight edge placed in any direction across the area. The surface on which other bearings (steel bearings, pot bearings) are to be placed shall be cast about 25mm below the bottom level of bearings and as indicated on the drawings. Specified rich levelling mortar shall be provided over this at the time of placing of bearing.

2.11.3 Dirt / Ballast Wall, Return Wall and Wing wall

Dirt and ballast walls shall be in RCC. Minimum grade of concrete shall be M_{25} unless otherwise specified. Return walls and wing walls can be of masonry (brick or stone), concrete or in RCC, as specified in drawings. Minimum grade of concrete for them shall be M_{20} unless otherwise specified.

i) Brick Work Stone: - Masonry, concrete and reinforcement shall conform to relevant chapters of these specifications and Drawings.

ii) In case of cantilever return walls, no construction joint shall generally be permitted. Wherever feasible, the concreting in cantilever return walls shall be carried out in continuation of the ballast wall.

iii) For gravity type masonry and concrete return and wing wall, the surface of foundation shall be prepared in the same manner as prescribed for construction of

abutment. No horizontal construction joint shall be provided. If shown on drawing or directed by the Engineer, vertical construction joint may be provided. Vertical expansion gap of 20mm shall be provided in return wall / wing wall at every 10 metre intervals or as directed by the Engineer. Weep holes shall be provided as prescribed for abutments or as shown on the drawings.

iv) Form work, reinforcement and concrete in dirt / ballast wall shall conform to relevant sections of these specifications.

v) The finish of the surface on the earth side shall be rough/form finish while the front face shall be smooth finished.

vi) Architectural coping for wing wall / return wall in brick masonry shall conform to Drawings.

2.11.4 Tests and Standards of Acceptance

The materials shall be tested in accordance with these specifications and shall meet the prescribed criteria.

The work shall conform to these specifications and shall meet the prescribed standards of acceptance.

2.11.5 Tolerances in Concrete elements

a) Variation in cross-sectional dimensions :+ 10mm, -5mm

b) Misplacement from specified position in plan:10mm

c) Variation of levels at the top :$\pm$ 10mm

d) Variations of reduced levels of bearing areas:$\pm$ 5mm

e) Variations from plumb over full height:$\pm$ 10mm

f) Surface irregularities measured with 3m straight edge

i) All surfaces except bearing areas: 5mm

ii) Bearing areas:3 mm

2.11.6 Measurements for Payment

Reference is drawn to Para 2.6.10

Chapter - 3
Bridge Works - Super Structure (RCC)

3.1 GENERAL

3.1.1 Coverage

This chapter covers specifications for Reinforced Concrete and Prestressed Concrete superstructure of bridges. Bridge superstructure work in form of

i) Slabs –both RCC and PSC

ii) RCC Beams and Slabs

iii) Prestressed concrete girders and slabs

3.1.2 The girders and slabs may be cast-in-situ or precast in units, transported and erected. The precast elements may be in complete units; individual girders or of girders-in segments. Deck slab shall be cast in situ in case of I or T section girders.

3.1.3 Codes and Specifications to cover

3.1.3.1 The provisions in codes listed in these specifications and specifications accompanying the contract documents so far as they are applicable to superstructure shall be strictly followed.

3.1.3.2 Contractor shall study the general arrangement drawings (GADs) and other detailed drawings accompanying contract documents and point out any discrepancies, short comings and contradictions and shall have them clarified and reconciled before start of the work. Any delay caused due to contractor in seeking such clarification during progress of work shall be considered to contractor's account.

3.1.3.3 Contractor shall be responsible for preparation of further detailing and preparation of bar bending schedules.

3.1.4 Methodology Statement

3.1.4.1 Contractor shall submit a 'methodology statement' if not already included in the bid offer at tendering stage itself and have it approved by the Engineer at start of work. This statement shall include:

i) Sequencing of work, vis-à-vis the substructure work

ii) PERT chart to fit in with overall duration within targeted completion date

iii) Requirement and arrangements proposed in base depot / precasting yard including form work designs and details.

iv) Scheme for transport of precast elements.

v) Girder erection scheme including prestressing, grouting, alignment etc.

vi) Scheme for providing accessories / appurtenances.

3.1.4.2 Before commencement of work, Contractor shall discuss with Engineer and finalise the details listed above. If any changes in the scheme are called for, the

Contractor shall promptly bring such necessity to notice of Engineers and give his proposals in writing. They will be discussed and finalised in a workmanlike manner. Any delay and cost involved shall be to contractor's account unless such change has been called for due to any major change in design or scope of the work or change of policy of Government.

3.1.4.3 Nothing extra is payable for preparation and finalisation of the Methodology / Methods Statement.

3.2 FORM WORK

3.2.1 General Requirement

Form work shall include all temporary or permanent forms required for forming the concrete of the shape, dimensions and surface finish as shown on the drawing or as directed by the Engineer, together with all props, staging, centering, scaffolding and temporary construction required for their support. Unless otherwise specified in contract documents or by the Engineer, the design, erection and removal of form work shall conform to IRC 87 "Guidelines for Design and Erection of False work for Road Bridges" and these specifications.

3.2.2 Materials

Forms shall be constructed with metal or timber. The metal used for forms shall be of such thickness that the forms remain true to shape. All bolts should be countersunk. The use of approved internal steel ties or steel or plastic spacers shall be permitted. Structural steel tubes used as support for forms shall have a minimum wall thickness of 4mm. Other materials conforming to the requirements of IRC 87, or other proven standard products may also be used if approved by the Engineer.

3.2.3 Pre-camber and Rigidity

3.2.3.1 The form work shall be constructed with pre-camber to the soffit to allow for settlement / deflection of the form work. Pre-camber to allow for deflection of form work shall be in addition to that indicated for the permanent structure in the drawings.

3.2.3.2 Where centering trusses or launching trusses are adopted for casting of superstructure, the joints of the centering trusses, whether welded, riveted or bolted should be thoroughly checked periodically. Also, various members of the centering trusses should be periodically examined for proper alignment and levels and unintended deformation before proceeding with the concreting. They shall also be periodically checked for any deterioration in quality due to steel corrosion, loose joints, damaged individual members etc.

3.2.3.3 The form work shall be so made as to produce a finished concrete true to shape, line and levels and dimensions as shown on the drawings, subject to the tolerances specified in respective sections of these specifications, or as directed by the Engineer.

3.2.3.4 Forms shall be made sufficiently rigid by the use of ties and bracings to prevent any displacement or sagging between supports. They shall be strong enough to withstand all pressure, ramming and vibration during and after placing the concrete. Screw jacks or hard wood wedges where required shall be provided to make up for any settlement in the form work either before or during the placing of concrete

3.2.3.5 Unless otherwise specified fillets of size 25mm x 25mm shall be provided at sharp corners. Where ties are used, they shall be used with HDPE sheathing, for ease of removal after concreting. Sheathing shall be grouted with cement mortar of same strength as precast concrete.

3.2.4 Preparation of Form work before Concreting

3.2.4.1 The inside surfaces of forms shall, except in the case of permanent form work or where otherwise agreed to by the Engineer be coated with a release agent supplied by approved manufacturer or of an approved material to prevent adhesion of concrete to the form work. Release agents shall be applied strictly in accordance with the manufacturer's instructions and shall not be allowed to come into contact with any reinforcement or prestressing tendons and anchorages. Different release agents shall not be used in form work for exposed concrete.

3.2.4.2 All forms shall be thoroughly cleaned immediately before concreting.

3.2.4.3 The Contractor shall give the Engineer due notice before placing any concrete in the forms to permit him to inspect and approve the form work, but such inspection shall not relieve the contractor of his responsibility for safety of form work, men, machinery, materials and finish or tolerances of concrete.

3.2.4.4 Where not specifically mentioned otherwise, the time of removal of form work (when ordinary Portland Cement is used without any admixtures at an ambient temperature exceeding 10 degrees Celsius) shall be as given in Para 2.10.5.

3.2.4.5 In order to verify the time and sequence of striking / removal of specialised form work, routine field tests for the consistency of concrete and strength development are mandatory and shall be carried out before adoption.

3.2.5 Measurements for payment

Shuttering area coming in contact with the concrete surface, necessary to cast designed shape in in-situ construction, shall be measured for payment.

3.3 CONCRETE FOR SUPERSTRUCTURE

3.3.1 General: Concrete used in any of the bridge structures shall conform to the provisions made in Concrete work & RCC, supplemented and / or modified to the extent the following clauses cover.

3.3.2 Basic Requirements: (i) Unless otherwise specified, minimum grades of concrete and maximum water cement ratio to be used for superstructure are as given in Table 3.1(a) and 3.1 (b) respectively below or as shown in the drawings.

Table 3.1 (a) Minimum Grade of Concrete

(i) For Bridges in Pre-stressed Concrete and Important Bridges:

Structural Member	Moderate Exposure	Severe Exposure	Extreme Exposure
PCC Member	M-25	M-30	M-35
RCC Member	M-30	M-35	M-40
PSC Member	M-35	M-40	M-45

(ii) For Bridges other than mentioned above and Sub-structure

Structural Member	Moderate Exposure	Severe Exposure	Extreme Exposure
PCC Member	M-15	M-20	M-25
RCC Member	M-20	M-25	M-30

Table 3.1 (b) Maximum Water Cement Ratio

Environment	Maximum Water – Cement Ratio		
	Plain Concrete (PCC)	Reinforced Concrete (RCC)	Prestressed Concrete (PSC)
Moderate	0.50	0.45	0.40
Severe	0.45	0.40	0.40
Extreme	0.40	0.35	0.35

For underwater concreting 10% extra cement shall be added.

ii) **Requirements of Consistency**

The mix shall have the consistency which will allow proper placement and consolidation in the required position. Every attempt shall be made to obtain uniform consistency.

The optimum consistency for various types of structures shall be as indicated in Table 3.2 or as directed by the Engineer. The slump of concrete shall be checked as per IS:1199.

Table 3.2 Slump Required for Workability

S. No.	Type	Slump (mm)

1	(a) Structures with exposed inclined surface requiring low slump concrete to allow proper compaction	25
	(b) Plain Cement Concrete	25
2	RCC structures with widely spaced reinforcements; e.g. solid columns, piers, abutments, footings, well steining	40-50
3	RCC structures with fair degree of congestion of reinforcement; e.g. pier and abutment caps, box culverts well curb, well cap, walls with thickness greater than 300mm	50-75
4	RCC and PSC structures with highly congested reinforcements e.g. deck slab girders, box girders, walls with thickness less than 300mm	75-125
5	Underwater concreting through tremie e.g. bottom plug, cast-in-situ piling	100-200

iii) **Additional Requirements**

Concrete shall meet with any other requirements as specified on the drawing or as directed by the Engineer. Additional requirements shall also consist of the following overall limits of deleterious substances in concrete:

a) The total chloride content of all constituents of concrete as a percentage of mass of cement in mix shall be limited to values given below:

i) Prestressed Concrete : 0.06 % for extreme and 0.1 % for severe and moderate condition

ii) Reinforced concrete exposed :0.15 per cent

b) The total sulphuric anhydride (SO_2) content of all the constituents of concrete as a percentage of mass of cement in the mix shall be limited to 4 per cent.

3.3.3 Admixtures

Use of admixtures such as super plasticiser for concrete may be made with the approval of the Engineer. As the selection of an appropriate concrete admixture is an integral part of the mix design, the manufacturers shall recommend the use of any one of his products only after obtaining complete knowledge of all the actual constituents of concrete as well as methodologies of manufacture, transportation and compaction of concrete proposed to be used in the project.

Manufacturer should provide satisfactory evidence that such admixtures do not have adverse effect the properties of concrete or mortar particularly with respect to strength, volume change, durability and has no deleterious effect on the reinforcement. Admixtures used should conform to provisions of IS:9103.

Calcium chloride or admixtures containing calcium chloride shall not be used in structural concrete containing reinforcement, prestressing tendon or other embedded metal. Also, admixtures containing Cl and SO_3 ions or nitrates shall not be used. Admixtures based on thiocyanate can promote corrosion and hence are prohibited.

3.3.4 Size of Coarse Aggregate

The size (maximum nominal) of coarse aggregates for concrete to be used in various components of bridges shall be given as Table 3.3.

TABLE 3.3 Coarse Aggregate Size

	Components	Maximum Nominal Size of Coarse Aggregate (mm)
i)	RCC well curb	20
ii)	RCC/ PCC well steining	40
iii)	Well cap or Pile Cap Solid type piers and abutments	40
iv)	RCC work in girders, slabs, wearing coat, kerb, approach slab, hollow piers and abutments, pier / abutment caps, piles	20
v)	PSC work	20
vi)	Any other item	As specified by Engineer

Maximum nominal size of aggregates shall also be restricted to the smaller of the following values:

a) 10mm less than the minimum lateral clear distance between main reinforcements

b) 10mm less than the minimum clear cover to the reinforcements

The proportions of the various individual size of aggregates shall be so adjusted that the grading produces densest mix and the grading curve corresponds to the maximum nominal size adopted for the concrete mix.

3.3.5 Equipment

Unless specified otherwise, equipment for production, transportation and compaction of concrete shall be as under:

a) For Production of Concrete:

i) Mobile concrete batching and mixing plant fully automatic with minimum capacity of 20 cum. per hour.

ii) Stationery RMC Plants at site

Selection shall be done from above as per the requirement of quantity and need of continuous pouring in certain circumstances. However, for minor bridges at isolated

location, RMC form approved plants may be used with the prior approval of Engineer if otherwise suitable.

All measuring devices of the equipment shall be maintained in a clean and serviceable condition. Its accuracy shall be checked over the range in use, when set up at each site and thereafter periodically as directed by the Engineer.

The accuracy of the measuring devices shall fall within the following limits:

Measurement of Cement: ± 3 per cent of the quantity of cement in each batch

Measurement of Water: ± 3 per cent of the quantity of water in each batch

Measurement of Aggregate: ± 3 per cent of the quantity of aggregate in each batch

Measurement of Admixture: ± 3 per cent of the quantity of admixture in each batch

b) For Concrete Transportation: depending upon actual requirement

i) Transit mixers: minimum 6.0 Cum capacity

ii) Powered hoists minimum 0.5 ton capacity

iii) Chutes

iv) Buckets handled by cranes

v) Transit truck mixer

vi) Concrete pump

vii) Concrete distributor booms

viii) Belt conveyor

ix) Cranes with skips

x) Tremies

c) For Compaction of Concrete:

i) Internal vibrators size 25mm to 70mm

ii) Form vibrators minimum 500 watts

iii) Screed vibrators full width of carriage way (upto two lanes)

3.3.6 Transporting, Placing and Compaction

i) The method of transporting and placing concrete shall be approved by the Engineer. Concrete shall be transported and placed as near as practicable to its final position, so that no contamination, segregation or loss of its constituent materials takes place. Concrete shall not be freely dropped into place from a height exceeding 1.5 metres.

ii) When concrete is conveyed by chute, the plant shall be of such size and design as to ensure practically continuous flow. Slope of the chute shall be so adjusted that the concrete flows without the use of excessive quantity of water and without any segregation of its ingredients. The delivery end of the chute shall be as close as possible to the point of deposit. The chute shall be thoroughly flushed with water before

and after each working period and the water used for this purpose shall be discharged outside the form work.

iii) All form work and reinforcement contained in it shall be cleaned and made free from standing water, dust, snow or ice immediately before placing of concrete.

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

v) If concreting is not started within 24 hours of the approval being given, it shall have to be obtained again from the Engineer. Concreting then shall proceed continuously over the area between the construction joints. Fresh concrete shall not be placed against concrete which has been in position for more than 30 minutes unless a proper construction joint is formed.

vi) Except where otherwise agreed to by the Engineer, concrete shall be deposited in horizontal layers to a compacted depth of not more than 450mm when internal vibrators are used and not exceeding 300mm in all other cases.

vii) Concrete when deposited shall have a temperature of not less than 5 degrees Celsius, and not more than 40 degrees Celsius. It shall be compacted in its final position within 30 minutes of its discharge from the mixer, unless carried in properly designed agitators, operating continuously. It may be necessary to add retarding admixtures to concrete if trials show that the periods indicated above are unacceptable. In all such matters, the Engineer's decision shall be final.

viii) Concrete shall be thoroughly compacted by vibration, or other means approved by Engineer, during placing and worked around the reinforcement, tendons or duct formers, embedded fixtures and into corners of the form work to produce a dense homogeneous void-free mass having the required surface finish. When vibrators are used, vibration shall be done continuously during the placing of each batch of concrete until the expulsion of air has practically ceased and in a manner that does not promote segregation. Over vibration shall be avoided to minimise the risk of forming a weak surface layer. When external vibrators are used, the design of form work and disposition of vibrator shall be such as to ensure efficient compaction and to avoid surface blemishes. Vibrators shall not be applied through reinforcement and where vibrators of immersion type are used, contact with reinforcement and all inserts like ducts etc., shall be avoided. The internal vibrators shall be inserted in an orderly manner and the distance between insertions should be about one and a half times the radius of the area visibly affected by vibration. Additional vibrators in serviceable condition shall be kept at site so that they can be used in the event of breakdowns.

ix) Mechanical vibrators used shall comply with requirement of IS:2505, IS:2506, IS 2514 and IS:4656.

3.3.7 Construction Joints

Construction Joints shall be avoided as far as possible and in no case the locations of such joints shall be changed or increased from those shown on the drawings, except

with express approval of the Engineer. The joints shall be provided in a direction perpendicular to the member axis.

Location, preparation of surface and concreting of construction joints shall conform to the additional specifications given in **Annexure 3.1** and concreting work chapter.

3.3.8 Concreting in Adverse Weather Conditions

3.3.8.1Cold Weather Concreting

Where concrete is to be deposited at or near freezing temperature, precautions shall be taken to ensure that at the time of placing, it has a temperature of not less than 5 degrees Celsius and that the temperature of the concrete shall be maintained above 4 degrees Celsius until it has thoroughly hardened. When necessary, concrete ingredients shall be heated before mixing but cement shall not be heated artificially other than by the heat transmitted to it from other ingredients of the concrete. Stock piled aggregate may be heated by the use of dry heat or steam. Aggregates shall not be heated directly by gas or on sheet metal over fire. In general, the temperature of aggregates or water shall not exceed 65 degrees Celsius. Salt or other chemicals shall not be used for the prevention of freezing. No frozen material or materials containing ice shall be used. All concrete damaged by frost shall be removed. It is recommended that concrete exposed to freezing weather shall have entrained air and the water content of the mix shall not exceed 30 litres per 50 kg of cement.

3.3.8.2 Hot Weather Conditions

When depositing concrete in very hot weather, precautions shall be taken so that the temperature of wet concrete does not exceed 40 degrees Celsius while placing. This shall be achieved by stacking aggregate under the shade and keeping them moist, using cold water, reducing the time between mixing and placing to the minimum, cooling form work by sprinkling water, starting curing before concrete dries out and restricting concreting as far as possible to early mornings and late evenings. When ice is used to cool mixing water, it will be considered a part of the water in design mix. Under no circumstances shall the mixing operation be considered complete until all ice in the mixing drum has melted.

The Contractor shall be required to state his methodology for the Engineer’s approval when temperatures of concrete are likely to exceed 40 degrees Celsius during the work.

3.3.9 Protection and Curing

3.3.9.1 Concreting operations shall not commence until adequate arrangements for concrete curing have been made by the Contractor. Curing and protection of concrete shall start immediately after compaction of the concrete to protect it from:

a) Premature drying out particularly by solar radiation and wind

b) High internal thermal gradients

c) Leaching out by rain and flowing water

d) Rapid cooling during the first few days after placing

e) Low temperature or frost

f) Vibration and impact which may disrupt the concrete and interfere with its bond to the reinforcement.

3.3.9.2 Where members are of considerable size and length, with high cement content, accelerated curing methods may be applied, as approved by the Engineer.

3.3.9.3 Water Curing

Water for curing shall be as specified in Concrete work chapter specification and approved by the Engineer. Sea water shall not be used for curing. Sea water shall not come into contact with concrete members unless it has attained adequate strength.

Exposed surfaces of concrete shall be kept continuously in a damp or wet condition by ponding or by covering with a layer of sacks, canvas, Hessian or similar materials and shall be kept constantly wet for a period of not less than 14 days from the date of placing of concrete.

3.3.9.4 Steam curing

i) Where steam curing is adopted, it shall be ensured that it is done in a suitable enclosure to contain the live steam in order to minimise moisture and heat losses. The initial application of the steam shall be after about four hours of placement of concrete to allow the initial set of the concrete to take place.

ii) Where retarders are used, the waiting period before application of the steam shall be increased to about six hours.

iii) The steam shall be at 100 per cent relative humidity to prevent loss of moisture and to provide excess moisture for proper hydration of the cement. The application of steam shall not be directly on the concrete and the ambient air temperature shall increase at a rate not exceeding 5 degrees Celsius per hour until a maximum temperature of 6 degrees Celsius to 70 degrees Celsius is reached. The maximum temperature shall be maintained until the Concrete has reached the desired strength.

iv) When steam curing is discontinued, the ambient air temperature shall not drop at a rate exceeding 5 degrees Celsius per hour until a temperature of about 10 degrees Celsius above the temperature of the air to which the concrete will be exposed, has been reached. The concrete shall not be exposed to temperatures below freezing for at least six days after curing.

3.3.9.5 Curing Compounds

a) Curing compounds shall only be permitted in special circumstances and will require specific approval of the Engineer. Curing compounds shall not be used on any surface which requires further finishing to be applied. All construction joints shall be moist, cured and no curing compound shall be permitted in locations where concrete surfaces are required to be bonded together.

b) Curing compounds shall be continuously agitated during use. All concrete cured by this method shall receive two applications of the curing compound. The first coat shall be applied immediately after acceptance of concrete finish. If the surface is dry, the concrete shall be saturated with water and curing compound applied as soon as the surface film of water disappears. The second application shall be made after the first application has set. Placement in more than two coats may be required to prevent streaking.

3.3.10 Finishing

i) Immediately after the removal of forms, exposed bars or bolts, if any, shall be cut inside the concrete member to a depth of at least 50mm below the surface of the concrete and the resulting holes filled with cement mortar. All fins caused by form joints, all cavities produced by the removal of form ties and all other holes and depressions, honeycomb spots, broken edges or corners, and other defects, shall be thoroughly cleaned, saturated with water, and carefully pointed and rendered true with mortar of cement and fine aggregate mixed in the proportions used in the grade of concrete that is being finished and of as dry a consistency as is possible to use. Adequate pressure shall be applied in filling and pointing to ensure thorough filling in all voids. Surfaces which have been pointed shall be kept moist for a period of twenty-four hours. Special pre-packaged proprietary mortars shall be used where appropriate or where specified in the drawing or by the Engineer.

ii) All construction and expansion joints in the completed work shall be left carefully tooled and free from any mortar and concrete. Expansion joint filler shall be left exposed for its full length with clean and true edges.

iii) Immediately on removal of forms, the concrete work shall be examined by the Engineer before any defects are made good.

a) The work that has sagged or contains honeycombing to an extent detrimental to structural safety or architectural appearance shall be rejected.

b) Surface defect of a minor nature may be accepted. On acceptance of such work by the Engineer, the same shall be rectified as directed by the Engineer.

3.3.11 Tests and Standards of Acceptance

3.3.11.1 Dividing into Lots

a) Concrete shall conform to the surface finish and tolerance as prescribed in these specifications for respective components.

b) Random sampling and lot by lot of acceptance inspection shall be made for the 28 days cube strength of concrete.

c) Concrete under acceptance shall be notionally divided into lots for the purpose of sampling, before commencement of work. The delimitation of lots shall be determined by the following:

i) No individual lot shall be more than 30 cum. in volume.

ii) At least one cube forming an item of the sample representing the lot shall be taken from concrete of the same grade and mix proportions cast on any day.

iii) Different grades of mixes of concrete shall be divided into separate lots.

iv) Concrete of a lot shall be used in the same identifiable component of the bridge.

Procedure for collection of samples and testing are given in relevant clause of RCC work chapter.

3.3.11.2 Sampling and Testing

a) Concrete for making 3 test cubes shall be taken from a batch of concrete at point of delivery into construction, according to procedure laid down in IS:1199.

b) A random sampling procedure to ensure that each of the concrete batches forming the lot under acceptance inspection has equal chance of being chosen for taking cubes shall be adopted.

c) 150 mm cubes shall be made, cured and tested at the age of 28 days for compressive strength in accordance with IS:516. The 28 days test strength result for each cube shall form an item of the sample.

3.3.11.3 Test Specimen and sample strength:

Three test specimens shall be made from each sample for testing at 28 days. Additional cubes may be required for various purposes such as to determine the strength of concrete at 7 days or for any other purpose. The test strength of the sample shall be the as per IS:456.

3.3.11.4 Frequency of Sampling:

The minimum frequency of sampling of concrete of each grade shall be in accordance with **Table 3.4**.

TABLE 3.4 Frequency of Sampling

Quantity of Concrete in work, m^3	No. of samples
1- 5	1
6-15	2
16-30	3
31-50	4
51 and above	4 plus one additional sample for each additional 50 m^3 or part thereof.

At least one sample shall be taken from each shift of work.

3.3.11.5 Acceptance Criteria

Compressive strength

The quantity of concrete represented by the test results include the batches from which the first and last samples were taken, together with all intervening batches.

3.3.11.6 Chloride and Sulphate content

The total chloride and sulphuric anhydride (SO_3) content of all the constituents of concrete as a percentage of mass of cement in the mix shall not exceed the values given in this section of the specifications.

3.3.11.7 Density of Fresh concrete

Where minimum density of fresh concrete is specified, the mean of any four consecutive samples shall not be less than the specified value and any individual sample result shall not be less than 97.5 per cent of the specified value.

3.3.11.8 Density of Hardened Concrete

Where minimum density of hardened concrete is specified, the mean of any four consecutive samples shall not be less than the specified value and any individual sample result shall not be less than 97.5 per cent of the specified value.

3.3.11.9 Permeability Test

The concrete should pass the following test if it is properly compacted and is not considered permeable.

i) Prepare a cylindrical test specimen 150mm dia and 160mm high

ii) After 28 days of curing, the test specimen is fitted in a machine such that the specimen can be placed in water under pressure up to 7 bars.

iii) At first a pressure of one bar is applied for 48 hours, followed by 3 bars for 24 hours and 7 bars for next 24 hours.

iv) After the passage of the above period, the specimen is taken out and split in the middle by compression applied on two round bars on opposite sides above and below.

v) The water penetration in the broken core is to be measured with a scale and the depth of penetration assessed in mm (max. permissible limit 25mm).

If the concrete is not able to meet any of the standards of acceptance as prescribed, the effect of such deficiency on the structure shall be investigated by the Contractor as directed by the Engineer. The Engineer may accept the concrete as sub-standard work. Any additional work required by the Engineer for such acceptance shall be carried out by the Contractor at his cost. In case the concrete is not found to be acceptable after investigation, the Contractor shall remove the rejected concrete forthwith.

3.4 PRESTRESSING

3.4.1 General

Concrete and HTS steel for the construction of Prestressed concrete members shall conform to the requirements of Concrete work & RCC chapter of specification for Structural Concrete and Steel Reinforcement respectively and provisions contained in Para 3.3 in so far as the requirements of these Sections apply and are not specifically modified by requirements set forth herein.

3.4.2 Sheathing

i) The sheathing ducts shall be of the spiral corrugated type. Unless otherwise specified, the material shall be Cold Rolled Cold Annealed (CRCA) Mild Steel conforming to IS:513 intended for mechanical treatment and surface refining but not for quench hardening or tempering.

ii) The material shall normally be bright finished. However, where specified, as in case of use in aggressive environment, galvanized or lead-coated mild steel strips shall be used. The thickness of sheathing shall be as shown on the drawing, but shall nevertheless not be less than 0.3mm, 0.4mm and 0.5mm for sheathing ducts having internal diameter of 50mm, 75mm and 90 mm respectively. For larger diameter of ducts, thickness of sheathing shall be based on recommendations of prestressing system supplier or as directed by the Engineer.

iii) For major projects, the sheathing ducts should preferably be manufactured at the project site utilising appropriate machines. With such an arrangement, long lengths of sheathing ducts may be used with consequent reduction in the number of joints and couplers. Where sheathing duct joints are unavoidable, such joints shall be made slurry tight by the use of corrugated threaded sleeve couplers which may be tightly screwed onto the outer side of the sheathing ducts.

iv) The length of the coupler should not be less than 150mm but should be increased upto 200mm wherever practicable. The joints between the ends of the coupler and the duct shall be sealed with adhesive sealing tape to prevent penetration of cement slurry during concreting. The couplers of adjacent ducts should be staggered wherever practicable. As far as possible, couplers should not be located in curved zones. The corrugated sleeve couplers are being conveniently manufactured using the sheath making machine with the next higher size of die set.

v) The internal diameter of the sheathing duct shall be in accordance with the recommendations of the system manufacturer and shall be about three times the area of the tendons. In case of 6T13, 12T13 and 19T13 sizes of tendons comprising 12/13mm dia strands, the inner diameter of the sheathing shall not be less than 50mm, 75mm and 90mm respectively or those shown in the drawing, whichever is greater.

3.4.3 Anchorages

i) Anchorages shall be procured from authorized manufacturers only. Anchorages shall conform to BS 4447. Test certificates from a laboratory fully equipped to carry

out the tests shall be furnished to the Engineer. Such test certificates shall not be more than 12 months old at the time of making the proposal for adoption of a particular system for the project.

No damaged anchorages shall be used. Steel parts shall be protected from corrosion at all times. Threaded parts shall be protected by greased wrappings and tapped holes shall be protected by suitable plugs until used. The anchorage components shall be kept free from mortar and loose rust and any other deleterious coating.

ii) Swages of prestressing strand and button heads of prestressing wire, where provided shall develop strength of atleast 95 per cent of the specified breaking load of the strand or wire as the case may be. Where swaging / button-heading is envisaged, the Contractor shall furnish details of his methodology and obtain approval of the Engineer, prior to his taking up the work.

3.4.4 Testing of Prestressing steel and Anchorages

All materials specified for testing shall be furnished free of cost and shall be delivered in time for tests to be made well in advance of anticipated time of use.

All wire, strand or bars to be shipped to the site shall be assigned a lot number and tagged for identification purposes. Anchorage assemblies to be shipped shall be like-wise identified.

All samples submitted shall be representative of the lot to be furnished and in the case of wire or strand, shall be taken from the same master roll. The Contractor shall furnish samples of atleast 5.0m length selected from each lot for testing. Also, two anchorage assemblies, complete with distribution plates of each size or types to be used, shall be furnished along with short lengths of strands as required.

3.4.5 Workmanship

3.4.5.1 Cleaning

Tendons shall be free from loose rust, oil, grease, tar, paint, mud or any other deleterious substance.

Cleaning of the steel may be carried out by immersion in suitable solvent solutions, wire brushing or passing through a pressure box containing carborundum powder. However, the tendons shall not be brought to a polished condition.

3.4.5.2 Straightening

High tensile steel wire and strand shall be supplied in coils of sufficiently large diameter such that tendons shall retain their physical properties and shall be straight as it unwinds from the coil. Tendons of any type that are damaged, kinked or bent shall not be used.

The packing of prestressing wire / strand shall be removed only just prior to making of cable for placement. Suitable stands shall be provided to facilitate uncoiling of wires / strands without damage to steel. Care shall be taken to avoid the possibility of steel coming into contact with the ground.

3.4.5.3 Positioning

a) For Post-Tensioning

Prestressing tendons shall be accurately located and maintained in position, both vertically and horizontally, as per drawings. Tendons shall be so arranged that they have a smooth profile without sudden bends or kinks.

The positioning of Prestressed cables shall be such as to facilitate easy placement and vibration of concrete in between the tendons. High-capacity tendon shall be used to reduce the number of cables thereby eliminating the necessity of grouping. The selected profiles of the tendons shall be such that their anchorages are not located in the top deck surface. Where two or more rows of cables have to be used, the cables shall be vertically in line to enable easy flow of concrete. The clear vertical and horizontal distances between any two cables shall in no case be less than 100mm anywhere along the length of the superstructure. Where precast segments are used, the clear distance shall be atleast 150mm.

Sheathing shall be placed in correct position and profile by providing suitable ladders and spacers. Such ladders may be provided at intervals of approximately 1.0m. Sheathing shall be tied rigidly with such ladders / space bars so that they do not get disturbed during concreting.

Sheathing in which the permanent tendon will not be in place during concreting shall have a temporary tendon inserted or shall be stiffened by some other method to be approved by the Engineer. The temporary tendon shall be pulled out before threading the permanent tendon into place by a special threading machine or other contrivance.

Where possible, tendons shall not be placed until immediately prior to stressing. Tendons shall be handled with care to avoid damage or contamination, to either the tendon or the sheathing. Any tendon damaged or contaminated shall be cleaned or replaced.

b) For Pre-Tensioning:

Prestressing steel shall be accurately located and maintained in position, both vertically and horizontally as per drawings.

c) Each anchorage device shall be set square to the line of action of the corresponding prestressing tendon and shall be positioned securely to prevent movement during concreting.

d) The anchorage devices shall be cleaned to the satisfaction of the Engineer prior to the placing of concrete. After concreting, any mortar or concrete which adheres to bearing or wedging surfaces shall be removed immediately.

3.4.5.4 Cutting

Cutting and trimming of wires or strands shall be done by suitable mechanical cutter only. Flame cutting shall not be resorted to in any circumstances.

In post-tensioning the ends of prestressing steel projecting beyond the anchorages, shall be cut after the grout has set.

3.4.5.5 Protection of Prestressing Steel

Prestressing steel shall be continuously protected against corrosion, until grouted. The corrosion protector shall have no deleterious effect on the steel or concrete or on the bond strength of steel to concrete. Grouting shall conform to these specifications or as directed by the Engineer or specified in Contract Specifications.

In the case of external prestressing, steel shall be encased in suitable polyethylene pipes before grouting.

3.4.5.6 Sheathing Joints and Couplings

Joints in sheathing shall, if so, instructed be sealed with a heat shrink tape.

Special attention should be paid to its junction at the anchorage. It should tightly fit on the trumpet end of anchorage and the junction should be sealed, preferably, with heat shrink tape.

The heat shrink tape is supplied in the form of bandage rolls which can be used for all diameters of sheathing ducts. The bandage is coated on the underside with a heat sensitive adhesive so that after heating the bandage material shrinks on the sheathing duct and ensures formation of a leak-proof joint. The heating is affected by means of a soft gas flame.

The sheathing and all joints shall be water tight. Any temporary opening in the sheathing shall be satisfactorily plugged and all joints between sheathing and any other part of the prestressing system shall be effectively sealed to prevent entry of mortar, dust, water or other deleterious matter. Sheathing shall be neatly fitted at joints without internal projection or reduction of diameter.

Enlarged portions of the sheathing at couplings or anchorages shall be of sufficient length to provide for the extension of the tendons.

3.4.5.7 Grout Vents

Grout vents of atleast 20mm diameter shall be provided at both ends of the sheathing and at all valleys and crests along its length. Additional vents with plugs shall also be provided along the length of sheathing such that the spacings of consecutive vents do not exceed 20m. Each of the grout vents shall be provided with a plug or similar device capable of withstanding a pressure of 1.0MPa without the loss of water, air pressure or grout.

3.4.5.8 Anchorages

All bearing surface of the anchorages shall be cleaned prior to concreting and tensioning. Anchor cones, blocks and plates shall be securely positioned and maintained during concreting such that the centre line of the duct passes axially through the anchorage assembly. The anchorages shall be recessed from the concrete surface by a minimum cover of 100mm. After the prestressing operations are

completed and prestressing wire / strands are cut, the surface shall be painted with two coats of epoxy of suitable formulation having a dry film thickness of 80 microns per coat and entire recess shall be filled with concrete or non-shrink / pre-packaged mortar or epoxy concrete.

3.4.6 Tensioning Equipment

3.4.6.1 All tensioning equipment shall be procured from authorized manufacturers only and be approved by the Engineer prior to use. Where hydraulic jacks are used, they shall be power driven unless otherwise approved by the Engineer. The tensioning equipment shall satisfy the following requirements:

i) The means of attachments of the prestressing steel to the jack or any other tensioning apparatus shall be safe and secure.

ii) Where two or more wires / strands constitute a tendon, a single multi-pull stressing jack shall be used which is capable of tensioning simultaneously all the wires / strands of the tendon. Suitable facilities for handling and attaching the multi-pull Jack to the tendons shall be provided.

iii) The tensioning equipment shall be such that it can apply controlled total force gradually on the concrete without inducing dangerous secondary stresses in steel, anchorage or concrete; and

iv) Means shall be provided for direct measurement of the force by use of dynamometers or pressure gauges fitted in the hydraulic system itself to determine the pressure in the jacks. Facilities shall also be provided for the linear measurement of the extension of prestressing steel to the nearest mm and of any slip of the gripping devices at transfer.

3.4.6.2 All dynamo meters and pressure gauges including a master gauge shall be calibrated by an approved laboratory immediately prior to use and then at intervals not exceeding 3 months and the true force determined from the calibration curve.

3.4.6.3 Pressure gauges shall be concentric scale type gauges accurate to within two per cent of their full capacity. The minimum nominal size of gauge shall be 100 mm. The gauge shall be so selected that when the tendon is stressed to 75 per cent of its breaking load, the gauge is reading between 50 per cent and 80 per cent of its full capacity.

Suitable safety devices shall be fitted to protect pressure gauges against sudden release of pressure.

3.4.6.4 Provision shall be made for the attachment of the master gauge to be used as a check whenever requested for by the Engineer.

3.4.7 Post Tensioning Procedure

3.4.7.1 Tensioning force shall be applied in gradual and steady steps and carried out in such a manner that the applied tensions and elongations can be measured at all

times. The sequence of stressing, applied tensions and elongations shall be in accordance with the approved drawing or as directed by the Engineer.

3.4.7.2 It shall be ensured that in no case, the load is applied to the concrete before it attains the strength specified on the drawing or as stipulated by the prestressing system supplier, whichever is more.

3.4.7.3 After prestressing steel has been anchored, the force exerted by the tensioning equipment shall be decreased gradually and steadily so as to avoid shock to the prestressing steel or anchorage.

The tensioning force applied to any tendon shall be determined by direct reading of the pressure gauges or dynamo meters and by comparison of the measured elongation with the calculated elongation. The calculated elongation shall be invariably adjusted with respect to the modulus of elasticity of steel for the particular lot as given by the manufacturer.

3.4.7.4 The difference between calculated and observed tension and elongation during prestressing operations shall be regulated as follows:

a) If the calculated elongation is reached before the specified gauge pressure is obtained, continue tensioning till attaining the specified gauge pressure, provided the elongation does not exceed 1.05 times the calculated elongation. If 1.05 times the calculated elongation is reached before the specified gauge pressure is attained, stop stressing and inform the Engineer.

b) If the calculated elongation has not been reached at the specified gauge pressure, continue tensioning by intervals of 5 kg/sq.cm until the calculated elongation is reached provided the gauge pressure does not exceed 1.05 times the specified gauge pressure.

c) If the elongation at 1.05 times the specified gauge pressure is less than 0.95 times the calculated elongation, the following measure must be taken, in succession, to determine the cause of this lack of discrepancy:

i) Check the correct functioning of the jack, pump and leads.

ii) De-tension the cable. Slide it in its duct to check that it is not blocked by mortar which has entered through holes in the sheath. Re tension the cable if free.

iii) Re-establish the modulus of elasticity of steel for the particular lot from an approved laboratory.

d) If the required elongation is still not obtained, further finishing operations such as cutting or sealing, should not be undertaken without the approval of the Engineer.

e) When stressing from one end only, the slip at the end remote from the jack shall be accurately measured and an appropriate allowance made in the measured extension at the jacking end.

f) A complete record of prestressing operations along with elongation and jack pressure data shall be maintained in the prescribed format. The number of stages of

prestressing and grouting shall be reduced to a minimum, preferably 2 in the case of simply supported girders.

3.4.7.5 Grouting of Prestressed Tendons

Grouting shall conform to provisions in **Annexure 3.2.**A record of grouting operations shall be maintained in a format given by Engineer.

3.4.8 Pre-tensioning Process

a) General

The planning and construction aspects of the tensioning bed, tensioning bench, abutments at location of anchorage, steam curing system, form work of the concrete elements and arrangements for demoulding, lifting, stacking and transportation of the pre-tensioned concrete elements are all specified items and shall be entrusted to engineers specifically experienced in this type of work.

The Contractor shall submit method of tensioning the tendons including the arrangement and layout of prestressing cables and all tensile deflection points to the Engineer for approval before manufacture commences.

b) Stressing Bed for pre-tensioning

i) The abutments and bed for pre-tensioning of tendons shall be designed to withstand the total tensioning force.

ii) A notice shall be displayed adjacent to the stressing bed showing the maximum tensioning force permitted.

iii) Where concrete elements are cast and Prestressed individually, the stressing bench or moulds shall be rigid enough to sustain the reaction of the prestressing force without distortion.

iv) In the long line method of prestressing, sufficient locator plates should be distributed throughout the length of the bed to ensure that the wires are maintained in their proper position during concreting. The moulds shall be free to slide in the direction of their length and thus permit the transfer of the prestressing force to all the concrete elements along the whole line.

v) Sufficient space shall be left in between the ends of concrete elements to permit access for cutting the strands / wires after transfer. Hold downs or deflectors shall be used for holding or deflecting the tendons in required position firmly. Deflectors which are in contact with the tendon shall have a diameter not less than the tendon or 15mm, whichever is greater.

vi) The tensioning force required to be applied as specified on the drawings shall be the force remaining in the strands / wires after all strands / wires have been anchored to the abutments of the stressing bed and after the anchorage slip has already taken place. The tensioning force shall be determined by direct reading of the pressure gauges or dynamo meters and by the measured elongation after slip.

vii) The Contractor shall carry out trial stressing operations to establish the frictional resistance offered by the hold downs and the slip during anchoring.

viii) Where sheathing of pre-tensioned tendons is required to prevent bond over a specified length, it shall consist of plastic tubing or other material approved by the Engineer and shall be of a quality, diameter and thickness such that bond shall be effectively prevented. The tubing shall be fastened to the tendon in such a manner that cement mortar cannot enter. The Engineer may order that the pull-in of the tendon be measured during the transfer of prestress.

ix) The Contractor shall also submit calculations showing that the hold downs and deflectors have been designed and constructed to withstand concentrated loads resulting from the application of the tensioning force.

c) Tensioning procedure

i) The tensioning of the wires and strands shall be done not too much in advance of concreting.

ii) The tensioning force shall be applied gradually and uniformly.

iii) In order to remove slack and to lift tendons off the bed floor, an initial force approved by the Engineer shall be applied to the tendons. Allowance shall be made for this force in calculating the required elongation.

iv) Tendons shall be marked for measurement of elongation after the initial force has been applied. When required by the Engineer, tendons shall be marked at both the jacking end and dead end of the stressing bed and at couplers if used so that slip and draw-in may be measured.

v) Where deflected strands have been specified, the Engineer may direct the elongation or strain gauge measurements be taken at various positions along the tendon to determine the force in the tendon at those positions.

d) Transfer of Prestress

While the process of tensioning can be accomplished by means of hydraulic jacks, some positive mechanical means shall be provided to maintain the tension during the entire period between the tensioning of the wires / strands and transfer of the prestressing force to the concrete element.

Transfer of prestress shall not proceed until the Engineer has approved the proposed method. Tendons and deflection devices shall be released in such a pre-determined order that unacceptable tensile stresses are not induced in the concrete.

Prior to transfer of the force to the units, all wire tendons shall be tested for tightness and any loose tendon shall be reported to the Engineer who will decide whether the units affected shall be rejected.

The Engineer may require that tendons be marked at each end of any unit to allow measurement of the pull in of the concrete.

Tendons shall be released gradually and preferably simultaneously.

e) Cutting of wires Precautions to be taken

Under no circumstances shall tendons / wire be cut while under tension.

On completion of the transfer of prestress, the projecting lengths of tendon shall be cut off flush with the end surface of the unit, unless otherwise shown, by a method approved by the Engineer.

In no case shall the transfer of prestressing force to the concrete elements take place before concrete attains the strength specified in the drawings. To determine the specified strength, additional cube testing shall be undertaken at the Contractor's cost. In case steam curing is employed, the cubes shall be placed in the same environment as the concrete elements to obtain an accurate assessment of concrete strength at the time of transfer.

The sequence of transfer of prestressing force shall be done strictly as indicated in the drawings and ensuring that eccentricities of the prestressing force in the vertical and horizontal directions of the concrete elements is a minimum during the entire sequence.

The maximum slip of any tendon during transfer shall not exceed 3mm at any end of the concrete element. In case this slip is exceeded, the concrete element in question shall be rejected.

f) Protection of Ends

The exposed ends of the tendons and the concrete surfaces of the ends of the units shall be wire brushed clean of all rust, loose mortar, grease and dirt.

The exposed ends of the tendons and concrete surface within 50mm of tendons shall be then abraded to provide a clean sound surface. An epoxy tar paint suitably formulated to give a dry film thickness of 80 microns per coat shall then be immediately applied over the ends of the tendons unless otherwise directed.

A second coat of paint shall be applied prior to the drying out of the first coat.

3.4.9 Safety Precautions during Tensioning

These are applicable for both pre-tensioning and post tensioning operations.

i) Care shall be taken during tensioning to ensure the safety of all persons in the vicinity.

ii) Jacks shall be secured in such a manner that they will be held in position, should they lose their grip on the tendons.

iii) No person shall be allowed to stand behind the jacks or close to the line of the tendons while tensioning is in progress.

iv) The operations of the jacks and the measurement of the elongation and associated operations shall be carried out in such a manner and from such a position that the safety of all concerned is ensured.

v) A safety barrier shall be provided at both ends to prevent any tendon, which might become loose from recoiling unchecked.

vi) During actual tensioning operation, warning sign shall be displayed at both ends of the tendon. No person shall stand behind in line with jacks while tendon / wire are being stressed.

vii) After prestressing, concrete shall neither be drilled nor any portion cut nor chipped away nor disturbed, without express approval of the Engineer.

viii) No welding shall be permitted on or near tendons nor shall any heat be applied to tendons. Any tendon which has been affected by welding, weld spatter or heat shall be rejected.

3.4.10 Transportation and Storage of Units

Precast girders or elements shall be transported in an upright position. Points of support and the direction of reactions with respect to the girder shall approximately be the same during transportation, and storage as when the girder is placed in final position.

When members are to be stacked, they shall be firmly supported at such bearing positions as will ensure that the stresses induced in them are always less than the permissible design stresses. Further, inclined side supports shall be provided at the ends and along the length of a precast girder to prevent lateral movements or instability.

Care shall be taken during storage, hoisting and handling of the precast units to prevent their cracking or being otherwise damaged. Units worked or damaged by improper storing or handling or transport shall be replaced by the Contractor at his expense.

3.4.11 Tolerances

Permissible tolerances for positional deviation of prestressing tendons shall be limited to the following:

a) Variation from the specified horizontal profile:5 mm
b) Variation from the specified vertical profile:5 mm
c) Variation from the specified position in member:5 mm

3.4.12 Measurements for Payment

a)Prestressed Concrete shall be measured in cubic metres unless otherwise specified. The volume occupied by mild steel reinforcement / HYSD bars, high tensile steel, sheathing and anchorages shall not be deducted.

b)High tensile (prestressing) steel shall be paid for separately and its length shall be measured as actually incorporated in the finished work as per drawing. From the length so measured its weight shall be calculated in tonnes on theoretical basis and paid for.

c)Anchorage devices, additional length of cables for attaching jack, ducts or sheathing, grout, Non-Prestressed steel reinforcement fixed to the anchorage devices, making of recesses and filling the same protection by painting with epoxy and furnishing samples for testing shall all be deemed to be included in the item of high tensile steel and shall not be measured separately.

Annexure 3.1

SPECIFICATION FOR CONSTRUCTION JOINTS

(Based on Appendix 1700/1 of MORTH Specifications for Roads and Bridges)

Location

The construction joints shall be located as shown in the drawings and/ or as specified by the engineer. When not shown in drawing, the following guidelines shall be followed for locating them:

i) Construction joist shall be provided in non-aggressive zones and on non-splash zones. If not feasible, joints shall be sealed.

ii) Location of joints should be easily accessible for preparation and concreting. e.g., where the cross section is relatively small and where there is no congestion of reinforcement.

iii) Joints should not be near support in beams and slabs. Construction joints between ribs and slabs should be avoided in composite construction.

iv) Soffit and webs of box girders should preferably cast without any construction joint between.

v) Locations of construction should be such as to minimize the effects of discontinuity on durability of structure and on appearance of structure are minimized.

Preparation of Surface of the Joint

All laitance shall be removed. The surface shall be roughened without dislodging the coarse aggregates of the set concrete. If the concrete has partially hardened, it shall be brushed with a stiff wire brush or stiff air jet followed by air jet immediately. Fully hardened concrete shall be roughened with mechanical hand tools or grit blasting, taking care not to split or crack the aggregate particles.

Surface shall be thoroughly cleaned, preferably with air jet to remove all accumulated particles and dust before further concrete is cast. If any delay is expected before placing next layer of concrete, all protruding reinforcement shall be protected (preferably with a cement wash). Before next concreting is done, all rust, loose mortar/ particles and any other contamination of the reinforcement shall be removed thoroughly. In aggressive environment, the concrete shall be cut back so as to expose the rods for about 50mmlength and all contaminated concrete around is removed.

Concreting of Joints

Old surface after cleaning shall be soaked with water as directed by Engineer. Any standing water shall be removed just before laying fresh concreting. Further concreting shall be well compacted and carried out continuously upto next construction joint.

Stopping boards shall be fixed in advance for vertical construction joints at predetermined positions and properly stayed. Concreting shall be done continuously upto the board.

Surface retarders can be used for improving quality of joint, if so desired with approval of Engineer, but at no extra cost.

Annexure 3.2

GROUTING POST TENSIONED CABLES IN PRESTRESSED CONCRETE

(Extracts from Appendix 1800 Specifications for Roads and Bridges of MORTH)

1. Materials

Cement - Ordinary Portland cement shall be used for preparing the grout. It shall be as fresh as possible and be free from any lumps.

Water - Only clean potable water free from any impurities and conforming to clause 4.3 of IRS: Concrete Bridge Code and with chloride content not exceeding 500 mg per litre shall be used.

2. Equipment

Equipments as detailed below shall be used or be available at site.

Grout Agitator- A grout agitator shall be used for preparation of the mortar in order to ensure its homogeneity. The grout shall be continuously agitated in a suitable mixer with a minimum speed of 1000 RPM and travel of discharge not exceeding 15 m per second.

Grout Pump - The pump used for grouting should be a positive displacement type and capable of injecting the grout in a continuous operation (and not by way of pulses). The grout pump shall be fitted with a pressure gauge for enabling pressure of grouting to be controlled. Minimum pressure of grouting shall be 0.3 MPA. The pump shall have a relief arrangement for bypassing when the grout pressure builds up to 1 MPA. Capacity of the grout pump shall be such as to forward speed of 5 to 10 metres per second. Slower rate is preferable for avoiding occurrence of voids.

If the capacity of grout pump is large, it is usual to grout two or more cables simultaneously using a common manifold.

Use of hand pump for grouting or use of compressed air operated equipment for grouting is strictly prohibited. They are likely to result in some air entrapment in the duct.

Water pump- Before commencement of grouting, a direct feed high pressure water pump should available at site as a standby. Adequate storage of clean potable water also should be available for use in the pump. In case of any problem in or during grouting operations, this pump shall be directly connected to the duct and all grout shall be flushed out by use of high-pressure water flushing.

Grout Screens- The grouting equipment should include a screen having mesh size of 100 µm (150 µm if sand is used). The grout shall be passed through this screen before being introduced into the grout pump. The screen should be easily accessible for inspection and cleaning.

3. Properties of Grout

i) Water cement ratio of the grout should be as low as possible consistent with the workability required. It should not exceed 0.45

ii) Before grouting the strength of the grout should be ascertained through laboratory tests ant it should be done for each job separately.

Cubes cast shall be moist cured for 24 hrs. and subsequently in water. The compressive strength on 100 mm cubes should not be less than specified.

4. Mixing of Grout

i) Mixing shall be done by measurement of materials by eight. Proportion of materials shall be based on field trials, but within limits specified above.

ii) Water shall be poured into the mixer, followed by cement, keeping the mix stirred. Approved admixture may be added with the Engineer's approval.

iii) Mixing shall be done for 2 to 3 minutes, depending on type of mixer. It should, however, be such as to obtain a uniform and thoroughly blended grout and not subjected to excessive rise of temperature or loss of expansive properties of the admixtures. Grout should be continuously kept agitated till it is injected.

iv) No water shall be added to the grout after it is mixed, for purpose of increasing fluidity.

v) Hand mixing is not permitted

5. Grouting Operation

i) Grouting should be carried out preferably within four hours of stressing the tendon /cables. Whenever this condition cannot be complied with due to unavoidable circumstances, adequate temporary protection of the cable against corrosion by methods or products, which will not impair the adherence properties of the injected grout, with the approval of the Engineer.

ii) The ends of anchorage shall be sealed in order to prevent ingress of moisture/ water and is desirable in all cases. Such sealing is mandatory in structures cast in regressive environment.

iii) Ducts shall be flushed with water before grouting, in order to clean the duct as well as keeping it wet for receiving the grout. Water should be of same quality as used for grouting. It may. However, contain upto about 1 % of slake lime or quick lime.

iv) The water should be blown out with use of oil free compressed air.

v) The connection between the nozzles of the injection pipe should be tight and such that no air can be sucked in. All vent openings should be kept open prior to commencement of injection of grout, unless some other sequence is specified by designers.

vi) All air in the pump and hose should be expelled before commencement of grouting. The junction circuit of the pump should be air tight.

6. Injection of Grout

i) After mixing, the grout should be kept in continuous motion/ movement.

ii) Injection of grout should be continuous and should not be interrupted.

iii) The method of injection used should ensure complete filling of the voids with no voids or air entrained. Volume of the annular space to be filled should be compared with the actual quantity of grout injected actually.

iv) Grouting shall be started initially with a low pressure of injection of 0.3 MPA and increased until the grout comes out at the other end. Grout should be allowed to flow freely at the other end till the consistency of the exiting grout is the same as that at injecting end. When such grout flows at the end, should be closed off and build up of pressure commenced. Full injection pressure of about 0.5 MPA shall be maintained for at least one minute before closing the injection pipe. If the build up pressure exceeds 1 Mpa and still the grout is not flowing at the other end, the grouting operation shall be stopped and the entire duct flushed with high pressure water. The duct should be examined for any blockage and seizure of cable by moving the cable up and down, and defect remedied before recommencing.

v) Grout should be used up within 30 minutes of mixing and any grout not used within 30 minutes shall be rejected.

Chapter - 4
Bridge Works - Super Structure (Steel)

4.1 GENERAL

4.1.1 Coverage

All steel work, whether in fabrication or in erection, shall be done in accordance with the relevant Codes of Practice, Indian Railway Standard Specification serial No. B1-2001 with latest correction slips and Standard Specifications, subject to any further provisions contained in this chapter. These specifications are equally applicable to steel structures in buildings and sheds except where specified otherwise. In the event of any of these provisions being at variance with the standard IRS specifications, the latter shall prevail unless otherwise specified by the Engineer or in Drawings.

4.1.2 Weight for Payment

(a) Weight for payment for steel work shall be based only on the theoretical weight of main components and gusset plates, without any additional weight on account of rivets, bolts, welds etc. unless specifically specified otherwise in the description of an item of Bill(s) of Quantity.

(b) In calculating the weight of the finished work, the overall lengths of the members used in the fabrication (i.e. as measured square) shall be taken into account and no deduction shall be made for rivet or bolt holes, skew cuts, notches etc. Gussets shall be measured as per the dimensions of the smallest enveloping rectangles.

(c) In case of composite work (welding and HSFG bolts), only HSFG bolts shall be paid in addition.

(d) Holding down bolts, nuts and washers as well as anchor channels or plates, shall be measured separately.

(e) Materials, used temporarily for assembly and erection but not forming part of the permanent work, shall not be payable.

4.2 MATERIALS

4.2.1 General requirements

General requirements relating to the supply of material shall conform to IS:1387, for the purpose of which the supplier shall be the Contractor and the purchaser shall be the Engineer.

Mild steel shall be to IS:2062 and HTS to IS:961 unless otherwise specified. In case of imported material, Steel work Specifications of the country of origin or equivalent IS Specifications shall be as indicated in the Contract or by the Engineer.

Finished rolled material shall be free from cracks, flaws, injurious seams, laps, blisters, ragged and imperfect edges and other defects. It shall have a smooth and uniform finish, and shall be straightened in the mill before shipment. They shall also be free from loose mill scale, rust, pitting or other defects affecting its strength and durability.

The acceptance of any material on inspection at the mill i.e. rolling mills, foundry or fabricating plant where material for the work is manufactured, shall not be a bar to its subsequent rejection, if found defective. Unless specified otherwise, high tensile steel rivet conforming to IS:1149 shall be used for members of high tensile steel conforming to IS:961 and shall not be used for mild steel members. Unless specified otherwise, bolted connection of structural joints using high tensile friction grip bolts shall comply with requirements of IS:4000. Cast iron shall not be used in any portion of the bridge structure, except where it is subject to direct compression and as shown in the drawings.

4.2.2 Standards Applicable

4.2.2.1 All materials shall conform to requirements of respective IS Codes and IRS Specifications listed below. Special requirements are given below:

Steel for bolts and nuts shall conform to IS:2062 and IS:1148 but have a minimum tensile strength of 44 kg/sq.mm and minimum percentage elongation of 14. High tensile steel for bolts and nuts shall conform to IS:961 and IS:1149 but with a minimum tensile strength of 58 kg/sq.mm. High strength friction grip bolts as per RDSO report No. BS-111 shall be permitted for use only on satisfactory evidence of performance to the requirements (not covered by these specifications) specified by the Engineer or included in the special provisions of the Contract.

4.2.2.2 For cast steel, the yield stress shall be determined and shall not be less than 50 per cent of the minimum tensile strength.

4.2.2.3 Plain washers shall be of steel. Tapered or other specially shaped washers shall be of steel or malleable cast iron.

4.2.2.4 Parallel barrel drifts shall have a tensile strength not less than 55 kg/ sq.mm. With elongation of not less than 20 per cent measured on a gauge length of 4 So (So = cross sectional area in sq.mm).

4.2.2.5 Materials for castings and forgings, fasteners and welding consumables shall be as per relevant IS code.

4.2.3 Use of Corrosion Resistant steel

In aggressive environment, corrosion resistant steel can be used. These are low-alloy steels containing a total of 1% to 2% alloys, in particular, copper, chromium, nickel and phosphorous.

4.2.4 Paints

All materials for paints and enamels shall conform to the requirements specified on the drawings or other special provisions laid down by the Engineer. Relevant Chapter of Specification on painting deals with Painting including of steel work and may also be referred to.

4.3 FABRICATION OF STEEL WORK

4.3.1 Codes of Specifications: The work shall be done in accordance with the following codes and specifications and any other requirements that may be prescribed in special cases.

(a) Bridge Work

1. IRS Steel Bridge Code
2. IRS Specification Serial No. B1-2001 for Steel Girder Bridges
3. IRS Specification No. M 3-Class I, II, III and IV Steel forgings, blooms for forgings and billets for re-rolling
4. IRS Specification No. M-28: IRS specification for classification, testing and acceptance criteria of manual Metal arc welding electrodes and gas welding rods.
5. IRS Specification No M-39: IRS specification for classification, testing and acceptance criteria of fire and flux for submerged arc welding of structural steel for use on Indian Railways.
6. IRS Specification No M-41 Corrosion resistance steel
7. IRS Specification No M-42 High strength low alloy structural steel with enhanced corrosion resistance.
8. IRS Specification No M-49 High strength excavating structural steel rivet bars with enhanced corrosion resistance.
9. Epoxy Zinc Phosphate Primer to RDSO Specification No. M&C/PCN/102/2020 or latest
10. Epoxy Based Micaceous Iron Oxide (MIO) to RDSO Specification. No. M&C/PCN/103/2020 or latest
11. High performance Anti-Corrosion Epoxy coating (Two Pack) conforming to RDSO Specification No. M&C/PCN/123/2018 or latest
12. Poly urethane based Aluminium finish paint to RDSO specification no. M&C/PCN/110/2020 or latest
13. Epoxy Based Coal Tar Paint (Two Pack) to RDSO specification No. M&C/PCN/105/2020 or latest
14. Fluoropolymer (Fluoroethylene / Vinyl ether co-polymer (FEVE) conforming to Japanese Industrial standard JIS K 5659:2008 (Long durable paints for steel structures).
15. Specification for Hot Dip Galvanizing on Structural steel and other allied products conforming to IS: 4759 and IS: 2629.
16. IS: 104 -Specification for Ready Mixed Paint, Brushing, Zinc Chrome Priming.
17. IS: 2074 -Ready Mixed Paint, Air Drying, Red Oxide Zinc Chrome Priming.
18. IS: 2339 –Specification for Aluminum Paint for General Purposes in Dual Container.
19. IS: 5666 - Specification for Etch (Pretreatment) Primer.
20. IS: 77- Specification for Linseed Oil, Boiled for Paints.
21. Grade SS 304 for stainless steel tubes, sheets, strips etc.
22. Grade 316L for stainless steel structural members

23. IS:1367 &IS:4000 for HSFG Bolts

The fabrication and erection of the steel work shall be in accordance with IRS Specification Serial No. B1-2001 supplemented by relevant provisions of this Specifications.

(b) Iron and steel tanks and staging: IRS Specification No. B-3-61 Part 4

4.3.2 Quality of Steel: The steel used for fabrication work shall conform to the appropriate quality as per latest amended standards specified below, unless the use of any other quality of steel is specially approved.

i) IS 2062: (Standard quality): For non-welded structures subjected to dynamic loading and for welded non-dynamically loaded structures, if the thickness of material welded does not exceed 20mm.

ii) IS:2062 (Fusion welding quality) - For all welded structures for which IS:2062 (Standard Quality) is not suitable.

iii) IS:2062 (Ordinary quality)

(a) Grade ST 44-0: For non-welded structures not subjected to dynamic loading other than wind (e.g. sheds, buildings, foot over bridges) except structures designed according to plastic theory.

(b) Grade ST-32-0: For general purposes where the load carried is not the main consideration (e.g. grills, railings)

4.3.3 Straightening of members: All members used shall be straight except those meant to be curved and any straightening necessary shall be carried out before the material is worked upon. The straightening shall be done by pressure and no heating resorted to except with the prior approval of the Engineer and with such safeguards as considered by him to be necessary.

4.3.4 Cutting of Steel

Cutting of steel for fabrication may be done by shearing, sawing or by gas. For less important works the Engineer may permit the use of chisels and Jim crows also. Gas cutting for important works shall preferably be done by mechanically controlled torches. Cut edges shall be machined where so specified. If machining is not specified, hand flame cut, chisel cut and Jim crowed edges shall be ground smooth where so directed by the Engineer. Para 17 of IRS Specification Serial No. B1-2001 may also be referred to in this connection.

4.3.5 Making of Holes

a) In all important works and in splices, the holes for rivets or bolts shall either be drilled to the correct sizes or sub-punched initially to a diameter 6mm less than the finished diameter and reamered subsequently to the correct sizes as indicated in Para 18 of IRS Specification Serial No. B1-2001. Sub-punching is, however, not permissible in the main truss members of open-web bridge girders.

b) Forming of holes by gas-cutting is strictly forbidden.

c) Holes for rivets and black- bolts shall be 1.5mm (1/16 inch) larger in diameter than the rivet bar or the bolt, and care shall be taken not to exceed this limit. In the case of turned bolts the holes shall be drilled to such tolerances as laid down in Para 18.5 of IRS Specification Serial No. B1-2001Specification for Steel girder Bridges and Locomotive turn-tables.

d) Marking and drilling of holes in members, especially for the end connections, shall preferably be done with the use of templates. Holes in rolled sections shall follow the standard gauge lines unless otherwise indicated in the drawings.

4.3.6 Riveting

a) Unless otherwise specified, the size of the rivet shall be designated by the diameter of the rivet bar and not that of the hole or the finished rivet. Rivets and Rivetting shall be in accordance with Para 23 of IRS Specification Serial No. B1-2001 supplemented by following specifications.

b) The rivet shank shall be of length just sufficient to fill the hole thoroughly and to form a full head of the standard proportions as shown below. Generally, the sizes in the Table at **Annexure 4.1** shall be found sufficient.

c) Rivets shall completely fill the holes and shall be machine driven, unless otherwise permitted by the Engineer under special circumstances. Riveting shall be done by means of pressure or percussion riveters of approved design. Hand riveting shall not be resorted to except with the prior approval of the Engineer. The rivets shall be at the proper heat and in no case shall the tip be hotter than the head. Rivets less than 10mm (or 3/8 in.) in diameter may be driven cold.

d) Before riveting is commenced, the work shall be kept tightly bolted together. Special care shall be taken to retighten the bolts frequently as the riveting proceeds.

e) Driven rivets, when struck sharply on the head with a 110 g (1/4 lb) rivet testing hammer, shall be free from movement and vibration. All loose and burnt rivets and those with cracked badly formed, eccentric or deficient heads shall be cut out and replaced. While cutting out rivets care shall be taken not to damage the surrounding metal and not to disturb adjoining rivets. Recouping and caulking shall in no circumstance be resorted to.

4.3.7 Welding

a)In the case of welded fabrication, the following directions shall be observed in addition to the provisions of the IRS welded Bridge Code.

i) Shop welding shall be adopted wherever possible in fabricating components and sub members for welding shall be done by submerged Arc Welding.

ii) Suitable jigs and fixtures shall be used, both in the field and in the shop, to avoid distortion during welding, and in the case of plated construction, to control distortions within the same limits as applicable to corresponding rolled sections.

iii) Components which are mass fabricated in the shops should be proved in master templates.

b) Unless specified otherwise, the lowest classes of electrodes to be used for different types of welding work shall be as given in **Table 4.1 (a**) under, based on IRS Specification No.M.28-2020 for the classification.

Table 4.1 (a) Classification of Electrodes as per their application

IRS Class	Purpose of use	IS Specification	IS/AWS Code*
A1	Fabrication of component meant for static application made of steels to IS: 2062-2016 Gr. E250 Quality A, IS:1875-2014 Class I & IA or equivalent. Suitable for joining steel sheets to IS: 513-2013, IS: 1079-2017 & Gr. Fe 330 to IS: 5986-2017 or equivalent and for repair welding of cast steels to IS: 1030-2012 Gr. 200-400W. This electrode can also be used for welding where strength requirement is not specified.	IS: 814-2004 (R2016)	ER4112 (Medium coated)
A2	Fabrication of component meant for semi-dynamic application such as bridges etc., made of steel to IS: 2062-2016 Gr. E250 Quality BR&B0, IS: 1875-2014 Class I & IA or similar. The weld deposit shall be of radiographic quality	IS: 814-2004 (R2016)	ER4211X (Medium coated)
A3	Fabrication of component meant for highly dynamic application made of steels to IS: 2062-2016Gr.E250 quality C or for other applications where low temperature impact property is required. The weld deposit shall be of radiographic quality.	IS: 814-2004 (R2016)	EB5326H2X (Heavy coated)
A4	Application same as A3 above with high deposition efficiency	IS: 814-2004 (R2016)	EB5326H2JX (Heavy coated)
A5	For pipe welding or other applications where high penetration of arc is needed.	IS: 814-2004 (R2016)	EC4316X (Medium coated)
B1	Fabrication of component made of steels to IS: 2062-2016Gr.E300 & E350 all quality, IS: 2002-2009 Gr. 1 & 2, IS: 1875-2014 Class 2, 2A and 3 or similar. Also suitable for repair welding of cast steels to IS: 1030-2012 Gr. 230-450W. The weld deposit shall be of radiographic quality. Also for joining of stainless steels type 3Cr12, IRS M-44 or its equivalent with mild steel/ low alloyed steel/ Corten steel.	IS: 814-2004 (R2016)	EB5426H3X (Heavy Coated)

B2	Application same as B1above with high deposition efficiency	IS: 814-2004 (R2016)	EB5426H3JX (Heavy coated)
B3	Fabrications of components made of steels to ASTM 516 Gr.70 or equivalent where low temperature (at -46°C) impact properties are required. The weld deposit shall be of radiographic quality.	IS:1395-2013	E55BC126 (Heavy coated)
B4	Application same as B3 above with high deposition efficiency	IS:1395-2013	E55BC126J (Heavy coated)
C1	Fabrication of component made of steels to IS: 2062-16 Gr.E410, E450, IS:2002-2009 Gr. 3, IS: 1875-2014 Class 3A or similar. The weld deposit shall be of radiographic quality.	IS:1395-2013	E63BD126 (Heavy coated)
C2	Application same as C1 above with high deposition efficiency	IS:1395-2013	E63BD126J (Heavy coated)
D	For joining weathering steels conforming to IRS M-41 or M-42 with same steel or steels to IS: 2062-2016, IS: 2002-2009 & IS: 1875-2014 as mentioned above. This can also be used for combination joint of IRS M-44 & IRS M-41 and IRS M-41 & M-42. The weld deposit shall be of radiographic quality.	AWS A5.5/5.5M:2014	E8018W2 (Heavy coated)
E1	For fabrication & repairing of Buckles, Gear cases, Protector Tubes, Door Patches, Side panels, End wall patches etc. of Rolling stock & locomotives. The electrode shall be low heat input type** with 350mm length.	IS: 814-2004 (R2016)	ER4211X (Medium coated)
E2	For repair welding of bogies, both cast and fabricated. The electrode shall be low heat input type** with 350mm length.	IS:1395-2013	E55BG1Ni26 (Heavy coated)

Note: In any strength weld, the first run shall not ordinarily be deposited with an electrode of gauge larger than 8 S.W.G. For subsequent runs the electrode shall not be increased by more than two sizes between consecutive runs.

4.3.8 Shop Painting

a) Fabricated steel work shall not be painted over except to the extent specified in Sub-Para (b) below until it has been inspected and passed by the Engineer or his representative and any defect, pointed out by him has been rectified. Till then, all rivet heads and weld metal shall be protected by coating with clean boiled linseed oil conforming to IS: 77.

b) All surfaces which shall be in permanent contact and any others which will not be accessible for painting later on, shall be cleaned thoroughly and given One coat of Ready Mixed Paint, Zinc Chrome Primer conforming to IS: 104 followed by one coat of Ready Mixed Paint, Red Oxide Zinc Chrome Primer conforming to IS: 2074 or other

approved composition in the prescribed number of coats immediately prior to assembly, and for this no extra payment shall be admissible

c) In case of riveted structures, the splice locations and inaccessible locations are to be painted with one coat of Ready Mixed Paint, Zinc Chrome Primer conforming to IS: 104 followed by one coat of Ready Mixed Paint, Red Oxide Zinc Chrome Primer conforming to IS: 2074 followed by one finishing coat of Aluminum Paint confirming to IS: 2339 before dispatch and the 2nd finishing coat of Aluminum Paint confirming to IS: 2339 to be applied before or after erection.

d) In case of HSFG bolted connections, after metallization, girders are to be painted with one coat of Etch primer IS: 5666 followed by one coat of Ready Mixed Paint, Zinc Chrome Primer conforming to IS: 104 followed by one coat of 1st finishing coat of Aluminum Paint except at Joining faces of splice locations where only metalizing to be done but no painting to be done. After final assembly and erection at site, the 2nd finishing coat of Aluminum Paint to be applied including splice location.

e) After the steel work has been inspected and passed, painting shall be done as stipulated in Para 39 of IRS Specification Serial No. B1-2001 for the prescribed number of coats, uniformly over the work. Payment for this painting shall be made separately unless it is specifically included in the rate for the fabrication.

f) Further reference is drawn to general provisions detailed in relevant chapter on painting.

4.4 WORKMANSHIP IN STEEL WORK

4.4.1 General

Fabrication - Such work shall be performed only within the plants and by fabricators who have at the tendering stage established, to the satisfaction of the Engineer / Railway, that they have the experience, knowledge, trained man power, quality controls, equipment and other facilities required to produce the steel work to desired quality. Prequalification of the plant and fabricator shall be established either by the submission of detailed written proof or through in plant inspection by the Engineer.

The contractor shall advise the Engineer in writing, atleast 20 calendar days in advance of the actual start of fabrication.

4.4.2 Rolling Margin

The rolling margin in plates, sections and bars shall be in accordance with the relevant Indian Standard and all materials outside these limits shall be liable to rejection.

4.4.3 Interchangeability of Parts

The Contractor shall arrange for corresponding parts of each unit manufactured from the same drawing to be interchangeable as far as economic manufacturing conditions permit and shall advise the Engineer of the precise arrangements made in this respect. There should be level, finished concrete floor of sufficient dimensions in the fabrication yard, on which the fabricator shall precisely set out the outline of the structure (to full

scale) as per drawings for the purpose of preparing templates. Only steel tapes shall be used for all measurements and they shall be held tight and level on the floor while measuring or marking.

4.4.4 Templates

The templates for the work shall be steel bushed in cases where the Engineer may consider necessary. Where actual materials from the work have been used as templates for drilling similar pieces, the Engineer shall decide whether they are fit for use as part of the finished structure.

4.4.5 Steel Tapes

Steel tapes used for marking out the work shall be calibrated at a temperature of 20^{o} C.

4.4.6 Universal Plates and Flats

Where universal plates or flats are used as part of a built-up section and with their edges exposed, such edges shall be true or planed true.

4.4.7 Drilling

a) Rivet and Bolt Holes: No holes shall be punched full size without the permission of Engineer. See also Para 4.3.5.

b) Reamered Holes: All holes for turned bolts shall be reamered in the manufacturer's works.

c) Holes in welded Members: All bolt and rivet holes in members built up by welding shall be drilled after welding has been completed.

d) Removal of Burrs: Holes which are drilled through two or more separable parts shall have all burrs removed after separating the parts.

e) Holes for Countersunk H.S.F.G. Bolts: Holes for countersunk H.S.F.G. bolts shall conform to the proportions for flat countersunk heads with 80^{o} included angle and head diameter approximately twice the diameter of the bolt. The counter sunk shall be truly concentric with the shank holes. Bolt heads shall be dressed flush where necessary for proper construction.

Close Butted Joints

i) Where close butted joints are required, they shall be indicated on the Drawings and the butting ends of the parts shall be machined to ensure close contact when the joint is made.

ii) Close contact shall be deemed to have been achieved when at least 90% of the area is in close contact and the remaining 10% or so also has clearance not exceeding 0.2mm.

4.4.8 Shearing of Plates: Shearing and grinding of steel plates shall not be carried out without the permission of the Engineer.

4.4.9 Notches: The roots of all notches shall be smoothened.

4.4.10 Procedure Trials for Welding and Cutting

Where required by the Engineer, welding and flame cutting trials shall be carried out and completed before fabrication on representative samples of materials to be used in the work, as follows:

a) The samples of materials shall be selected and marked by the Engineer when the materials for the work are inspected at the mills.

b) Trials on material 19mm thick may be taken to include all material under 19mm thick and on material 38mm thick to include material between 19mm and 38mm thick. Over 38mm thickness material shall be tested for every thickness increment of 6mm. The trials of flame cutting shall be carried out on material representative of all thicknesses to be used in the work.

c) The welding and flame cutting trials shall demonstrate workmanship / quality to the satisfaction of the Engineer. The procedures to be adopted shall include:

i) Welding procedure in accordance with IRS welded Bridge Code supplemented by IS:813 (1986).

ii) The heat control techniques required to ensure that the flame cut surfaces of any imported steel like steel to B.S. 4360 Grade WR 50, 50B, WR 50B, 50C and WR 50C are suitable for inclusion in welds.

d) The trials shall include specimen weld details from the actual construction which shall be welded in a manner simulating the most unfavourable instances of fit up and preparation which it is expected will occur in the particular fabrication. After welding, the specimens shall be held as long as possible at room temperature, but in any case, not less than 72 hours, and shall then be sectioned and examined for cracking.

e) Procedure Trials: Testing shall be done as prevalent IS Code or if approved to B.S. 709. The following groups of tests, shall be carried out in accordance with the type of welds.

i) Butt welds: - Transverse tensile test. Transverse and longitudinal bend test with the root of the weld in tension and compression respectively and Charpy V notch impact test.

ii) Fillet welds: Fillet weld fracture test

iii) Tack welds: Inspection for cracking

iv) All welds: Macro examination specimen for each type of weld. Additional tests not included in (i) and (ii) above shall be specified by the Engineer as required. Shop welded joints shall be 100% examined radiographically and with other Non-destructive methods.

4.4.11 Welding Requirements

4.4.11.1Qualification and Testing of Welders as per IS: 7310, IS:7307 and approved WPSS

Only qualified welders will be engaged in the work and they also will be tested for their skill in welding to full satisfaction of the Engineer as directed below.

i) No welding operator shall be employed on the work until he has, in the presence of the Engineer, passed the appropriate tests laid down in relevant codes.

ii) Where plates of 12mm thick and over are to be butt welded the tests. Engineer may specify other tests to be conducted.

iii) Routine re-testing of welding operators may be required every six months if considered necessary by Engineer.

iv) The Engineer can also require any welding operator to be retested at any time during the Contract.

4.4.11.2 Supervision of Welding

i) The Contractor shall appoint welding supervisors whose competence and qualifications shall be subject to approval of the Engineer and all welds shall be carried out under their direction.

ii) Except where agreed by the Engineer, a record shall be kept to enable butt welds to be identified with the welders responsible for the work but material shall not be marked by hard stamping for this purpose.

4.4.11.3 Welding Plant

The welding plant shall be capable of maintaining at the weld, the voltage and current specified by the manufacturer of the electrodes used. The Contractor shall supply instruments for verifying voltage and current as and when required by the Engineer.

4.4.11.4 Welding

Metal Arc welding shall be carried out in accordance with IRS Welded Bridge Code (and if so required with B.S. 5135) and the following additional requirements.

i) The general welding programme for shop and site welds, including particulars of the preparation of fusion faces, pre-heating where required and methods of making welds shall be submitted in writing to the Engineer for approval before the work is put in hand. No deviations shall be made from the welding programme or from the details shown on the Drawings, without the prior approval of the Engineer.

ii) Approval of the welding procedure shall not relieve the Contractor of his responsibility for correct welding and for minimising of distortion in the finished structure.

iii) The procedures for welding and flame cutting established by the procedure trials under Para 4.4.11 shall be strictly followed.

iv) All main butt welds shall have complete penetration and shall comply with the requirements of IRS Welded Bridge Code. They shall be made between prepared fusion faces. Where possible they shall be welded from both sides. The ends of the welds shall have full throat thickness. This shall be obtained on all main welds by the use of extension pieces adequately secured on either side of the main plates. Additional metal remaining after the removal of the extension pieces shall be removed by machining, or by other approved means and the ends and surfaces of the welds shall be smoothly finished.

v) In the fabrication of built-up assemblies all butt welds in the component parts shall be complete before the final assembly.

vi) Pre-heating and temperature conditions, electrodes, and size of single runs shall be as follows:

a) Grades 43A and 43C steel – no welding of these and similar mild steels shall be undertaken where the ambient or plate temperature is 0^{o} C or below.

b) Grades WR 50B and WR 50C Steel - for all welding of steel to Grades 50B and 50 C and similar carbon manganese steels the temperature shall be not less than 10^{o}C when welding is commenced.

vii) Controlled hydrogen electrodes shall be dried out and used in strict accordance with the manufacturer's instructions.

viii) Loose flux used for automatic and semi-automatic welding shall be kept free from contamination and used in accordance with the manufacturer’s instruction.

ix) All tack welds shall be of the same quality and size as the first run of the main weld. The main weld shall fuse completely with the ends of the tack welds to form a regular profile. Where preheat is required for the main welds the tack welds shall be made under the same heat conditions. The length of the tack welds shall not be less than four times the thickness of the thicker part or 50mm whichever is the smaller.

x) The position of welds required for temporary attachments shall be approved by the Engineer before the work starts.

xi) Temporary attachments shall be removed without damage to the parent metal, which shall be finished smooth by grinding in the direction of the applied stress in the finished structure.

xii) All cracked welds shall be cut out to the satisfaction of the Engineer before re-welding.

xiii) Where automatic or semi-automatic welding processes are used, back gouging shall not be required when it is demonstrated to the Engineer that satisfactory welds are produced.

xiv) Where butt welds are to be ground flush, there shall be no loss of parent metal. The final grinding shall be in the direction of the applied stress.

xv) Run – off plates and run-on plates.

a) One pair of “run-on” plates and one pair of “run-off” plates all prepared to the same thickness and profile as the parent metal shall be attached by clamps to the start and finish respectively of all butt welds so that the direction of rolling of the added plates is parallel to that of the parent metal.

b) Except as directed by the Engineer the plates in approximately 1 in 5 pairs of run-off plates shall each be 150mm wide by 200mm long, the length being measured in the rolling direction of the metal and at right angles to the weld.

c) The welds shall run the full length of the joint and extend at full section for a minimum distance of 25mm into the run-off plates.

d) On completion of the welds the 150mm x 200mm run-off plates shall not be removed until they have been marked by the Engineer to identify them with the joints to which they are attached.

e) When removing the run-off and run-on plates by flame cutting the cuts shall not be nearer than 6mm to the sides of the parent metal and remaining metal shall be removed by grinding in the direction of the applied stress or by other method approved by the Engineer.

f) Specimens for test shall be selected from the run-off plates as required by the Engineer.

4.4.12 Welding Inspection

Radiographic or other non-destructive examinations shall be conducted on all main welds carrying tension and on other welds to the satisfaction of Engineer. If required, samples of the welds in permanent or temporary works shall be cut out for examination by the Engineer.

4.4.13 Stress Relieving

If required by the Engineer or specified elsewhere herein or specified on the Drawings, welds shall be stress relieved and special units may require to be normalized.

4.4.14 Flame Cutting

Where the flame cut surface is not subsequently incorporated in a weld, machine flame cutting may be used subject to the following requirements.

i) Grades 43A and 43C steel. All irregularities in the cut face, edges and corners shall be removed by grinding in the direction of the main stress to be carried by the material.

ii) Grades WR 50, 50B, WR 50B, 50C and WR 50C steel: The heat input and cooling condition shall be in accordance with the procedures specified in Clause 13 of B.S. 5135, unless otherwise specified.

4.4.15 Welding of stud shear connectors

The stud shear connectors shall be welded in accordance with the manufacturer’s instructions including preheating. The stud and the surface to which studs are welded

shall be free from scale, moisture, rust and other foreign material. The stud base shall not be painted, galvanised or cadmium plated prior to welding. Welding shall not be carried out when temperature is below 10 degrees Celsius or surface is wet or during periods of strong winds unless the work and the welder are adequately protected. The welds shall be visually free from cracks and shall be capable of developing at least the nominal ultimate strength of studs. The procedural trial for welding the stud shall be carried out when specified by the Engineer.

4.4.16 Tolerances

Tolerances in dimensions of components of fabricated structural steel work shall be specified on the drawings and shall be subject to the approval of the Engineer before fabrication. Unless otherwise specified, all parts of an assembly shall fit together accurately within tolerances specified in **Table 4.2**.

A machined bearing surface, where specified by the Engineer, shall be machined within a deviation of 0.25 mm for surfaces that can be inscribed within a square of side 0.5m.

TABLE 4.2: FABRICATION TOLERANCES

	A. INDIVIDUAL COMPONENTS	
1.	Length	
	a) Member with both ends finished for contact bearing	± 1mm
	b) Individual components of members with end plate connection	+ 0 mm - 2 mm
	c) Other members i) Upto and including 12M ii) Over 12M	 ± 2mm ± 3.5mm
2.	Width	
	a) Width of built-up girders	± 3mm
	b) Deviation in the width of members required to be inserted in other members	+ 0mm - 3mm
3.	Depth	
	Deviation in the depths of solid web and open web girders	+ 3mm -2 mm
4.	Straightness	
	a) Deviation from straightness of columns	L/3000 subject to a maximum of 15mm

		where L is length of member
	i) In elevation	+ 5mm - 0 mm
	ii) In plan	L/1000 subject to a maximum of 10mm
5.	Deviation of centre line of web from centre line of flanges in built-up members at contact surfaces	3mm
6.	Deviation from flatness of plate of webs of built-up members in a length equal to the depth of the member	0.005 d to a maximum of 2mm where d is depth of the member
7.	Tilt of flange of plate girders a) At splices and stiffeners, at supports, at the top flanges of plate girders and at bearings	0.005 b to a maximum of 2mm where b is width of the member
	b) at other places	0.015b to a maximum of 4 mm where b is width of the member
8.	Deviation from squareness of flange to web of columns and box girders	L/1000, where L is nominal length of the diagonal
9.	Deviation from squareness of fixed base plate (not machined) to axis of column. These dimensions shall be measured parallel to the longitudinal axis of the column at points where the outer surfaces of the column sections make contact with the base plate.	D/500 where D is the distance from the column axis to the point under consideration on the base plate
10.	Deviation from squareness of machined ends to axes of columns	D/1000, where D is as defined in 9 above
11	Deviation from squareness of machined ends to axes of beams or girder	D/1000, where D is as defined in 9 above
12	Ends of members abutting at joints through cleats or end plates, permissible deviation from squareness of ends	1/600 of depth of member subject to a maximum of 1.5mm

4.5 ERECTION OF STEEL WORK

4.5.1 Reference Specifications

The erection of steel work for different types of structures shall be done in accordance with the respective Indian Railway standard specifications as listed below.

(a) Bridge work: IRS Specification Serial No. B1-2001 for Erection and Riveting of Bridge Girders.

(b) General Structural Work: IRS Specification No.B2 for Steel Structures (other than Girder Bridges) - Part 3.

(c) Iron and Steel tanks and staging – IRS Specification No.B3- Part 4.

The important provisions of IRS Specification Serial No. B1-2001 (Part 3) which is commonly required to be followed in the field for all steel girders are extracted and given below for ready reference, duly amplified where necessary.

4.5.2 Material Handling

a)The materials, on receipt, shall be carefully unloaded, examined for defects, checked, sorted and stacked securely on a level bed, out of danger from flood or tide and out of contact with water or ground moisture. They shall be supported on timber or concrete plinths so that they do not touch the ground.

b)The materials shall be verified with the marking shown on the marking plan, if any, or with the detailed drawings issued for the work.

c)Any material found damaged or defective shall be stacked separately. The materials should, as far as possible, be inspected before unloading from trucks to ascertain if any damage has occurred in transit. The portions found damaged or defective shall be marked with paint of distinctive colour. Such materials shall be dealt with under orders of the Engineer and without delay. Slightly distorted parts may be straightened by gradual pressure without heating, whereas badly damaged portions may require to be replaced. In exceptional cases, where rectification of badly distorted or broken parts is allowed by the Engineer, it shall be done in such manner and with such safeguards as directed by him. Connection plates, if slightly bent or twisted shall be straightened cold. If bent so sharply as to require heating, the whole plate thus treated shall be annealed before use on work. Engineer at his discretion may have such rectified component tested for its load carrying capacity before use on work.

4.5.3 Preliminary Requirements

i) Before starting the work, the method of erection and the details of the erection equipment proposed to be used shall be got approved by the Engineer, but such approval shall not be considered as relieving the Contractor of his responsibility for safety or for carrying out the work in full accord with the drawings and specifications. All temporary works shall be properly designed and substantially constructed for the loads they would be called upon to sustain, including wind and lateral forces, etc. according to the local conditions.

ii) A careful inspection of plant and tackle shall be made to ensure that they are in good order and well upto the capacity required. When chains or ropes are used for lashing, care must be taken to protect them as well as the members lashed, to avoid damage to either.

iii) Frame and steel skeleton structures shall be carried up true and plumb. Temporary bracings shall be provided, if required, to take care of stresses from erection

equipment or other loads carried during erection and also to ensure lateral stability of structures during the process of erection.

iv) All surfaces which shall be in permanent contact after assembly shall be thoroughly cleaned to remove all paint and mill scale and shall receive, immediately before being assembled one coat of Ready Mixed paint, Zinc Chrome Primer conforming to IS: 104 followed by one coat of Ready Mixed Paint, Red Oxide Zinc Chrome Primer conforming to IS: 2074 or in accordance with relevant Para in Painting Iron Work, with the prescribed number of coats. Care shall be taken to see that any burr or other surface defects are removed before the parts are assembled. Field rivets, welds and bolted connections shall be protected by a coat of clean boiled linseed oil till the work is inspected and passed by the Engineer's representative. After passing, these shall be cleaned and painted with one coat of Ready Mixed Paint, Zinc Chrome Primer conforming to IS: 104 followed by one coat of Ready Mixed Paint, Red Oxide Zinc Chrome Primer conforming to IS:2074, irrespective of whether the final painting of the finished structure is to be done by the Contractor or not.

4.5.4 Assembling Steel

4.5.4.1 The parts shall be accurately assembled as shown on the drawings and match marks shall be followed. The material shall be carefully handled so that no parts will be bent, broken or otherwise damaged.

4.5.4.2 Hammering which will injure or distort the members shall not be done. Bearing surface or surfaces to be in permanent contact shall be cleaned, before the members are assembled. The truss spans shall be erected on blocking, so placed as to give the proper camber. The blocking shall be left in place until the tension chord splices are fully riveted and all other truss connections pinned and bolted. Rivets in splices of butt joints of compression members and rivets in railings shall not be driven until the span has been swung.

4.5.4.3 All joint surfaces for bolted connections including bolts, nuts, washers shall be free from scale, dirt, burrs, other foreign materials and defects that would prevent solid seating of parts. The slope of surface of bolted parts in contact with bolt head and nut shall not exceed 1 in 20, to the plane normal to bolt axis, otherwise suitable tapered washer shall be used.

4.5.4.4 All fasteners shall have a washer under nut or bolt head whichever is turned in tightening. Any connection to be riveted or bolted shall be secured in close contact with service bolts or with a sufficient number of permanent bolts before the rivets are driven or before the connections are finally bolted. Joints shall normally be made by filling not less than 50 per cent of holes with service bolts and barrel drifts in the ratio 4:1. The service bolts are to be fully tightened up as soon as the joint is assembled. Connections to be made by close tolerance or barrel bolts shall be completed as soon as practicable after assembly.

4.5.4.5 Any connection to be site welded shall be securely held in position by approved methods to ensure accurate alignment, camber and elevation before welding is commenced.

4.5.4.6 The field riveting, and bolted and pin connection shall conform to the requirements of Para 4.5.5 as appropriate.

4.5.4.7 The correction of minor misfits involving harmless amounts of reaming, cutting and chipping will be considered a legitimate part of erection. However, any error in the shop fabrication or deformation resulting from handling and transportation which prevents proper assembling and fitting up of parts by moderate use of drifts or by a moderate amount of reaming and slight chipping or cutting shall be reported immediately to the Engineer and his approval of the method of correction obtained. The correction shall be made in the presence of the Engineer.

4.5.5 Riveting

(a) Riveted connections shall be securely bolted up before the rivets are driven.

(b) Parallel barrel drifts, with their greatest diameter not exceeding that of the rivet hole, may be used for drawing members into position; but no drifting to match up unfair holes shall be allowed. Any apparent error in fabrication work which prevents assembling and fitting up of the parts by the proper use of these drifts shall be investigated immediately. No reamering shall be undertaken without the written authority of the Engineer, and if it be approved, any special rivets that may be required shall be used to fill such holes, and for this no extra payment shall be admissible to the Contractor. All correspondence relating to the recourse to reamering and the use of special rivets shall invariably be recorded by the Engineer for information.

(c) In cases where the joint has to withstand stresses arising from special methods of erection before being riveted up, parallel barrel drifts and turned bolts shall be used to withstand the whole of such stresses, the number of drifts being subject to a maximum of 40 per cent of the total.

(d) In the event of any emergency arising, such as staging being in danger of being carried away by floods before the riveting can be completed, the joints shall be made secure by filling 40 per cent of the holes with drifts and an equal number with service bolts fully tightened up.

(e) Riveting shall not be started until such time as the Engineer or his representative has personally satisfied himself that the alignment and levels of the members are correct, the verticals plumb, all joints and cover plates well in order, service bolts tight and the field rivet holes properly matching.

(f) Joints shall normally be made by filling not less than 50 per cent of the holes with service bolts and parallel drifts in the ratio of 4 to 1. The service bolts shall be fully tightened up.

4.5.6 Bolted Connection: Permanent bolted connections shall be used only were shown on the drawings or where specially approved by the Engineer. In all such

cases, washers not less than 6mm thick shall be used under the heads and nuts, and the nuts drawn tight and “checked” by burring over the threads with a chisel. In case of High Strength Friction Grip (HSFG) bolts, Sub-Para 7.12 of Steel Bridge Code shall be followed.

4.6 PAINTING STEEL WORK

4.6.1 General: Unless otherwise specified all painting and protection coating work shall be done in accordance with Para 39 of IRS Specification Serial No. B1-2001 and IS:1477 (Part 1) supplemented by the specifications given below. In locations where girders are subjected to satisfy such as close vicinity of sea and or over creeks, metalizing with sprayed aluminium as given is Appendix VII to IRS Specification Serial No. B1-2001 shall be done followed by painting with (i) one coat of Etch Primer to IS:5666 (ii) one coat of zinc chrome primer to IS:104 the zinc chrome to be used in the manufacturer conforming to Type- 2 of IS:51 and (iii) two coats of Aluminium paint to IS:2339 by brushing or spraying as specified. One coat is to be applied in shop before dispatch and second after erection after touching up the earlier coats if damaged in transit or during erection.

4.6.2 Surface Preparation

Steel surface to be painted either at the fabricating shop or at the site of work shall be prepared in a thorough manner with a view to ensuring complete removal of mill scale by one of the following processes as agreed to between the fabricator and the Engineer.

a) Dry or wet grit / sand blasting

b) Pickling which should be restricted to single plates, bars and sections

c) Flame cleaning

Primary coat shall be applied as soon as practicable after cleaning and in case of flame cleaning, primary coat shall be applied while the metal is still warm.

All slag from welds shall be removed before painting. Surfaces shall be maintained dry and free from dirt and oil. Work out of doors in frosty or humid weather shall be avoided.

4.6.3 Coatings

Prime coat to be used shall conform to the specification of primers specified hereinafter or in Drawings / Contract and should be approved by the Engineer. Metal coatings shall be regarded as priming coatings. Primer shall be applied to the blast cleaned surface before any deterioration of the surface is visible. In any case, the surface shall receive one coat of primer within 4 hours of abrasive blast cleaning. In case the Primer coat is not applied in the stipulated time, boiled linseed oil to IS: 77 to be applied to avoid rusting of members.

All coats shall be compatible with each other. When metal coatings are used, the undercoat shall be compatible with the metal concerned. The primer undercoat and

finishing coat shall preferably be from the same manufacturer to ensure compatibility. Successive coats of paints shall be of different shades or colours and each shall be allowed to dry thoroughly before the next is applied. Particular care shall be taken with the priming and painting of edges, corners, welds and rivets. Typical guidelines for epoxy-based paints and the conventional painting system for bridge girders as given below may be complied with:

a) Epoxy Based Painting

i) **Surface preparation**: Remove oil / grease by use of petroleum hydrocarbon solution (IS:745) and Grit blasting to near white metal surface and the prepared surface shall match to minimum Sa 2.5 of ISO Specification No. 8501-1:2007 or latest.

ii) **Paint system**: 2 coats of Epoxy Zinc Phosphate Primer to RDSO Specification No. M&C/PCN/102/2020 or latest (70-micron DFT/per coat) followed by one coat of Epoxy Based Micaceous Iron Oxide (MIO) to RDSO Specification. No. M&C/PCN/103/2020 or latest (100 - 175-micron DFT/per coat. Finished coats approved by --- Air less Spray of coats of Epoxy Zinc Phosphate Primer to RDSO Specifications No. No. M&C/PCN/102/2020 or latest (Total 5 coats = 350-micron, Min).

b) Conventional Painting System for areas where corrosion is not severe

Priming Coat: One coat of ready mixed zinc chrome priming conforming to IS:104 followed by one coat of ready mixed red oxide zinc chrome primer conforming to IS:2074 or two coats of zinc chromate red oxide primer conforming to IRS P-31.

Finishing Coats: Two coats of approved paint shall be applied over the primer coat. One coat shall be applied before the fabricated steel work leaves the shop. After the steel work is erected at site, the second coat shall be given after touching up the primer and the cover coats if damaged in transit.

c) Conventional Painting System for areas where corrosion is severe

Priming Coat: One coat of ready mixed zinc chrome primer conforming to IS:104 followed by one coat of red oxide zinc chrome conforming to IS:2074.

Finishing Coats: Two coats of aluminium paint conforming to IS:2339 shall be applied over the primer coat. One coat shall be applied before the fabricated steel work leaves the shop. After the steel work is erected at site, the second coat shall be given after touching up the primer and the cover coats if damaged in transit.

4.6.4 Painting in the Shop

i) All fabricated steel shall be painted in the shops after inspection and acceptance with at least one priming coat unless the exposed surfaces are subsequently to be cleaned at site or are metal coated. No primer shall be applied to galvanised surfaces.

ii) Shop contact surfaces, if specifically required to be painted, shall be brought together while the paint is still wet.

iii) Field contact surfaces and surfaces to be in contact with cement shall be painted with primer only. Paint shall be completely dried before loading and transporting to site.

iv) Surface not in contact but inaccessible after shop assembly shall receive the fully specified protective treatment before assembly.

v) Where surfaces are to be welded, the steel shall not be painted or metal coated within a suitable distance from any edges to be welded if the specified paint or metal coating would be harmful to welders or is expected to impair the quality of site welds.

vi) Exposed machined surfaces shall be adequately protected.

vii) In case of HSFG Bolted structures, the contact surfaces shall not be painted over metalized surface as friction to be developed between the contact surfaces.

4.6.5 Painting at Site

i)Surfaces which will be inaccessible after site assembly shall receive the full specified protective treatment before assembly.

ii) Surfaces which will be in contact after site assembly shall receive a coat of paint (in addition to any shop priming) and shall be brought together while the paint is still wet.

iii) Damaged or deteriorated paint surfaces shall be first made good with the same type of coat as the shop coat.

iv) Where steel has received a metal coating in the shop, this coating shall be completed on site so as to be continuous over any welds, bolts and site rivets.

v)Specified protective treatment shall be completed after erection.

4.6.6 Methods of application

The methods of application of all paint coatings shall be in accordance with the manufacturer's written recommendation and approved by the Engineer or as indicated in painting chapter to the extent they are applicable to major steel structures. Spray painting may be permitted provided it will not cause inconvenience to the public and is appropriate to the type of structure being coated. Areas hard to gain access for painting and areas shaded for spray application shall be coated first by brushing.

The primer, intermediate and finishing coats shall all be applied so as to provide smooth coatings of uniform thickness. Wrinkled or blistered coatings or coatings with pinholes, sags, lumps or other blemishes, shall not be accepted. Where the Engineer so directs, the coating shall be removed by abrasive blast cleaning and replaced at the Contractor's expense.

4.6.7 Guideline of Specifications for Protective Coating System in Different Environments

a) Since the seriousness of the problem of corrosion depends upon atmospheric conditions and these vary enormously, there is no single protective system or method of application that is suitable for every situation.

b) However, as a guide to specifying authorities, broad recommendations in this respect are given in **Table 4.3** for various types of coatings in various environmental conditions, extracted from MORTH Specifications for Roads and Bridges. Approximate life to first maintenance is also indicated and can be used as a guide.

TABLE 4.3 RECOMMENDATIONS FOR TYPES OF PROTECTIVE COATINGS

System	Environment
i) Wire brush to remove all loose rust and mill scale: (a) Primer coat: One coat of Ready mixed paint, brushing, Zinc chromate priming to IS: 104 (Dry film thickness of approx. 25 microns) (b) Primer coat: One coat of Ready mixed paint, brushing, red oxide zinc chrome primer to IS: 2074 (Dry film thickness approx. 25 microns) (c) Top coat: Two coats of Aluminium finish paint to IS: 2339 (Dry film thickness approx. 40 microns) Total DFT=100 Micron, Min	Suitable for mild conditions where appearance is of some importance and where regular maintenance is intended. This system may deteriorate to a marked extent if it is exposed to moderate aggressive atmospheric conditions for lengthy period.
(ii) Wire brush to remove all loose rust and mill scale; Painting System: (a) One coat of High-performance Anti -Corrosion Epoxy coating (Two Pack) conforming to RDSO Specification No. M&C/PCN/123/2018, DFT Min 125 Micron. (b) One coat of Epoxy Based Micaceous Iron Oxide (MIO) to RDSO Specification. No. M&C/PCN/103/2020 or latest (100–175 micron DFT/per coat) (c)Top coat: One coat of Polyurethane (PU) Based Aluminium finish paint to RDSO Specification No. M&C/PCN/110/2020 (Three Pack) (Dry film thickness approx. 35 microns) (Total DFT=300 Micron, Min)	Similar to (i) but where appearance is not very important provides longer life in mild condition. Will provide upto 5 years life to first maintenance in polluted inland environment
(iii) Blast-clean the surface **to minimum Sa 2.5 grade as per ISO: 8501-1**: (a)Apply one coat of Epoxy Zinc Phosphate Primer to RDSO Specification No. M&C/PCN/102/2020 or latest (70 micron DFT/per coat). (b) One coat of Epoxy Based Micaceous Iron Oxide (MIO) to RDSO Specification. No. M&C/PCN/103/2020 or latest (100-175 micron DFT/per coat). (Total 5 coats = 350 micron, Min).	Compared to (i) this would provide a longer life in mild conditions and could be used in less mild situation e.g. inland polluted, where maintenance could easily be carried out at regular intervals

System	Environment
(c) Top coat: Two coat of Polyurethane (PU)Based Aluminium finish paint to RDSO Specification No. M&C/PCN/110/2020(Three Pack) (Dry film thickness approx. 70 microns) (Total DFT=300 Micron, Min)	
iv) Blast clean the surface **to minimum Sa 2.5 grade as per ISO: 8501-1**; (a)Apply one coat of Epoxy Zinc Phosphate Primer to RDSO Specification No. M&C/PCN/102/2020 or latest (70 micron DFT/per coat) (b) One coat of Epoxy Based Micaceous Iron Oxide (MIO) to RDSO Specification No. M&C/PCN/103/2020 or latest (100-175 micron DFT/per coat.) (c) Top Coat: Two coats of Poly urethane based Aluminium (PU) finish paint to RDSO specification no. M&C/PCN/110/2020 or latest (dry film thickness approx.70 microns, Min) (Total 4 coats = 250 micron, Min).	Suitable for general structural steel work exposed to ordinary polluted inland environments where appearance is not of primary importance.
v) Blast clean the surface **to minimum Sa 2.5 grade as per ISO: 8501-1**; (a) 1 coat of sprayed Zn/Aluminium 150 microns. (b) High performance Anti -Corrosion Epoxy coating (Two Pack) conforming to RDSO Specification No. M&C/PCN/123/2018, DFT Min 125 Micron. (c) Top coat: One coat of Polyurethane (PU) Based Aluminium finish paint to RDSO Specification No. M&C/PCN/110/2020 (Three Pack) (Dry film thickness approx. 35 microns) (Total DFT = 300 Micron, Min)	Suitable for structures in reasonably aggressive conditions e.g. near the coast. Will provide, long term protection than (iv) in non-coastal situations. Also suitable for aggressive interior situations such as industrial areas.
vi)Blast clean the surface **to minimum Sa 2.5 grade as per ISO: 8501-1**: Coal tar Epoxy Based Coal Tar Paint (Two Pack) to RDSO specification No. M&C/PCN/105/2020 or latest, Total Dry Film Thickness (350-450) µm, Min.	Suitable for sea water splash zones or for conditions of occurrence of frequent salt sprays

vii) Pickle: (a) Hot Dip Galvanised (Zinc) conforming to IS: 4759 and IS: 2629. Total thickness: 85 Micron. (b) One coat of High performance Anti -Corrosion Epoxy coating (Two Pack) conforming to RDSO Specification No. M&C/PCN/123/2018, DFT Min 125 Micron. (c) One Intermediate coat Fluoropolymer (Fluoroethylene / Vinyl ether co-polymer (FEVE) conforming to Japanese Industrial standard JIS K 5659:2008 (Long durable paints for steel structures), DFT=30 Micron (d) One top coat of Fluoropolymer (Fluoroethylene / Vinyl ether co-polymer (FEVE) conforming to Japanese Industrial standard JIS K 5659:2008 (Long durable paints for steel structures)-Class-1 ,DFT=30 Micron Total dry film thickness: 250 µm, Min	Suitable for steel work in reasonably mild conditions. Life of 15-20 years before first maintenance could be expected in many situation
viii)Grit blast **to minimum Sa 2.5 grade as per ISO: 8501-1**, (a) Hot Dip Galvanised (Zinc) conforming to IS: 4759 and IS:2629. Total thickness = 140 Micron (b)One coat of High performance Anti -Corrosion Epoxy coating (Two Pack) conforming to RDSO Specification No. M&C/PCN/123/2018, DFT Min 125 Micron. (c) One top coat of Fluoropolymer (Fluoroethylene / Vinyl ether co-polymer (FEVE) conforming to Japanese Industrial standard JIS K 5659:2008 (Long durable paints for steel structures)-Class-1, DFT=25 Micron Total dry film thickness: 300 µm, Min	Provides a longer life than (vii) because of thicker zinc coating

ix) Grit blast **to minimum Sa 2.5 grade as per ISO: 8501-1**: (a) 1 coat of Zn/Aluminium spray, 150 µm, Min (b) One coat of High-performance Anti -Corrosion Epoxy coating (Two Pack) conforming to RDSO Specification No. M&C/PCN/123/2018, DFT Min 125 Micron. (c) One Intermediate coat Fluoropolymer (Fluoroethylene / Vinyl ether co-polymer (FEVE) conforming to Japanese Industrial standard JIS K 5659:2008 (Long durable paints for steel structures), DFT=30 Micron (d) One top coat of Fluoropolymer (Fluoroethylene / Vinyl ether co-polymer (FEVE) conforming to Japanese Industrial standard JIS K 5659:2008 (Long durable paints for steel structures) - Class-1, DFT=25 Micron Total dry film thickness: 325 µm, Min	Expected to provide long term protection approx. 15-20 years in aggressive atmosphere

4.7 Tests and Standards of Acceptance

The materials shall be tested in accordance with relevant IS specifications and necessary test certificates shall be furnished. Additional tests, if required, shall be got carried out by the Contractor at his own cost.

The fabrication, furnishing, erecting, painting of structural steel work shall be in accordance with these specifications and shall be checked and accepted by the Engineer.

4.8 MEASUREMENTS FOR PAYMENT

a) The measurements of steel work shall be as Para 4.1.2.

b) The weight of rolled and cast steel and cast iron shall be determined from the dimensions shown on the drawings on the following basis:

i) Rolled or cast steel: 7.85×10^3 kg/cum.

ii) Cast Iron: 7.21×10^3 kg/cum

c) Weight of structural sections shall be nominal weight. No additions shall be made for the weight of protective coating or weld fillets.

d) No separate payment shall be made for supply of bolts and nuts and drifts required in temporary connections for erection purposes and any wastages thereof.

e) In the event of a dispute arising as to the weight of a portion of steel work, a weighment shall be made in the presence of Inspecting Officer.

Annexure 4.1

(Refer Para 4.3.6)

Lengths (L) Required for Different Diameters of Rivets

(All dimensions in mm).

Grip Length	(i) Cuphead Rivets						(ii) Countersunk Head Rivets					
	10	12	16	18	20	22	10	12	16	18	20	22
12	31 32	33 32	38 40	41 40	..	..	23	..	..	..	..	..
14	33 32	36	41 40	43	46	..	25 26	..	..	..	..	..
16	36	38 40	43	46	48 49	51 52	28 29	..	..	..	..	..
18	38 40	41 40	45 46	48 49	51 52	53 52	30 29	31 32	32	..	..	..
20	41 40	43	48 49	50 49	53 52	56 55	33 32	33 32	35 36	..	..	..
22	44 43	46	50 49	53 52	55	58	36	36	37 36	..	..	..
24	46	48 49	53 52	55	58	60 61	38 40	38 40	40	40	..	..
26	49	51 52	55	57 58	60 61	63 64	41 40	41 40	42 43	42 43	43	..
28	51 52	53 52	57 58	60 61	62 61	65 64	43	43	44 43	45 46	45 46	..
30	54 55	56 55	60 61	62 61	65 64	67	46	46	47 46	47 46	48 49	49
34	..	61	64	67	69 70	72 73	51 52	51 52	51 52	52	52	54 55
38	..	66 67	69 70	71 70	74 73	76	..	56 55	56 55	56 55	57 58	58
42	..	71	74	76	78	81	..	61	61	61	61	63

Grip Length	(i) Cuphead Rivets						(ii) Countersunk Head Rivets					
		70	73		80	80						64
46	..	76	79 80	81 80	83	85 86	..	66 67	66 67	66 67	66 67	67
50	..	81 80	83	85 86	88 89	90 89	..	71 70	70	70	71 70	72 73
55	..	87 86	89	91 92	93 92	96 95	..	77 76	76	76	76	78 80
60	..	..	95	97 99	99	101 102	..	83	82 83	82 83	82 83	83
65	..	..	101 102	103 102	105 108	107 108	..	..	88 89	88 89	88 89	89
70	..	..	107 108	109 108	111 114	113 114	..	..	94 95	94 95	94 95	95
75	..	..	113 114	115 114	116 118	118	..	..	100 99	100 99	99	100 99
80	..	..	..	120 118	122 125	124 125	..	..	106 108	105 108	105 108	106 108
85	..	..	..	..	128 125	130 132	..	..	112 114	111 114	111 114	112 114
90	..	..	..	..	..	135	..	..	..	117 118	117 118	117 118
95	..	..	..	..	..	141 140	..	..	..	..	122 125	123 125
100	..	..	..	..	..	..	..	..	..	..	..	129 132

Notes:

1) The lengths given above are those required theoretically, except that where two lengths are indicated, the figure in the denominator represents the length to which rivets are generally produced by standard manufacturers.

2) Interpolate between the theoretical lengths for intermediate grip lengths.

Chapter-5
Bridge Works –Misc.

5.1 BRIDGE BEARINGS

Types and General Requirements

a) Types of Bearings can be:-

i) Steel Plate Bearings
ii) Pin Bearings
iii) Rocker and Roller Bearings
iv) Neoprene Bearings and Elastomeric Pads
v) PTFE/ POT Bearings
vi) Spherical Bearings

b) Common requirements of different types of bearings are:

i) Bearing plates, bars, rockers, assemblies and other expansion or fixed devices shall be constructed in accordance with the details shown on the drawings.

ii) The bearings may either be procured directly by the Engineer from the manufacturers, and supplied to be installed by the Contractor or the Contractor may be required to supply and install the bearings as part of the contract. In the former case, the manufacturer shall be associated with the installation of the bearings to the full satisfaction of the Engineer, whereas in the latter case, the Contractor shall be solely responsible for the satisfactory supply and installation of the bearing. In the detailed description of the specification, a general reference shall be made to the Contractor or manufacturer and the interpretation shall be as per terms of contract.

iii) The Contractor shall exercise the utmost care in transporting, setting and fixing all bearings in their correct positions and ensuring that uniformity is obtained on all bearing surfaces.

iv) Bearings shall be handled with care and stored under cover.

v) When bearing assemblies or plates are shown on the drawings to be placed (not embedded) directly on concrete, the concrete bearing area shall be constructed slightly above grade (not exceeding 12mm) and shall be finished by grinding.

vi) It shall be ensured that the bearings are set truly level and in exact position as indicated on the drawings so as to have full and even bearing on the seats. Thin mortar pads (not exceeding 12mm) may even be made to meet with this requirement. If the levels to be adjusted are more than 12mm thickness, suitable steel packing to be provided under Bed plates and should be treated as Bed plates.

vii) It shall be ensured that the bottoms of girders to be received on the bearings are plane at the locations of these bearings and care shall be taken that the bearings are not displaced while placing the girders.

viii) Unless otherwise specified for sliding plate bearings, stainless steel surface sliding on stainless steel plate with mild steel matrix shall be used. The other option shall be to provide PTFE surface sliding on stainless steel.

ix) These specifications cover the types of bearings which have been successfully used in various bridges in India. For other types of structures (like cable stayed bridges or similar and in special cases, special types of bearings to suit the requirements may have to be provided, for which special specifications may be laid down by designers and approved by the Engineer.

5.2 STEEL BEARINGS

5.2.1 Materials

The material for steel bearings shall conform to the requirements of Chapter 4. Some additional requirements for materials for steel bearings are indicated below:

a) For the purpose of checking the soundness of cast steel components, castings shall be ultrasonically examined following procedures as per IS:7666 with acceptance standard as per IS:9565. The castings may also be checked by any other accepted method of non-destructive testing as specified in IS:1030. Quality level of castings shall be level 3 as per IS:9565.

The grease for bearings shall conform to the requirements of IS:503 (Grade 4).

5.2.2 Fabrication

i) All work shall conform strictly to the drawings and shall be in accordance with the provisions of this section if not in contradiction to the applicable codes or manuals. Care shall be taken to ensure that all parts of an assembly fit accurately together. The workmanship shall satisfy all relevant provisions laid down in Chapter 4.

ii) Knuckle pins, rolling surfaces of the rollers and bearing surface of the bearing plates shall be machined and all bolt holes shall be drilled. The whole bearings shall be fitted and finished as required for good quality machined work to the satisfaction of the Engineer. However, in case of bearings which are to be grouted or bedded on a suitable yielding material on any surface which is to be in permanent contact with the grout or the yielding material may be left un-machined.

iii) Fabrication shall be carried out by an organization experienced and qualified to undertake precision engineering of this type and be approved by the Engineer.

iv) Workmanship shall be of good quality, neatly finished and of good appearance.

v) Castings shall be true to the forms and dimensions shown on the drawings and shall be free from pouring faults, sponginess, cracks, blow holes and other defects on position, affecting their appearance or strength. Warped or distorted casting shall not be accepted. Exposed surfaces shall be smooth and dense.

vi) All castings shall be cleaned by sand or shot blasting to remove sand or scale and to present a clean uniform surface.

vii) All irregularities, fins or risers shall be ground off flush with the adjacent surface. Castings with visible cracks, blow holes or similar blemishes shall be rejected if the imperfections are located in bearing surfaces or cannot be remedied to the satisfaction of the Engineer.

viii) Imperfections which are not located in bearing surfaces shall be cleaned out and filled with weld metal of the appropriate composition and ground flush.

ix) All surfaces of major components like top plates, saddle plates, base plates and rollers of the bearings shall be machined all over for correct alignment, interchangeability, proper fitting etc.

5.2.3 Tolerances

Tolerances for its individual components or of the assembled bearings shall be as shown on the drawings or subject to the approval of the Engineer. In all other cases, unless otherwise directed, the following tolerances shall be maintained:

a) Diameter of Rollers, Knuckle Pins and Bores

Tolerances on diameter of rollers and all convex surfaces shall conform to K7 of IS:919.

Tolerances on diameter of all concave surfaces shall conform to D8 of IS:919.

b) Height of Bearings

Tolerances on height of any component casting shall not exceed + 0.5mm. No minus tolerance shall be allowed. The edges of all ribs shall be parallel throughout their length.

c) Base Plate

Tolerance on length and width of the base plate shall not exceed + 1.0mm, tolerance on the thickness of the plate shall not exceed + 0.5mm. No minus tolerance shall be allowed. All rocking, rolling and sliding surfaces shall have a machine smooth finish to 20-micron maximum mean deviation as per IS:3073.

d) Castings

No minus tolerance shall be allowed in the thickness of any part of the castings. The edges of all ribs shall be parallel throughout their length.

5.2.4 Installation of Steel Bearings

5.2.4.1 General

a) Bearings shall be placed in the positions as shown on the drawings with all bearing surfaces in full contact and to the tolerances as specified.

b) Roller and rocker bearings shall be placed so that their axes of rotations are horizontal and normal to the direction of movement of the members they support. Upper and lower bearing plates shall be set horizontal in both directions.

c) During installation the bearings shall be pre-set with respect to the bearing axis to account for the movement due to the following:

i) Temperature variation between the average temperature prevailing at the time of installation and the mean design temperature.

ii) Shrinkage, creep and elastic shortening.

d) For bridges in gradient, the bearing plates shall be placed in a horizontal plane.

e) In pre-stressed concrete construction where, launching of girders is employed, in order to avoid slipping or jumping of rollers due to vibration or jolts, adequate measures may be taken to ensure that the roller assembly is not disturbed. It is normal practice to provide rocker bearings on the launching end and place the beam on the rocker end slightly in advance of placing on the roller.

f) During concreting of girders, the bearings shall be held in position securely by providing temporary connection between the top and bottom plates in case of fixed bearings and between top plate, base plate and saddle plate in case of roller cum rocker bearing or by any other suitable approved arrangement which prevents the relative displacement of the components.

g) In pre-stressed precast girders, where recesses are left on the underside of girders to receive the anchor bolts, grout holes extending to the beam sides or to the deck level shall be provided. The cement sand grout shall have a mix of 1:1.

5.2.4.2 Checking, Cleaning and Lubrication

Before erection, each bearing shall be uncrated, disassembled and checked. Any damaged part shall be made good for approval by the Engineer.

All bearings with sliding surfaces shall be cleaned and lightly lubricated with an approved lubricant immediately before erection.

5.2.4.3 Testing

Testing of steel Roller and Rocker bearings shall be done in accordance with provisions of IRS Specification Serial No. B1-2001.

A) If required, a suitable number of complete bearings as specified by an accepting authority shall be tested to 1.25 times the design load. Recovery should be 100 per cent. Contact surfaces shall be examined by illumination source for any defects, cracks, etc. Segmental roller shall be tested for design movements.

B) For large lots (consisting of 12 sets or more), a quality control report shall be submitted as detailed below:(One set consists of Roller & Rocker bearing at Free end and One Rocker bearing at Fixed end)

a) Unless otherwise agreed upon by the Engineer and the manufacturer, the latter shall furnish a complete report on the process of quality control. The Engineer may appoint an authorized inspection agency for inspection purpose on his behalf. Such

an inspection agency shall also submit reports to the Engineer regarding various tests performed on the bearing or certify the acceptance of the bearings.

b) Test Certificates of all raw materials shall be submitted. If manufacturer's test certificates are not available for the raw materials, the bearings manufacturer shall perform the necessary confirmatory tests as per relevant codes of practice and shall furnish the test results.

c) A detailed quality control system including stage by stage inspection, starting from raw materials upto the finished bearing shall be submitted by the bearing manufacturer.

d) The Engineer shall reserve the right to witness such inspection at manufacturer's works with or without prior permission of the manufacturer. For this, the bearing manufacturer shall have in plant testing facilities as far as possible and practicable.

e) The bearing manufacturer shall maintain a list of consumption of raw materials for a period of at least previous one year.

f) Test certificates of bearings manufactured during preceding one year shall be made available at the manufacturer's works.

g) In case the lot size of similar bearings exceeds 12 sets as per the direction of the Engineer, one extra set of bearings for each 24 sets of bearings or part thereof shall be manufactured and the cost of such extra bearings shall be borne by the user.

h) The Engineer shall select the extra bearing (s) at random and shall perform various tests including destructive testing on it at his discretion, either at the manufacturer's works or at any other approved test laboratory, notwithstanding the test reports submitted.

i) In case there is a major discrepancy regarding material, the Engineer shall declare the whole lot of bearings as unacceptable.

j) In case minor defects in fabrication, like welding or machining is found in the test bearing before destructive testing and if the test bearing is found to be acceptable after destructive testing, the minor defects in the test bearings shall not be a bar to the acceptance of the entire lot.

k) The opinion of the Engineer in cases (i) and (j) above shall be binding on the manufacturer.

5.2.4.4 Placing

a) On supporting structures, pockets shall be provided to receive anchor bolts; one side of the pocket shall project beyond the bearing plate. The pocket shall be filled with mortar of mix 1:1 and the concrete bearing area also shall be finished level by a thin and stiff mortar pad of mix 1:1 (the thickness not exceeding 12mm) just before placing of bearing assemblies or bottom plate on the concrete seat.

b) In case of precast girders, a recess of 6mm shall be provided on the underside with a level finish for housing the bearing plate. A thin and stiff mortar pad of mix 1:1 with

thickness not exceeding 3mm shall be provided over the top plate before lowering the precast beam in position in order to ensure full and even pressure on the plate surface.

c) It shall be ensured that while placing the girders, the bearings are in their exact positions as indicated on the approved drawing and not displaced therefrom.

d) All concrete surfaces to be in contact with the mortar shall be thoroughly cleaned and kept saturated with water for a period not less than 24 hours before placing mortar and operations are to be carried out when the surface temperatures of the exposed bearings are the minimum practical.

e) No mortar that is more than 30 minutes old after completion of mixing, shall be used.

f) After placing and finishing the mortar, the bearing shall be checked for position and shims or other temporary supports removed and the mortar made good. If the bearing has moved, the bearing or the plate shall be lifted, the mortar removed and the whole procedure repeated.

g) Exposed faces of the mortar shall be cured under damp Hessian for 7 days.

h) Placing of the bearing and mortar shall only be carried out in the presence of the Engineer.

5.3 ELASTOMERIC BEARINGS

The term “bearing” in this case refers to an elastomeric bearing consisting of one or more internal layers of Elastomer bonded to internal steel laminates by the process of vulcanization. The bearing shall cater for translation and / or rotation of the superstructure by elastic deformation.

5.3.1 Raw Material

a) Chloroprene (CR) only shall be used in the manufacture of bearing.

Grades of raw Elastomer of proven use in elastomeric bearings, with low crystallization rates and adequate shelf life (e.g. Neoprene WRT, Bayprene 110, Skyprene B-5 and Denka S-40V) shall be used.

b) No reclaimed rubber or vulcanized wastes or natural rubber shall be used.

The raw Elastomer content of the compound shall not be lower than 60 per cent by its weight. The ash content shall not exceed 5 per cent (as per tests conducted in accordance with ASTM D-297, sub-section 10)

c) EPDM and other similar elastomers for bridge bearing use shall not be permitted.

d) Properties and Tests

The Elastomer shall conform to the properties specified in **Table 5.1**

Table 5.1 Properties of Elastomer for Bearings

	Property	**Unit**	**Test Method, IS Specification reference**	**Value of the characteristic specified**
1	**Physical properties**			
1.1	Hardness	IRHD	IS:3400 (Part -2)	60+5
1.2	Minimum Tensile Strength	Mpa	IS:3400 (Part -1)	17
1.3	Minimum Elongation at break	Per cent	IS:3400 (Part -1)	400
2	**Maximum Compression Set**	Per cent	IS:3400 (Part -10) duration (h)	Temperature (deg C)
	CR		+0 to 24.2	100±1
3	**Accelerated Ageing**		IS:3400 (Part -4) duration (h)	Temperature (deg C)
	CR		70	100±1
3.1	Max. change in Hardness	IRHD		+15
3.2	Max. change in Tensile Strength	Per cent		-15
3.3	Max. change in Elongation	Per cent		-40

Shear modulus of the Elastomer bearing shall neither be less than 0.80 MPa nor greater than 1.20 MPa.

e) The adhesion strength of Elastomer to steel plates determined according to IS:3400 (Part -14) method A shall not be less than 7 kN/m.

For elastomeric bearings (CR) used in adverse climatic conditions the following ozone resistance test shall be satisfied:

f) The ozone resistance of Elastomer shall be proved satisfactory when assessed by test according to IS:3400 (Part -20). The strain, temperature, duration and ozone concentration of the test shall be 20 per cent, 40 ± 1 degree Celsius, 96h and 50 pphm by volume respectively.

g) No cracking detected by visual observation at the end of the test shall be considered satisfactory. No specific tests for assessment of low temperature resistance may be deemed necessary.

Note: For use of Elastomer in extreme cold climates, the Engineer may specify special grade of low temperature resistant Elastomer in conformity with operating ambient temperature conditions. The specifications of such special grade Elastomer including the tests for low temperature resistance shall be mutually agreed to by the Engineer and the producer supplier and are outside the purview of these specifications.

h) Laminates of mild steel conforming to IS:2062 shall only be permitted to be used. Use of any other material like fibre glass or similar fabric as laminates shall not be permitted.

i) The manufacturers of elastomeric bearings shall satisfy the Engineer that they have in-house facilities for testing the Elastomer for carrying out the following tests in accordance with the relevant provisions of ASTM D-297 as given below:

1) Identification of polymers:to confirm the usage of Chloroprene (Appendix X-2)

2) Ash content test:to determine the percentage (sub-section 34)

3) Specific gravity test:(sub-section 15)

4) Polymer content test:(sub-section 10)

j) The Engineer shall invariably get the test (a) performed in his presence or in the presence of his authorized representative to satisfy the requirement. In case of any disputes regarding interpretation of results, the Engineer may carry out test as per ASTM S-3452-78 (Chromatography test) at the manufacturer's cost in a recognized test house.

k) The Elastomer specimen to conduct the test shall be obtained from the bearings selected at random for destructive test. Remaining part of the test bearing shall be preserved by the Engineer for any test to be done in future, if required.

5.3.2 Fabrication

a) Steel plates for laminates shall be sand blasted, clean of all mill scales and shall be free from all contaminants, prior to bonding by vulcanization. Rusted plates with pitting shall not be used. All edges of plates shall be rounded.

b) Each bearing with steel laminates shall be cast as a single unit in a mould and vulcanised under heat and pressure. Casting of elements in separate units and subsequent bonding shall not be permitted, nor shall cutting from large size cast be permitted.

Bearings of similar size to be used in particular bridge project shall be produced by identical process and in one lot as far as practicable. Phased production may only be resorted to when the total number of bearings is large enough.

The moulds used shall have standard surface finish adequate to produce bearings free from any surface blemishes.

c) Spacers used in mould to ensure cover and location of laminates shall be of maximum size and number practicable. Any hole at surface or in edge cover shall be filled in subsequently.

Care shall be taken to ensure uniform vulcanising conditions and homogeneity of Elastomer through the surface and body of bearings.

d) The bearings shall be fabricated to comply with the tolerances specified in Table 5.2.

TABLE 5.2 TOLERANCES

Sl. No.	ITEMS	TOLERANCES
1.	Overall plan dimensions	-0, + 6mm
2.	Total bearing thickness	-0, + 5mm
3.	Parallelism	
a)	Of top surface of bearing with respect to the bottom surface as datum	in 200
b)	Of one side surface with respect to the other as datum	1 in 100
4a)	Thickness of individual internal layer of elastomer	± 20 per cent (max. of 2mm)
b)	Thickness of individual outer layer	-0, +1mm
5a)	Plan dimensions of laminates	-3mm, +0
b)	Thickness of laminates	± 10 per cent
c)	Parallelism of laminate with respect to bearing base as datum	1 in 100

e) The vulcanising equipment / press shall be such that between the platters of press the pressure and temperature are uniform and capable of being maintained at constant values as required for effecting a uniform vulcanization of the bearing.

f) The moulding dies utilised for manufacturing the bearings shall be so set inside the platen of the press so that the pressure developed during vulcanizations of the product is evenly distributed and the thickness maintained at all places within acceptable tolerance limits taking into consideration the shrinkage allowance of vulcanizate.

g) The raw compound which has been introduced inside the metal dies for vulcanization shall be accurately weighed each time and it must be ensured that sufficient quantity has been put inside the die for proper flow of material at every place so that a homogeneous and compact bearing is produced without any sign of sponginess or deficiency of material at any place.

h) Before any vulcanizate of any batch of production is used for producing vulcanised bearings, test pieces in the form of standard slab and buttons shall be prepared in accordance with prescribed standards and salient properties tested and recorded regularly against each batch of production to monitor the quality of the products.

5.3.3 Acceptance Specifications

a) All acceptance and process control tests shall be conducted at the manufacturer's plant. Cost of all materials, equipment and labour shall be borne by the manufacturer unless otherwise specified or specially agreed to between the manufacturer and the Engineer.

The manufacturer shall have all the test facilities required for the process and acceptance control tests installed at his plant to the complete satisfaction of the Engineer. The test facilities and their operation shall be open to inspection by the Engineer on demand.

b) Acceptance testing shall be commenced with the prior submittal of testing programme by the manufacturer to the Engineer and after obtaining his. Any acceptance testing delayed beyond 180 days of production shall require special approval of the Engineer and modified acceptance specification, if deemed necessary by him.

All acceptance testing shall be conducted by the Engineer with aid of the personnel having adequate expertise and experience in rubber testing provided by the manufacturer, working under the supervision of the Engineer and to his complete satisfaction.

c) The size and composition of acceptance lot shall be got approved by the Engineer. Acceptance lot shall comprise all bearings including pair of extra bearings, where applicable, of equal or near equal size produced under identical conditions of manufacture to be supplied for the particular project.

d) Testing lots shall be classified as follows:

Large Lot: a lot of size 24 or larger number of bearings shall be defined as a large lot

Small Lot: a lot of less than 24 bearings shall be defined as a small lot

When production of a number of bearings of equal or near equal size for a large (single) bridge project is permitted to be manufactured in phases, the number of bearings supplied from each phase shall be treated as a lot and each such lot shall be considered a large lot.

e) Lot by lot inspection and acceptance shall be made.

5.3.4 Levels of Acceptance Inspection and Testing

a) The level of acceptance testing shall generally be graded into the following two levels depending on lot size:

Level 1 acceptance testing

Level 2 acceptance testing

b) Acceptance testing Level 1 is a higher-level inspection and shall be applicable to large lots only, unless otherwise specified. This shall involve manufacture of two extra bearings for each lot to be used as test bearing and eventually consumed in destructive testing.

c) Acceptance testing Level 2 shall be applicable to small lots only, (i.e. less than 24 sets) for which one extra bearing shall be manufactured. Out of the lot, one bearing shall be selected at random for carrying out material tests. This bearing shall be excluded from the lot accepted.

d) Acceptance inspection level 1 may be specified at the sole discretion of the Engineer taking into account the special importance of bridge project for small lots also under the purview of special acceptance inspection. The cost of extra bearings, in such cases shall be borne by the user, while the cost of all other materials, equipment and testing shall be borne by the manufacturer.

e) Testing**:** Acceptance testing shall comprise general inspection, test on specially moulded test pieces and test on complete bearings or sections for measurement of various quality characteristics as detailed in 2005.3.3 to 2005.3.7 of MOST Specifications for Roads and Bridges and IRC 83 Part II – 1996 Appendices 2 and 3, which may be referred to for details.

5.3.5 Certification and Marking

a) Bearings shall be transported to bridge site after final acceptance by the Engineer and shall be accompanied by an authenticated copy of the certificate to that effect.

b) An information card giving the following details for the bearings, duly certified by the manufacturer shall also be appended:

i) Name of manufacturer

ii) Date of manufacture

iii) Elastomer grade used

iv) Bearing dimensions

v) Production batch no.

vi) Acceptance lot no.

vii) Date of testing

viii) Specific bridge location, if any

c) Explanation of markings used on the bearing

d) All bearings shall have suitable index markings for identifying the information. The markings shall be made in indelible ink or flexible paint and if practicable should be

visible after installation. The top of the bearing and direction of installation shall be indicated.

5.3.6 Storage and Handling

Each elastomeric bearing shall be clearly labeled or marked. The bearing shall be wrapped in a cover. They shall be packed in timber crates with suitable arrangement to prevent movement and to protect corners and edges. Care shall be taken to avoid mechanical damage, contamination with oil, grease and dirt, undue exposure to sunlight and weather to the bearings during transport and handling prior to and during installation.

5.3.7 Installation of Elastomeric Bearings

i) Multiple bearings to be installed one behind the other on a single line of support shall be of identical dimensions.

ii) Bearings must be placed between true horizontal surfaces (maximum tolerance 0.2 per cent perpendicular to the load) and at true plan position of their control lines marked on receiving surfaces (maximum tolerance + 3mm.)

iii) Concrete surfaces shall be free from local irregularities (maximum tolerance $\pm$ 1mm in height)

iv) Design shall be checked for the actual inclination in seating if larger inaccuracies than those specified are permitted.

v) For cast-in place concrete construction of superstructure, where bearings are installed prior to its concreting, the forms around the bearings shall be soft enough for easy removal. Forms shall also fit the bearings snugly and prevent any leakage of mortar grout. Any mortar contaminating the bearings during concreting shall be completely removed before setting.

vi) For precast concrete or steel superstructure elements, fixing of bearing to them may be done by application of epoxy resin adhesive to interface, after specified surface preparation. The specifications for adhesive material, workmanship and control shall be approved by the Engineer. Care shall be taken to guard against faulty application and consequent behaviour of the adhesive layer as a lubricant. The bonding by the adhesive shall be deemed effective only as a device for installation and shall not be deemed to secure bearings against displacement for the purpose of design.

As a measure of ample safety against accidental displacement, the bearings shall be placed in a recess, as shown in Fig. 9 of IRC: 83 (Part II).

5.3.8 Seating of Elastomeric Bearings on a Non-Horizontal Plane

Installation of elastomeric bearings on a Non-Horizontal Plane shall be as follows:

Elastomeric bearings shall be delivered with MS backing plate fastened to the bearing from the manufacturer. Template of 6mm M.S. plate and of size same as bearing holding base plate with matching holes for the anchor screws shall be used. Anchors

shall be fitted to the templates with the anchor screws but with MS washers in place of Elastomer washers. The above template assembly shall be fitted in the form work at its proper location and in a vertical plane. After casting of the pedestal and removal of the form work, the template is to be removed.

A. Installation with Face Plate and without Template in-situ Casting

i) The sub-assembly of elastomeric bearing with the MS backing plate shall be fitted to the embedded anchors with anchor screws and elastomeric washers replacing the steel washer.

ii) A clearance is required between the stainless-steel face of the elastomeric bearing and that of the vertical face of the face plate with stainless steel top installed on the projection below the soffit. This shall be achieved by inserting removable steel sheeting of thickness as per the drawing, during preparation of the form work before casting of the superstructure.

iii) The face plate with stainless steel top and pack plate shall be assembled with the anchors with elastomeric washers and anchor screws. The assembly shall be fitted in the form work at its proper location and in a vertical plane. The removable steel shims shall be removed at an appropriate time after the casting of the super-structure.

B. Installation with Face Plate and with Template in-situ Casting

a) Template of 6 mm MS plate and of size same as face plate with stainless steel top and matching holes for the anchor screws shall be used. Anchors shall be fitted to the templates with the anchor screws but with MS washers in place of Elastomer washers. Separate screws may be used in case of inconvenience of fixing the washers in the length of original anchor screws. The above template assembly shall be fitted in the form work for the super structure at its proper location and in a vertical plane.

b) After removal of the superstructure form work, the template shall be removed.

c) The face plate with the required thickness of pack plate shall be loosely fitted to the anchors embedded in the projection below the superstructure, with Elastomer washers and anchor screws.

d) The sub-assembly of elastomeric bearing with the MS backing plate shall be fitted to the embedded anchors in the pedestal with anchor screws and elastomeric washers replacing the steel washer this time.

e) The required clearance between the stainless-steel face of the elastomeric bearing and that of the vertical face plate installed on the projection below the soffit shall be checked. After adjustment of the required working clearance the small gap between the vertical face of the projection below the soffit and the back of the face plate (with pack plates, if any) shall be grouted with epoxy grout.

5.4 POT BEARINGS

5.4.1 General

Pot type bearings shall consist of a metal piston supported by a disc or reinforced Elastomer confined within a metal cylinder to take care of rotation. Horizontal movement, if required, shall with a system of sealing rings be provided by sliding surfaces of PTFE pads sliding against stainless steel mating surfaces. The pot bearings shall consist of cast steel assemblies or fabricated structural steel assemblies.

Provisions of IRC-83 (Part I) shall be applicable for all metallic elements. Provisions of IRC:83 (Part II) shall be applicable for all Elastomer elements. When any item is not covered by IRC:83 (Parts I and II), the same shall be as per guidelines given hereunder and BS:5400 (Sections 9.1 and 9.2), except that no natural rubber shall be permitted. If there is any conflict between BS on the one hand and IRC on the other, the provisions of IRC shall be guiding.

Combination bearings using any judicious combination and sliding element shall be permitted. Some examples are shown in **Table 5.3** below.

Table 5.3: Combination of Elements for POT Bearings

Name	**Rotation Element**	**Sliding Element**	**Generally for**
Pot	Pot	None	Vertical Load
Elastomer	Elastomer	None*	Horizontal Buffer
Pot PTFE	Pot	PTFE-SS**	Vertical Load and Horizontal Load
Spherical Knuckle PTFE	Spherical Knuckle	PTFE-SS**	Vertical Load and Horizontal Load
Elastomer PTFE	Elastomer	PTFE-SS**	Transverse Guide
Elastomer SS**	Elastomer	SS-SS**	Transverse Guide

* Elastomer shall permit movement by shear

** Stainless Steel

For special and innovative bridges, new combinations beyond what is indicated may be required. The same may be used after approval by the Engineer.

5.4.2 Fabrication

i) The surface mating with the PTFE in the sliding pair shall be of corrosion resistant stainless steel. Normally, the stainless steel shall form the upper component. The stainless steel shall overlap the PTFE after full movement on all sides. If stainless steel sheet is used, it should be bonded by continuous welding along the edges.

Adhesive or any other bonding can be approved by the Engineer. The surface shall be prepared by thorough cleaning to remove grease, dust or any other foreign substance.

ii) PTFE modular sheets of the sliding pair shall be located by confinement assisted by bonding. Confined PTFE shall be recessed into the metal backing plate. The shoulders of the recess shall be sharp and square to restrict the flow of PTFE.

iii) The thickness of the PTFE shall not be less than 4.5mm with projection above the recess not exceeding 2.0mm. When the piston is subjected to tilting, the seal must slide along the wall and alter its shape according to the angle of tilt. At the same time, it must be sufficiently rigid to bridge the gap between the piston and the wall of the pot. However, the percentage of plan area of the lubrication cavities to the gross area shall not exceed 25 per cent. The depth of the cavity shall not exceed 2.0mm.

iv) The diameter to thickness ratio of the confined Elastomer shall not exceed 15. The surface of the confined Elastomer shall be smooth.

v) A seal shall be provided to prevent extrusion of the confined Elastomer between the piston and the pot wall. The seal should stay functional under the loads and rotations acting on it. Additional seal shall be provided to prevent entry of dust into the pot. Sealing rings for pot bearing shall be fabricated from stainless steel. When the piston is subjected to tilting, the seal must slide along the wall and alter its shape according to the angle of tilt. At the same time, it must be sufficiently rigid to bridge the gap between the piston and the wall of the pot.

vi) The hardness of the piston and pot wall at their contact region shall be minimum 350BHN to reduce wear. The surface finish of the pot base in contact with the confined Elastomer shall be very smooth.

vii) All bearings shall be installed with anchor and anchor screws or some similar device such that while replacing, the bearings can be removed with minimum lifting of the superstructure.

viii) The external surfaces of the assemblies shall be completely cleaned by sand blasting. After sand blasting, dust shall be removed from the surface using clean and dry compressed air or a clean brush after which suitable coating shall be applied.

ix) Pot bearings including all parts as shown on the drawings shall be fully shop assembled at the manufacturer's works to ensure proper fitting of all the parts.

5.4.3 Materials for POT/ PTFE Bearings

a) Steel

i) Structural steel shall conform to IS:2062, as applicable.

ii) Cast steel shall conform to Gr.280-520W of IS:1030 with 0.3 to 0.5 per cent copper added to increase the corrosion resistance properties.

iii) Stainless steel shall conform to AISI:304 or X04Cr 18 Ni9 of IS:6911 for ordinary applications. For applications with adverse / corrosive environment, the stainless steel shall conform to AISI: 316L or XO2Cr17Ni12Mo2 of IS:6911.

b) PTFE

PTFE (Poly Tetra Fluoro Ethylene) shall be of unfilled pure virgin quality. It shall be free sintered. The mechanical properties of unfilled PTFE shall comply with Grade A of BS:3784.

c) Elastomer

The confined Elastomer inside pot shall have the following properties:

i) Hardness IRHD IS:3400 (Part II): 50 + 5

ii) Min. tensile strength MPA IS:3400 (Part I): 15.5

iii) Min. elongation at break shall be as per Table 5.1 “Properties of Elastomer”

Max. Compression set and Accelerated ageing).

For other details, refer to Para 5.3.1

5.4.4 Workmanship

5.4.4.1 Welding

All welding shall conform to IS:9595 with electrodes of suitable grade as per IS:814. Preheating and post weld stress relieving shall be done as per IS:9595.

a) Cast Steel assemblies: Cast steel for pot bearing assemblies shall conform to requirements of relevant IS Codes. Castings shall be true to the forms and dimensions shown on the drawings, and shall be free from pouring faults, sponginess, cracks, blow holes and other defects affecting their appearance or their strength. Warped or distorted castings shall not be accepted. Exposed surfaces shall be smooth and dense.

All irregularities, fins or risers shall be ground off flush with the adjacent surface. Castings with visible cracks, blow holes, or similar blemishes shall be rejected if the imperfections are located on bearing surfaces or cannot be remedied to the satisfaction of the Engineer.

Imperfections which are not located on bearing surfaces shall be cleaned out, filled with weld metal of the appropriate composition and ground flush with adjacent surfaces.

b) Structural steel assemblies: Defects arising from the fabrication of the steel shall be inspected by the Engineer, who will decide whether the materials may be repaired by the Contractor or shall be rejected. The cost of repairs or replacement shall be borne by the Contractor.

All steel whether fabricated or not, shall be stored on platforms, skids, or other supports above the ground and adequately protected against corrosion. Excessively rusted, bent or damaged steel shall be rejected.

All plates shall be flat, and rolled bars and shapes straight before marking out or being worked. Straightening shall be done by methods which shall not damage the material. Sharp kinks and bends shall be the cause for rejection.

Steel may be flame cut to shape and length so that a regular surface, free from excessive gouges and striation is obtained. Flame cutting by hand shall be done only with the approval of the Engineer. Exposed corners shall be machined or ground.

c) Tolerances

i) Plan dimensions : -0 to +5mm

ii) Overall height : -0 to +3mm

iii) Height of Elastomer: $\pm$ 5 percent

iv) Height of any steel component

Machined : -0 to + 1mm

Un-machined : Class of IS:4897

v) Stainless steel sliding surface

Flatness : 0.0004L, where L= length in direction of measurement

Surface Finish : Ra $\leq$ 0.25 pm as per IS:3073

d) Painting

i) All non-working surfaces shall be coated with one coat of Epoxy Zinc Phosphate Primer to RDSO Specification No. M&C/PCN/102/2020 or latest (70 micron DFT/per coat, Min) followed by one coat of Epoxy Based Micaceous Iron Oxide (MIO) to RDSO Specification No. M&C/PCN/103/2020 or latest (100-175 micron DFT/per coat). Finished coats Epoxy Zinc Phosphate Primer to RDSO Specifications No. No. M&C/PCN/102/2020 or latest (Total 3 coats = 250 micron, Min) or any other painting scheme as approved by the Engineer.

ii) Silicon grease shall be applied at the PTFE /SS interface after testing.

iii) Anchor sleeves shall be cement coated at the manufacturer's works.

5.4.5 Test

Raw Materials: Necessary test certificates for all raw materials listed in Para 5.4.3 above shall be furnished by the manufacturers. Reference may also be made to Para 5.3.1 for tests on Elastomers.

Test on Casting: Tests specified in IS:1030 shall be performed. Castings shall be ultrasonically tested and certificates submitted. Quality level of castings shall be level 3 as per IS:9565.

Test on Welding: All welding shall be tested by Dye Penetration method. Butt welding shall be tested by Ultrasonic method. Soundness of welding shall be certified by the manufacturer.

Acceptance test on Bearing

i)All bearings shall be checked for overall dimensions.

ii) All bearings shall be load tested to 1.1 times maximum design capacity including seismic force. Bearing tested at higher loads cannot be used.

iii)A pair of bearings selected at random shall undergo testing in order to determine the coefficient of friction "μ". The coefficient of friction shall be $\leq$ 0.05 at the design load.

iv) Two bearings selected at random shall be tested for permissible rotation.

5.4.6 Installation of POT –cum-PTFE Bearings

a) General

i) Care shall be taken during installation of the bearings to permit their correct functioning in accordance with the design scheme.

ii) To prevent contamination, dismantling of the bearings at site shall not be done.

iii) The load shall be transferred on to the bearings only when the bedding material has developed sufficient strength. The props for the form work shall be removed only after lapse of appropriate time. In special cases, this can be ensured by suitable devices like jacks etc.

iv) Temporary clamps and shims (introduced to maintain working clearance) shall be removed at an appropriate time, before the bearing is required to permit movement.

v) Permitted installation tolerance of the bearing from plane of sliding shall be maintained.

vi) Cement based non-shrink grout with air releasing additive and epoxy-based grout, whichever is specified, shall be first tried at the site. For the proprietary grout mixes, appropriate instructions from the manufacturer shall be followed especially with regard to the following:

1. Preparation $\rightarrow$ concrete cleaning, roughening, pre-soaking, etc.
2. Forms $\rightarrow$ sturdiness, leak proofing, shape, header funnel vents, etc.
3. Bearing Base $\rightarrow$ cleaning, etc.
4. Placement $\rightarrow$ mixing, consistency, time period, finishing etc.
5. Protection $\rightarrow$ curing, ambient temperature, etc.

b) In-situ Casting of Superstructure

i) Form work around the bearing shall be carefully sealed to prevent leakage.
ii) Sliding plates shall be fully supported and care taken to prevent tilting, displacement or distortion of the bearings under the weight of wet concrete.

iii) Bearings shall be protected during concreting operation. Any mortar contaminating the bearing shall be completely removed before it sets.

c) Seating of bearing

A. Using Template

a) Template with required rigidity and matching holes corresponding to the base of the bearing shall be used.

b) All the anchors shall be fitted to the lower face of the template using the anchor screws but with steel washer replacing the Elastomer washers. Separate screws may be used in case of inconvenience in the length of the original anchor screws.

c) The template assembly shall be located with regard to level and alignment. It shall be ensured that the top of the anchors lie in a horizontal plane at the required elevation. The anchors shall be tied / welded to reinforcements to avoid displacement during concreting.

d) Concreting of the pedestal / pier cap shall be done to a level leaving a gap of 25-50mm below the template.

e) The template and steel washers shall be removed prior to placement of the bearing assembly with temporary clamps. The bearing assembly shall be fitted to the anchors with the help of anchor screws and Elastomer washers. Level at the bearing shall be checked.

f) The gap below the bearing assembly shall be grouted with cement-based grout. Reference may be made to Para 5.4.6 (a) (vi).

B. Without Template with Gap

a) Pockets commensurate with the sizes of the anchors shall be kept in pedestals during concreting of the same. The pedestal shall be cast approximately 25mm short of the required finished level.

b) Anchors shall be fitted to the bearing bottom with Elastomer washers and anchor screws. The bearing assembly shall be seated in the location on steel chairs / packs. The anchors fitted below the bearing shall go into pockets in the bed block. Level and alignment of the bearing shall be checked. It shall be ensured that the bearing sits in a horizontal plane.

c) The gap below the bearing assembly including anchor pockets shall be grouted with cement-based grout.

C. Without Template without Gap

Elongated pockets commensurate with the sizes of the anchors shall be kept in pedestals during concreting of the same. The geometry and location of the anchor pockets (with tapered funnel extension, if required) shall be such that after placement of the bearing the pockets can be successfully grouted. The pedestal shall be cast 5mm to 15mm short of the required finished level. The required level shall be achieved by chipping before placement of the bearing. Careful control shall be exercised to cast at the exact finished level or 1mm to 3mm down from the required finished level.

D. Seating of bearings shall be as per manufacturer's instructions.

5.4.7 Inspection and Testing

Where any patents are used, the manufacturer's certificate with test proofs shall be submitted along with the design and got approved by the Engineer before their use in work

5.4.8 Tests and Standards of Acceptance

The materials shall be tested in accordance with these specifications and shall meet the prescribed criteria.

The work shall conform to these specifications and shall meet the prescribed standards of acceptance.

5.5 MEASUREMENTS AND RATES FOR ALL TYPES OF BEARINGS

5.5.1 Measurements for payment

Bearings shall be measured in numbers of bearing supplied and installed with all required accessories, unless otherwise specified in the contract, according to their types, capacities and particular specifications given on the drawings except elastomeric bearings, which shall be measured in cubic centimeters of finished dimensions.

5.6 RIVER TRAINING AND PROTECTION WORKS

5.6.1 The following section covers works provided in the rivers / streams for safely guiding flow of water and preventing damage to bridge and approach banks by scour, undermining, outflanking etc. This work shall consist of construction of embankment of guide bund and provision of pitching/revetment on slopes, apron, toe protection, curtain walls etc., as indicated on the drawing in accordance with these specifications or as approved by the Engineer. The provisions given hereunder are applicable only to guide bunds for bridges across alluvial rivers. Guide bunds for bridges across sub mountain rivers shall call for supplemental specifications.

5.6.2 Guide Bund

5.6.2.1 Guide bunds shall generally be made of locally available materials from the river bed preferably not Cohesionless soil. Trial pits shall be taken in borrow holes to examine suitability of soil for construction and also to decide the types of earth moving machinery to be arranged. The borrow pits should be sufficiently away from the location of any apron. No borrow pits should be dug on the river side of the guide bunds.

Construction of guide bund shall be taken in hand along with the construction of the bridge. Every effort shall be made to complete the work of the guide bund in one working season. Where there is any doubt about completion of the whole guide bund within one working season, suitable measures shall be planned and executed for protection of completed work. In such cases the construction of guide bund shall be started from abutment towards upstream. It shall be built up and compacted in

accordance with relevant specifications for construction of a bank as given in Chapter 1 unless otherwise specified.

5.6.2.2 The Contractor shall furnish his proposed methodology and sequencing of works for approval of the Engineer. It should include details regarding transport of stones from the quarries to the site of work taking into account the quantities of stone required to be transported every day, type of transport facility available and labour available for loading and unloading and for laying within the time frame for construction of guide bund. Adequate reserve of stones should be maintained for major works as decided by the Engineer. Stones shall be stacked sufficiently away from the main channel of the river, as instructed by the Engineer.

5.6.2.3 Where the alignment of guide bund or the approach embankment crosses a branch channel of the river, the branch channel may be either diverted to the main channel of the river with the help of spurs, etc., or closed by a properly designed closing dyke or closure bund before taking up construction of guide bund. Such work shall be separately paid for, unless otherwise provided in the contract.

5.6.2.4 Guide bunds shall be provided with a slope pitching with stones laid over a filter media or as shown in the drawing. The toe shall be protected with an apron laid horizontal on bed, all as shown in drawing or as directed. Normally stones weighing not less than 35 kg shall be used for pitching, unless otherwise specified Apron shall be laid at as low level as possible by excavation of bed. Material thus excavated can be used for construction of guide bund, if found suitable and approved by the Engineer. Detailed specifications for Pitching and Apron have been given in subsequent Paras.

5.6.3 Filter Media for Pitching

A filter has to be provided below the layer of pitching stone over the finished earth bank, so that it forms a barrier. Otherwise, the flowing water will tend to suck the soil particles forming the bank through the interstices between stones in the pitching. A graded filter media of specified thickness (one layer preferably 200 to 300 mm thick and not less than 150mm thick) is therefore provided below the stones so as to prevent the flow of finer soil through to the pitching. The filter will not only prevent escape of embankment material through the voids of stone pitching, but also allow free movement of water through it so as to prevent any uplift head developing against the pitching stone. The filter media shall be made up of granular material as given below -

The material for filter shall consist of coarse sand, gravel or stone chips. The gradation of material shall satisfy the following requirements. It shall be made up of one or two layers of material satisfying the following criteria.

D15 (Filter) / D85 (Base) <5;

4 < D15 (Filter) / D15 (Base) <20; and

D 50 (Filter) / D 50 (Base) < 25

In the above relationships, D15 means the size of sieve which allows 15% of material to pass through. Similar is the meaning of D 50 and D 85. If filter is provided in two layers, the above-mentioned requirement shall be followed for each layer.

5.7 STONE OR BLOCK KANKAR PITCHING

The position, dimensions and slope of the pitching shall be as shown in the drawings or specified by the Engineer. The pitching shall be hand packed or roughly deposited as ordered by the Engineer or as shown in the drawing.

5.7.1 Material and Laying

a)Pitching Stone: The pitching stone shall be obtained from sources approved by the Engineer. The stone shall be sound, hard and durable. The stone should weigh between 35 to 60 kg and no stone shall be less than 15 cm in any direction unless otherwise specified, except the smaller stones for filling gaps.

b) Pitching Methodology. Dry stone pitching shall be of two kinds - dressed stone pitching and rough stone pitching.

i)Rough Stone pitching*:* The stones for rough stone pitching shall be set in the work as received from the quarry and without any dressing except knocking off weak corners and edges with a mason's hammer. A small proportion of stone chips may be allowed to show in the face work. The face stones must in general weight at least 35 kg and be well bedded and hand set. The ground on which the pitching shall be done shall be dressed to the correct profile and joint openings to the underlying fill shall be avoided by carefully arranging the various sizes of stones, and by closing the openings with small stone fragments or smaller size stones. The work shall be done so as to have a reasonably smooth surface and uniform thickness. In *roughly deposited pitching*, the stone shall be roughly leveled off to the correct section.

c) Precautions to be taken in Laying

i) All earth surfaces that are to be pitched and subsequently exposed to the action of running water, shall be covered with a filter layer of gravel, ballast or quarry chips to a depth of 15 cm to 30 cm as ordered by the Engineer, or with two layers of bricks laid flat before the placing of pitching stone, as mentioned in Para 5.6.3. The bricks, when used, shall be laid flat in a diagonal manner with top layer being laid in directly opposite direction to the lower layer. This filter layer prevents the finer material of the bank from being sucked out by the flowing water,

ii) For pitching carried out below water level, the stone shall be thrown carefully so that it may spread as uniformly as possible. This shall be ensured by taking frequent soundings to guide the dumping of stone. For this, necessary arrangement including bamboo poles, plank pathways, floating bridges or boats etc. shall be provided by the contractor and the element of their cost is included in the rate. Pitching under water shall, as far as possible, be carried out when the water level is at its lowest.

iii) Before laying stones, the sides of the bank shall be trimmed to the required slope and template cross walls shall be built to the full height of the intended thickness of

slope and apron at intervals of 30m to ensure regular straight work and a uniform slope throughout.

5.8 APRON AND CRATING

5.8.1 Apron Pitching

a) Apron pitching stone should only be flung in as it will lie and should be roughly leveled off to the correct section. There is no advantage in hand packing the apron pitching and this should never be done. Size of stone used shall vary between 35 kg and 60 kg and the proportion of different sizes shall be decided by the Engineer, unless otherwise specified in Drawings and Contract Documents.

b) The stones shall not be dressed except knocking of weak edges and corners with a mason's hammer. The face stones must be bigger size stones selected from the lot.

c) For pitching carried out under water the stone shall be thrown carefully so that it may spread as uniformly as possible. For this reason, man with poles or sounding leads must be engaged to take frequent soundings to guide the work people where to throw the stone. The cost of bamboo and plank pathway shall be borne by the Contractor and if floating bridges are necessary, their erection and maintenance shall also be borne by the Contractor.

Pitching under water should where possible shall be carried out when the water level is at its seasonal lowest.

5.8.2 Measurements for payment:

Volume of pitching, involving supply of stones, laying and filling of voids with spalls etc., shall be measured in Cubic metres without any deduction for voids.

In case of supply of pitching stones, deductions shall be made @ 15%from the volume of stacks for voids/ shrinkage. Guidelines as applicable for stacking Ballast on ground shall be followed for stacking of pitching stone.

5.8.3 Sausage and Crated stones

Galvanized iron wire: GI wire used for crating and sausages shall be of mild steel quality conforming to IS:280. The wire shall be sound, free from splits, surface flaws, rough jagged and imperfect edges and other harmful surface defects. The minimum tensile strength shall be 32 to 44 kg/mm^2 and the galvanised coating shall conform to the test given under clause 10 of IS:280.

Stones: Shingle boulder weighing 35 kg. to 60 kg (size between 20 and 40 Cm) as specified in contract or by the Engineer shall be used in filling the sausage crates with stones of smaller size to fill up the gaps in between. For pitching also size of stones used shall be of similar size.

Crating

i) Sausage – Standard practice for netting wire sausage is with 4mm dia, (8 SWG) galvanized wire mesh of 15 cm or 10 cm, double locked and non-slipping type.

ii) Sausage Crate – In case of rectangular sausage crate the same quality of materials and procedure for weaving as shown in approved drawings shall to be followed. The sequence of operations for assembling the crate and the process narrated for end binding with illustrations should be followed as in approved drawings. In absence of any drawing following guide lines (extracted from Section 2503.3 of MOST specifications) may be followed.

"The mesh of the crate shall not be more than 150 mm".

Wire crates for shallow or accessible situations shall be 3 m x 1.5 m x 1.25 m in size. Where they have to be deposited and there is a chance of overturning, the crate shall be divided into 1.5 m compartments by cross netting. For deep and inaccessible situations, wire crates can be made smaller subject to the approval of the Engineer.

Wire crates built in-situ, shall not be larger than 7.5 m x 3.0 m x 0.6 m, nor smaller than 2 m x 1m x 0.3m. Sides of large crates shall be securely stayed at intervals of not more than 1.50 m to prevent bulging.

Wherever possible, crates shall be placed in position before filling with boulders. The crates shall be filled carefully by hand packing of the boulders as tightly as possible and not merely throwing stones or boulders."

5.9 MEASUREMENTS FOR ALL TYPES OF PROTECTION WORKS

i) The earthwork in construction of embankment for guide bund shall be measured in cubic metres unless otherwise specified. The boulders /cement concrete blocks and wire crates in apron shall be measured in cubic metres.
ii) The filter and stone pitching shall be measured separately in cubic metres unless otherwise specified.
iii) Rubble stone/ cement concrete blocks, flooring and cement concrete bedding shall be measured in cubic metres for each class of work. Preparation of base for laying the flooring shall be deemed incidental to the work.
iv) For laying apron, excavation upto an average depth of 150 mm shall be deemed to be included in the main item and shall not be measured separately unless otherwise specified. Excavation more than 150 mm shall be measured in cubic metres as given in Chapter -1 for earthwork. If any of the quantity excavated is used in the guide bund, such quantity shall be deducted from such measurement for excavation.
v) The item of work also includes excavation upto an average depth of 150 mm unless specified otherwise.

5.10 SPECIFICATIONS OF STEEL WIRE ROPENET FOR ROCKFALL PROTECTION WORKS

High strength steel wire rope nets comprise of galvanized steel wire ropes in both vertical and horizontal directions. At the intersections, vertical and horizontal chords have a tucked joint fixed with special clamps. The nets comprise an upper hang portion with only vertical chords for anchorage and a lower net portion with both vertical and horizontal chords so as to retain the boulders. The appropriate aperture size and

length of the hang and net portions are selected to suit site requirements. The product is suitable for rock-fall protection applications requiring high strength and durability.

5.10.1 Specifications of High Strength Steel Wire Ropenet

Property	Specification
Product Types	450mm x 600mm
Properties of the Steel Wire Rope	
Material	Galvanised Steel Wire Rope
Rope Grade	1770 N/mm2
Nominal Diameter	9 mm
Min. breaking force	4500 Kgf
Construction of wire rope	6 x 19 with fibre (polypropylene) core
Tensile Strength of wires & zinc coating	IS:1835
Properties of the Ropenet	
Construction of the net	Joints tucked in one direction and clamped
Aperture Size	450mm (horizontal) x 600mm (Vertical)
Tensile Strength of Net Vertical Direction: Horizontal Direction:	 8500 Kg/m 6700 Kg/m
Punching strength	7000 Kg
Dimensions of Ropenet	
Length of hang portion	6 m (or as per site requirement)
Length of net portion	10 / 15 / 20 / 25 / 30 / 35m (as per site requirement)
Width	5m (± 5%)

Note: 9mm steel wire rope for Rope net to be specifically made with pitch of 75± 5mm to suit specific application of fabrication of Rope nets.

5.10.2 Construction of Rope

6 x 19 S (9-9-1) with fibre (Polypropylene) core or 6 x 19 M (12/6-1) with fiber (Polypropylene) core as per IS:2266

a)If it is 9-9-1, diameters of wires in 3 layers may be as follows:

Outer 9 wires of 0.72 mm diameter

Middle layer 9 wires of 0.42 mm diameter.

Centre wire 1 of 0.92 mm diameter.

b) If it is 12/6-1, diameters of wires in 3 layers may be as follows:

Outer layer – 12 wires of 0.60 to 0.63 mm diameter

Middle layer – 6 wires of 0.60 to 0.63 mm diameter

Centre layer – 1 of 0.72 to 0.76 mm diameter.

5.10.3 Tensile Strength of Wire & Zinc Coating

As per IS:1835

i) Strength of wires: 1770 N/mm2

ii) Zinc Coating AB type as follows:

Diameter of Wires in mm	Zinc Coating in gm/sqm
0.40-0.50	60
0.50-0.60	70
0.60-0.80	85
0.80-1.00	95

5.10.4 Installation Methodology

The installation of High Strength Steel Wire Rope nets and Hexagonal Double twisted wire mesh for rock fall protection involves the following steps:

5.10.4.1 Site Preparation

Remove all surface vegetation including trees & shrubs in the cutting where rope netting has to be done. Loose boulders have to be removed in block condition on slope of rock cutting including removing of loose rock/undulations & dressing side slope to facilitate spreading of Rope net.

5.10.4.2 Top anchoring

Position of top anchoring should be at a minimum distance of 6 m from the face of cutting. For any deviation from the above mentioned, approval of Engineer-in-Chief is mandatory.

In case of soft soil or moorum present on top of cutting, a top trench of 1.0 m depth & 0.6 m width has to be excavated at a distance of approximately 6.0 m from edge of cutting for top anchoring of Rope net. Rope nets are available with eyes or loops in vertical chords for anchoring.

A Precast RCC beam of 0.15 m x 0.15 m x 2 m of M15 concrete is used for top anchoring. RCC beam is inserted through loops of chords & beams are placed inside excavated trench.

Precast beam along with anchoring chords is embedded inside trench by M10 concrete of 0.3 m depth. After curing of concrete, the trench is filled with backfill muck with moderate compaction.

5.10.4.3 Lacing of adjacent rope nets and / or hexagonal wire mesh with Rope nets

After top anchoring of repents, adjacent nets are laced so as to form a continuous net. If Hexagonal wire mesh is also specified, mesh is laced beneath ropenet. Specially designed galvanized steel spiral locks are used for lacing. One spiral lock for each mesh of net is used.

5.10.4.4 Spreading

After lacing, the continuous nets / nets and mesh are rolled from top to bottom of cutting so as to cover the cutting.

5.10.4.5 Intermediate anchoring

Nets are anchored on the cutting slope using anchor bolts/fasteners of 10–12 mm diameter and 110mm length. For every 5sqm of surface area, one anchor bolts is fixed with epoxy coated M.S. plate of 200mm x 200mm x 6mm as washer. Intermediate anchoring is required so that nets take the shape of cutting profile and hug the rock surface. Anchor bolts are fixed by drilling a hole for anchors and applying a torque of 65 to 70 Nm after washer plates are placed over the rope nets.

5.10.4.6 Bottom Anchoring

HYSD bolts of 1m depth & 16mm diameter, having a thread of 200mm on top are used for bottom anchoring. Bottom anchoring is done in a staggered manner such that each vertical chord of rope net is anchored.

A drill hole of 20 mm diameter is made with the help of a jack hammer upto a depth of 1m in a staggered manner. Each hole is filled with 3-4 cement capsules and bolts are driven to desirable depth. Nuts are tightened on threaded portion of anchor bolts after epoxy coated washer plates of 200 mm x 200 mm x 6 mm are placed over ropenet.

5.11 SPECIFICATIONS OF MECHANICALLY WOVEN DOUBLE TWISTED HEXAGONAL SHAPED WIRE MESH GABIONS

5.11.1 Mechanical Properties

a) Tensile Strength – Tensile strength of wire used for mechanically woven, double-twisted hexagonal shaped mesh, lacing wire and stiffener, when tested shall be in accordance with requirements of specification BS 1052 – (350 to 550 N/mm^2) at minimum elongation of 10%.

b) Tensile strength of Mesh Panel –Minimum tensile strength of Mesh panel must be 32 kN/m in the parallel to twist direction.

5.11.2 Physical Properties

a. Zinc Coating – Coating weights shall be **Heavily Galvanized** conforming to requirements of specifications: ASTM A 641.

b. Adhesion of Zinc Coating – No flakes shall be observed while testing for adhesion of Zinc coating as per ASTM A 641.

Mesh Type	10 x 12	Specifications
Mesh Opening ‘D’ mm	100	EN10223
Mesh Tolerance	+16% to –4%	EN10223
Unit Dimensions	L x W x H	
Tolerances in sizes of units	L & W +/- 5%: H <= 0.3m +/- 10%: H > 0.3m +/- 5%	ASTM A975
Characteristics	Only Zn + PVC Coated	
Mesh Wire Dia mm	2.7/3.7 (I.D/O.D)	EN10223
Tolerance (+/-) mm	0.08	BS1052
Zn Coating Min (gsm)	240	ASTM A 641
Selvedge / Edge Wire Dia mm	3.4/4.4 (I.D/O.D)	EN10223
Tolerance (+/-) mm	0.10	BS1052
Zn Coating Min (gsm)	260	ASTM A 641
Lacing Wire Dia mm	2.2 / 3.2 (I.D/O.D)	
Tolerance (+/-) mm	0.06	BS1052
Zn Coating Min (gsm)	220	ASTM A 641
PVC Coating		

Thickness Nominal (mm)	0.50	ASTM A 975
Thickness Minimum (mm)	0.38	ASTM A 975
Hardness	Between 50-60 Shore D	ASTM D 2240
Colour	Grey RAL 7037	ASTM D 1482
Tensile Strength	Min. 20.6 MPa	ASTM D 412
Specific Gravity	1.3 to 1.35	ASTM D 792

5.11.3 Installation Methodology

5.11.3.1 Assembly

Gabions are supplied folded flat and packed in bundles. Larger units may be supplied in rolls. Units are assembled individually by erecting the sides, ends and diaphragms, ensuring that all panels are in correct position and tops of all sides are satisfactorily aligned. The four corners shall be connected first, followed by the internal diaphragms to the outside walls. All connections should use lacing wire. Procedure for using lacing wire consists of cutting a sufficient length of wire and first looping and/or twisting the lacing wire to wire mesh. Proceed to lace with alternating double and single loops through every mesh opening approximately every 150mm, pulling each loop tight and finally securing the end of lacing wire to wire mesh by looping and/or twisting.

5.11.3.2 Installation

After initial assembly, gabions are carried to their final position and are securely joined together along the vertical and top edges of their contact surfaces using the same connecting procedure(s) described in the previous section. Whenever a structure requires more than one layer, upper empty baskets shall also be connected to the top of the lower layer along the front and back edges of contact surface using the same connecting procedure(s) described in previous section.

5.11.3.3 Filling

Gabions shall be filled with rock or stone fill. Rock for gabions shall be hard, angular to round, durable and of such quality that they shall not disintegrate on exposure to water or weathering during the life of structure. Gabion rocks shall range between 150mm and 200mm. Range in sizes shall allow for a variation of 5% oversize and/or 5% undersize rock, provided it is not placed on gabion exposed surface. During filling operation, good hand packing & stone placement is required to minimize voids. Exposed faces of vertical structures may be carefully hand placed to give a neat, flat and compact appearance. Care shall be taken when placing fill material to assure that sheathing on PVC coated baskets will not be damaged. Cells shall be filled in stages so that local deformation may be avoided, i.e. at no time shall any cell be filled to a depth exceeding (0.30 m) higher than the adjoining cell. It is also recommended to slightly overfill the baskets to allow for settlement of the rock. Behind gabion walls, compact the backfill material simultaneously to same level as the filled gabions.

5.11.3.4 Internal Connecting Wires

Internal connecting wires should be used when a structure requires layers of gabions to be stacked on top of each other. Internal Connecting Wires shall connect exposed face of a cell to the opposite side of cell. An exposed face is any side of a gabion cell that will be exposed or unsupported after the structure is completed. Lacing wire or prefabricated internal connecting wires may be used.

1m High Gabions

1.0 m high gabions shall be filled in three layers, 0.3m at a time. Connecting wires shall be installed after the placement of each layer, i.e. at 0.3m high and 0.6m high.

0.5m High Gabions

0.5 m high gabions do not require connecting wires unless the baskets are used to build vertical structures. In some cases, these units shall be filled in two layers; connecting wires shall be installed after the placement of the first layer.

5.11.3.5 Lid Closing

Once the gabion baskets are completely full, the lids shall be pulled tight until lid meets the perimeter edges of basket. Lid must then be tightly laced and/or fastened along all edges, ends and tops of diaphragm(s) in the same manner as described in the previous section.

5.11.3.6 Backfilling

Suitable backfill material as per project specifications should be provided after a layer of gabions is erected. Layer wise compaction needs to be done. Ensure a light weight roller is used when compacting upto a distance of 1.0m from the gabion. Adequate care should be taken so that Geo-textile is not damaged.

5.12 SPECIFICATIONS OF POLYMER ROPE GABIONS

The polymer ropes shall be manufactured from polypropylene. Polymer Rope Gabions shall be fabricated from polymer rope nets (4 strands - 9 mm dia rope) with woven joints and mesh sizes as mentioned in the specifications. Length of gabions shall be decided by ease of handling and site conditions. All gabions shall be supplied in the collapsed form, either folded and bundled or rolled for shipping.

Gabions of length more than 1.5m shall have diaphragms at a spacing of 1.0m. It is suggested to use PP Tarred rope gabions than normal PP rope gabions for its better abrasion resistance and UV resistance.

5.12.1 Specifications

The specifications of PP Tarred Rope Gabions of 9mm Dia. rope, 4 strand, with aperture sizes of 100mm x 100mm and 150mm x 150mm with/without lid and slings are given in Table as below:

Specifications of 9mm Tarred Rope Gabion, 100mm X 100mm Mesh Size: 4 Strand

Properties	**Specifications**
Size of body and border rope	9 mm having a weight of 42gm/m with a tolerance of ±8%.
Material of rope	PP (with adequate UV stabilizer)
Mesh opening size	100mm X 100mm
Tensile Strength	(a) 9 mm PP Tarred Rope 1560 Kg Breaking Strength (min.) (b) Rope Net 15000 Kg /m width Breaking Strength (c) Punching Shear Strength 6000 Kg.
Structure of the rope	4 strand shroud laid
Construction of net	Woven joint at the intersection of ropes
Abrasion resistance	The rope when tested as per procedure shall have a residual B.S. of at least 90% of the stipulated rope strength at the end of 1000 cycles.
Thermal Stability	The rope when tested as per procedure shall have a residual strength of 90%.
Type approval as per OCIMF 2000 by LRA / ABS / BVQI	Type approval Certificate from LRA / ABS / BVQI to be submitted.

Cyclic Load Fatigue Test (TCLL)	Minimum 60 % of NWBS Certificate from independent Inspection Agency such as LRA / ABS / BVQI to be submitted
Wt. % of Tar	5 to 10 %
Resistance to UV radiation	Material shall be adequately UV stabilized

Note:

1. Testing of Linear Density & Pitch (Length of Lay) of 9 mm 4-Strand PP Rope to be done as per Indian Standard IS:7071 (Part I to III).

2. Breaking strength of Rope, Rope Net, Abraded rope and Rope subjected to thermal stability to be done as per IS:7071 - Part IV

Installation Guidelines

Profile shall be prepared to the extent shown on the plans or as directed by the engineer. All Loose or unwanted materials shall be removed. All depression shall be carefully backfilled up to desire grade and compacted. Any buried debris protruding from foundation that will impede proper installation and final appearance of gabion or gabion mattress shall also be removed and void carefully backfilled and compacted as specified in the drawing.

Gabions shall be filled with rock or stone fill. The rock for gabions shall be hard, angular to round, durable and of such quality that they shall not disintegrate on exposure to water or weathering during life of structure. Gabion rocks shall range between 150mm and 200mm. Range in sizes shall allow for a variation of 5% oversize and/or 5% undersize rock, provided it is not placed on the gabion exposed surface.

During the filling operation good hand packing & stone placement is required to minimize voids. The exposed faces of vertical structures may be carefully hand placed to give a neat, flat and compact appearance. Cells shall be filled in stages so that local deformation may be avoided, i.e. at no time shall any cell be filled to a depth exceeding

(0.30 m) higher than the adjoining cell. It is also recommended to slightly overfill the baskets to allow for settlement of rock. 1m high gabions shall be filled in three layers, 0.3m at a time.

Once gabion baskets are completely full, lids shall be pulled tight until lid meets the perimeter edges of basket. Lid must then be tightly laced along all edges, ends and tops of diaphragm(s) in the same manner as described in previous section.

SPECIFICATIONS FOR P.WAY WORKS

GENERAL

1. The latest version of following codes, manuals, standards and guidelines with up-to-date addendum/corrigendum shall be used for different items of Permanent Way Works for execution, quality assurance, tests, check and acceptance and form parts of the specification.

a) Indian Railway Permanent Way Manual, 2020 (with latest CS)

b) Manual for Ultrasonic Testing of Rails and Welds - Revised in year 2022 (with latest Correction Slips, specifications and guidelines)

c) Manual for Fusion Welding of Rails by Alumino – Thermic Process -2022 (with latest CS)

d) RDSO Guidelines for Handling and Stacking of Rails (CT-35, October-2014)

e) Manual for Glued Insulated Rail Joints (First Reprint-2022) Embodying all advance Correction Slips up to No. 07 dated 28.02.2020 and ACS-8 to Manual for Glued Insulated Rail Joints (1998)

f) Manual for Flash Butt Welding of Rails – 2022 (with latest CS)

g) Indian Railways Standard Schedule of Dimensions 2004 (with latest CS)

h) General & Subsidiary Instructions

i) Indian Railways Small Track Machine Manual-2005 (with latest CS)

j) Track Manual Volume-I

k) Track Manual Volume-II

l) Indian Railway Works Manual

m) Manual for Reconditioning of Medium Manganese (MM) Steel Points and Crossings and SEJs-1996 and revised in year 2020

n) Work Procedure for Reconditioning of Cupped AT Welding Joints and Wheel Burn/Scabs Using “Robotic Welding Machine” (Provisional) 2019

o) Indian Railways Code for The Engineering Department

p) Accident manual

q) All track circulars of zonal Railways with up-to-date correction slips.

r) All Engineering Standing orders of zonal Railways up-to-date.

s) Other standard specifications in force.

t) If latest version of any Codes, Specifications and manuals as aforesaid are issued stand alone or clubbing different Codes, Specifications and manuals, the latest version with updated correction slips as on date prescribed in the tenders/contracts shall be applicable.

2. All safety precautions prescribed while working near running track and OHE must be in place to start any works. Any effect in the safety of existing works/structures on account of new works should be assessed and necessary precautions should be taken.

3. Contractor has to engage on the works his labour, materials, machinery, consumables, tools & plants etc. required to complete the work in all respect unless specifically specified otherwise. He should engage qualified technical person(s) who is well versed in track works for supervising the works safely and he should possess a valid competency certificate issued by Railways to carry out all P. way works as prescribed.

4. Protection of work site on running track or adjacent track shall be ensured by Railway at Railway's cost. However, necessary look out men to ensure safety of contractor's workman/work women to be made available at site by contractor with clear instructions of contractor's representative/Engineer-in-charge/contractor himself. Contractor's men must have ID issued jointly by Railway and contractor to work on track.

5. Materials which are to be supplied by Railways free of cost as per description of items etc. will be supplied at specified location(s). Contractor should transport these materials from source of supply to site of work & back at his own cost for which no extra payment shall be made unless otherwise specified in contract agreement.

6. Cost of any material (supplied by Railway) if used in excess of authorized quantity by Railway as specified against the relevant items shall be recovered from the contractor's bills at 'twice' the issue rate or as per extant orders in force.

7. No work on track to be taken up without authorized Railway Official's presence.

8. After packing under sleepers, it has to be ensured that track parameters like gauge, levels, alignment, packing etc., are within the permissible tolerances specified in latest IRPWM.

9. During course of any work, if any materials get damaged due to negligence of contractor, recoveries shall be made from the contractor bills and Engineer's decision in this regard shall be final.

10. Measurements:

a) Track meter/Track Running meter: Means full track including side rails, shoulder & crib ballast, length to be measured physically along centerline using standard tape unless otherwise specified. Measurements shall be made nearest to centimeter

b) Running metre: Means only one side rail of track to be measured physically using standard tape. Measurements shall be made nearest to centimeter.

c) 1 MTKM: Means Transporting 1 ton of material to a distance of 1km. Distance shall be made nearest to 0.01km and weight shall be made nearest to 0.01 tons.

d) MT: Means Metric Ton for which nominal weight of material to be considered and weight shall be made nearest to Kilogram.

e) In case of Sqm, Cum, measurements shall be made nearest to cm and areas & volumes shall be calculated nearest to two places of decimal.

f) Packing (unit per sleeper) means half the sleeper spacing on either side of sleeper along track and below sleeper.

g) While carrying out works like Deep Screening/Sleeper renewal/Rail renewal/Through packing etc., gauge, levels, alignment, packing, boxing of ballast etc. of all the disturbed approaches (adjacent length also) are to be attended as per the instructions of Engineer in charge.

11. Set means

1) For rail renewal

1 in 8½ -29.50M and 1 rail length each in all the 3 approaches.
1 in 12-41.00M and 1 rail length each in all the 3 approaches.
1in 16-52.50M and 1 rail length each in all the 3 approaches.

2) For sleeper renewal/Deep screening (fan shaped lay out)

1 in 8½ -67 nos. sleepers
1 in 12-96 nos. sleepers
1 in 16-114 nos. sleepers

3) For through packing (fan shaped layout)

1 in 8½ -37M
1 in 12-52M
1 in 16-66M

Chapter-6
Rails, Sleepers and Fittings Renewal

6.1 Renewal of Rails

6.1.1 The item of the work envisages removing existing rails/rail panels from existing track at various locations complete with removal of rail Sleeper fastenings, fish plate, bolts etc. and all incidental works.

6.1.2 No consideration shall be given to the loss of weight of Rail on account of wear/corrosion etc. and only nominal rail section would be considered for purpose of payment in case of second-hand rails.

6.1.3 The work shall be carried out as per the Railway's standard drawings, provisions contained in Indian Railways Permanent Way Manual and the extant instructions.

6.1.4 The work shall involve removing fishplates and fish bolts, sleeper-rail fastenings and removing the rail/rail panels from the sleepers leading and stacking them at a safe distance away from the track in segregated manner.

6.1.5 The rails removed from the track should be cleared from the existing track so as not to infringe the Railway's Schedule of Dimensions.

6.1.6 Fish plates, bolts, nuts, clips and keys etc. removed during the operation shall be stacked neatly at specified location(s).

6.1.7 For handling rails, slings, rail tongs, rail dollies etc. or other similar standard equipment shall only be used. All necessary precautions shall be taken for handling of rails as per guidelines issued by RDSO.

6.1.8 The above provisions shall also be applicable to tongue rails, switch assembly and crossing assembly.

6.2 HANDLING OF RAILS.

6.2.1 Any carelessness in loading, unloading, handling and laying of rails is liable to cause damage, which will not only contribute towards bad running but also result in irreparable damage to, or incipient failures of rails.

6.2.2 During loading and unloading, ramps of un-serviceable rails should be made and the rails slid over them, intermediate supports being given to prevent excessive sagging. Preferably, crane may be used for loading/unloading of single rails using lifting beam with number of supports specified as per length. For handling rails, slings or tongs should be used.

6.2.2.1 When hauled into position, prior to linking or otherwise, rails should be so spread as to rest evenly along their entire length or on supports closely spaced and should lie on the foot.

6.2.2.2 During any operation requiring marking of rails such as yard surveys, curve adjustments, and realigning operations etc., the marking on rail shall be done by paint mark only and chisel or punch marking is not permitted.

6.2.2.3 The gas cutting of rails; and making of holes using gas is prohibited.

6.2.2.4 While stacking rails, care shall be taken that:

(a) The ground is level and well drained.

(b) Free rails are supported at least at four points, evenly along their length; Welded rail panels shall be so spread on cess as to rest evenly along their entire length on supports spaced at 4 metre centre to centre to prevent formation of kinks.

(c) Each stack of the rail should be of the same section and class.

(d) Detailed guidelines on stacking of rails as contained in RDSO's Guidelines for Handling and Stacking of Rails (No. CT-35) *or latest* may be followed in this regard.

6.3 LAYING AND FIXING RAILS/RAIL PANELS

6.3.1 The work envisages laying and inserting rails of section as specified in the schedule and fixing rail and rail-sleeper fastenings and fittings etc. including all leads, lifts/descents etc. and all incidental works.

6.3.2 The work to be carried under full traffic block only, unless specified.

6.3.3 No consideration shall be given for loss of weight on account of wear/corrosion etc., and only nominal rail section would be considered etc., for purpose of payment in case of secondhand rails.

6.3.4 The work shall be carried out as per the Railway’s standard specifications, drawings, provisions contained in Indian Railways Permanent Way Manual and the extant instructions.

6.3.5 Laying and fixing will include predrilled and precut rails on previously laid sleepers as per Railway’s drawing and/or as per extant instructions.

6.3.6 Rail/Rail panels of equal length shall be used in pairs for laying and fixing.

6.3.7 Rail joints shall be square to alignment, while on the curved alignment, cutting of inner rails shall be done at suitable intervals when lead of inner rail is equal to half pitch.

6.3.8 Fixing fish plates and fish bolts and other rail and rail-sleeper fastenings as per Railway’s drawing and/or as per extant instructions. The fish bolts shall be applied one coat of black oil as prescribed.

6.3.9 Hammering of fish bolts is prohibited. The fish bolts shall not be over tightened and shall be tightened with standard spanner/torque spanner. The inner two fish bolts should be tightened first.

6.3.10 This work shall include fixing grooved rubber pads, liners and elastic rail clips with prescribed tools and as per standard drawing and as per extant instructions.

6.3.11 The frozen (gapless) joints are required to be provided at specified locations such as at combination fish plates, joints behind CMS crossings and SEJs with closure end etc.

6.3.12 It shall be ensured that the handling of rail is as per extant instructions and shall not infringe the Railway's Schedule of Dimensions.

6.3.13 Longitudinal movement of rails / pairing to be done with rail dollies/rollers by pulling and not by hitting with rail piece.

6.3.14 Use of kinky rail may be avoided.

6.3.15 Marking on rails with punch or chisel is strictly prohibited.

6.3.16 The above operation shall be completed on the base rail first which shall be first aligned and fixed in position before the other rail is fixed to the gauge as stipulated.

6.3.17 The gauge shall be maintained as per the Indian Railways Permanent Way Manual or as per extant instructions.

CASUAL RENEWAL OF RAILS AT ISOLATED LOCATIONS

6.3.18 Renewal of rails at isolated locations includes renewals of rails with Glued joints, defective/corroded rails, REM/IMR Rails/Welds (advised by USFD operator) as per the instructions of Engineer in Charge.

6.3.19 The rails to be inserted in track shall be of

i) USFD tested and free from corrosion, corrugation, scabbing, wheel burns, flattening of rail table etc.
ii) Hogged and battered ends should be eliminated by cutting suitably.
iii) Cutting should be true to vertical.

6.3.20 The work shall be carried out as specified in latest IRPWM

6.3.21 The work shall be done under full block protection.

6.3.22 Local de-stressing may be necessitated if the renewal of rail falls in LWR/CWR region. In this case provision shall be made for local de-stressing and welding of rails joints.

6.3.23 Renewal of SLEEPERS.

6.3.24 The work of removal of sleepers envisages removing shoulder ballast, ballast adjacent to sleepers and loosening ballast below sleepers along with removal of rail /sleeper fastenings for easy removal without using force causing any damage to sleepers, and stacking the released material at specified location and all other incidental works.

6.3.25 The work shall be carried out as per the Railway's standard drawings, and provisions contained in Indian Railways Permanent Way Manual and extant instructions.

6.3.26 The sleepers removed from the track shall be cleared from the existing track so as not to infringe the Railway's Schedule of Dimensions.

6.3.27 Sleepers and the fittings removed during the operation should be stacked properly class wise.

6.3.28 For handling sleepers, approved equipment shall be used and it must be ensured that no damage is caused to the rails, sleepers and fastenings.

INSERTION OF SLEEPERS IN EXISTING TRACK

6.3.29 The above item of the work envisages inserting sleepers as specified in the schedule at locations as per Railway's requirements.

6.3.30 The work shall be carried out as per the Railway's Standard drawings, provisions contained in Indian Railways Permanent Way Manual and the extant instructions.

6.3.31 Inserting the sleepers in the track including fixing of sleeper with fastening etc. at prescribed location.

6.3.32 The sleeper position shall be paint marked on the rail and the sleepers shall be inserted exactly at these locations. Work shall be executed in a manner so as not to infringe the Railway's Schedule of Dimensions.

6.3.33 The rail-sleeper fastenings like ERCs, rubber pads, liners, etc. shall be fitted as per the Railways standard drawing and/as per extant instructions.

6.3.34 For handling sleepers approved equipment shall be used and it must be ensured that no damage is caused to the sleeper.

6.3.35 While laying concrete sleepers necessary steps have to be ensured to prevent seizure of ERCs in MCI inserts. All the ERCs and MCI inserts shall be thoroughly cleaned. Grease graphite "O" to IS:408 specifications should be applied on the central leg of the ERC and eye of MCI insert and then these clips should be driven at the time of laying sleepers.

6.3.36 On stretches where deep screening is not being done simultaneously, the work shall also include:

i) Removing ballast at location where sleeper is to be inserted up to 50mm below the bottom of sleeper to be inserted.
ii) Putting back the ballast so removed into track after the insertion of the sleeper.
iii) Initial packing of the sleeper so inserted so as to maintain track geometry fit for specified speed.

6.4 LEADING/CARRYING, COLLECTING AND STACKING/SPREADING RAILS

6.4.1 Leading/Carrying, collecting rails up to 13m in length or welded rail panels from nominated Depots/Stacks Locations complete within leads as specified in the schedule, including all lifts/descents and incidental works.

6.4.2 Stacking/Spreading the rails or rail panels at nominated Depots/Stacks/Locations and complete with leads as specified in the schedule, all lifts descents and incidental works.

6.4.3 The work shall be carried out as per the relevant provisions in Indian Railways Permanent Way Manual and the extant instructions.

6.4.4 Carrying rails on the heads or shoulders is prohibited. For handling rails, slings, rail tongs, rail dollies etc. or other similar equipment shall only be used.

6.4.5 While stacking/spreading rails care shall be taken to ensure that:

a) The rails are sorted rail-section wise and class wise

b) The rails are stacked on level ground.

c) The rails are so spread as to rest evenly along their entire length or on supports closely spaced with flat-footed rails resting on the foot.

d) In case of spreading rails alongside track, single rails/short welded panels not proposed to be converted into LWR/CWR, shall be paired to ensure squaring of joints.

6.4.6 While working in the vicinity of existing open track it shall be ensured that the Railway's Schedule of Dimensions are not infringed with. It shall be ensured that the rails do not move under vibrations of running trains or otherwise. While working in track circuited areas, particular care shall be taken to avoid short circuiting. Damage to signaling gadgets should also be avoided.

6.4.7 Use of rail dollies/dip lorry for leading/hauling of rail on open line track can be resorted to only with the approval of the Engineer and it should be carried out only under the supervision of the Railway engineer or his authorised representative holding a competency certificate for working lorries/trolleys in the mid-section.

6.5 CUTTING OF RAILS

6.5.1 The above item of work envisages cutting of rails on cess/running track at isolated locations/nominated Depots/Stacks complete.

6.5.2 The item includes handling of rails if required to keep in position for cutting and all incidental works.

6.5.3 For cutting/drilling, only contractor's own machines are to be used, no manual drilling/cutting is permitted.

6.5.4 The work shall be carried out as per provisions in Permanent Way Manual and extant instructions issued from time to time.

6.5.5 The cut shall be vertically made in a plane at right angle to the foot as well as the running edge of the rail.

6.5.6 Flame/Gas cutting is forbidden. Use of Jim-crow to avoid cutting is forbidden and breaking of rails by not fully cutting is also forbidden.

6.6 DRILLING HOLES IN RAILS

6.6.1 The work of drilling holes in rail includes chamfering of holes of prescribed diameter in rails on cess/running track at isolated locations/nominated Depot/Stacks complete.

6.6.2 The item includes handling of rails if required to keep in position for drilling and all incidental works.

6.6.3 The work shall be carried out as per the Railway's standard drawings and/or as given in the Indian Railway Track Manual. Indian Railways Permanent Way Manual and extant instructions.

6.6.4 The hole shall be drilled at the exact location and truly perpendicular to rail axis and horizontal.

6.6.5 Chamfering of holes is to be done using standard chamfering tool invariably after drilling hole to remove burrs and for work-hardening.

6.6.6 The finished diameter of the hole in the rail shall be as follows;

6.6.7 For Rails of sections 60Kg, 52Kg, 90R - 32mm, 28mm, 26.5mm, 18mm, 7.2mm etc depending on the site requirement.

6.6.8 Punching or Reaming/Drifting on rail shall not be permitted.

6.6.9 The use of flame/gas cutting equipment for drilling of holes is forbidden.

6.7 RENEWAL OF ERCs/GREASING OF ERCs / THROUGH RENEWAL OF FITTINGS.

6.7.1 The work shall be done as stipulated in IRPWM and guidelines issued from time to time.

6.7.2 Grease used for lubrication shall be to IS:408 ('0' graphite) specifications.

6.7.3 In LWR track Renewal/greasing shall not be done simultaneously at more than one sleeper at a time and at no point of time ERC to be removed for two consecutive sleepers in a continuous length of 15 sleepers in case rail is not to be lifted, and 30 sleepers if rail is to be lifted.

6.7.4 The work shall be done under direct supervision and satisfaction of the person in charge not less than the grade of JE/P.Way.

6.7.5 The work shall be carried out under caution order.

6.7.6 Removal and driving of ERC to be done by ERC Extractor in general. However, for works at isolated locations, standard hammer may be used taking due precaution ensuring no damage to ERCs and MCI inserts.

6.7.7 The ERCs should be driven in such a way that the leg of the ER clips flush with the end face of the MCI insert.

6.7.8 The work shall be confined to the hours when the rail temperature is between td+10 degrees and td-30 degrees Centigrade.

Chapter - 7
Turnouts and Renewals

7.1 ASSEMBLING POINTS AND CROSSINGS OF FAN-SHAPED LAYOUTS WITH PSC SLEEPERS.

The work shall be done as per the standard layout drawings and as stipulated in IRPWM.

7.1.1 Correct spacing of sleepers as stipulated in standard layout drawing shall be marked on non-gauge face side of rails and fix the sleepers accordingly.

7.1.2 Plate screws, ERC central leg and eye of the MCI insert shall be applied with approved quality of grease of specification IS:408 (‘0’ graphite).

7.1.3 Assembling shall be done in such a way that the joints of crossing and stock and tongue rails are of gap less.

7.1.4 Provision shall be made to weld all the remaining fish plated joints.

7.2 REMOVAL AND INSERTION OF BROKEN/DAMAGED SLEEPERS ON POINTS AND CROSSING.

7.2.1 The work includes removal of ballast around and underneath the sleeper without disturbing approach sleepers, fittings and taking out the sleepers.

7.2.2 Insertion of new sleepers at correct location, re-fixing the fittings, packing and putting back the ballast. The work shall be done with due care under traffic condition without block protection.

7.3 RENEWAL OF CMS/BUILT UP CROSSINGS

7.3.1 The work shall include removal of fittings, crossings, insertion of new/reconditioned crossing and re-fixing the fittings duly replacing worn-out/missing fittings if any.

7.3.2 Care shall be taken to see that gapless joints are maintained after renewal.

7.3.3 Packing shall be done duly correcting cross levels, unevenness and alignment. Correct gauge should be maintained.

7.3.4 The work shall be done under full traffic block protection and under the supervision of not lower than the grade of JE/P.WAY

7.4 REMOVAL /LAYING OF SWITCH.

7.4.1 The work shall be done under full **traffic** block protection.

7.4.2 The setting of tongue rail to stock should be to suit as per the instructions laid down in latest IRPWM and S&T manual.

Chapter – 8
Deep Screening and Ballast Related Activities

8.1 DEEP SCREENING OF TRACK

8.1.1 The item of work envisages deep screening of ballast below the bottom of the sleeper as required with disposal of muck/spoils within specified lead and lifts/descent. The procedure for doing the work has been described in Indian Railways Permanent Way Manual and other extant instructions and the same is to be adhered to. The work of deep screening is to be carried out under a speed restriction of 20KMPH without traffic block under direct supervision of Railway representative not lower than the grade of JE/P. Way.

8.1.2 The work shall include removing ballast including the core below the sleeper and excavating up to the prescribed depth below the bottom of sleeper. The ballast so removed, shall be screened by using portable ballast cleaners/inclined ballast screens. Use of wire baskets is not permissible for screening. Muck/Spoils should be disposed off suitably for ensuring proper drainage of track.

8.1.3 The excavation should be so carried out so as to ensure that the cross slope of 1 in 30is provided. The excavation should be over the entire width of formation.

8.1.4 The track shall be surveyed in advance and pegs indicating the final level should be provided at 30m intervals. The rail level after deep screening shall be ensured to the levels as indicated on the pegs.

8.1.5 Sufficient nos. of wooden blocks/temporary supports required for the work as prescribed in the manual shall be arranged by agency before start of the work.

8.2 DEEP SCREENING OF POINT AND CROSSINGS

8.2.1 The operations of the work shall be as is done in case of ordinary track and as directed by Engineer in charge.

8.2.2 Extra care should be taken while doing switch portion so that interlocking should not be failed and S&T staff to be informed for their presence during the work.

8.2.3 Not more than one sleeper shall be tackled at a time in switch portion. Only after thorough packing of the tackled sleeper next sleeper should be taken up.

8.2.4 In the same way crossing portion also shall be done.

8.2.5 The work of deep screening is to be carried out under a speed restriction of 20KMPH without traffic block and under direct supervision of Railway representative not lower than the grade of JE/P. Way.

8.3 SHALLOW SCREENING PLAIN TRACK AND POINTS AND CROSSINGS

8.3.1 Shallow screening shall be done as specified in latest IRPWM and standing orders in force.

8.3.2 The work of shallow screening shall be done under traffic condition without block protection, but all safety precautions for train service to be observed for safety purpose.

8.3.3 For screening, only inclined ballast screen of specified size shall be used. Use of wire baskets shall not be permitted.

8.3.4 Muck/spoils arising out of screening to be deposited on cess if low or on slopes of the bank as directed by Engineer or on spoil bank above the top of cutting, away from the track.

8.3.5 Where track is laid with LWR/CWR, extra care and precautions to be taken as per IRPWM and correction slips issued up to date.

8.3.6 Shallow screening of Points and Crossings shall include all the operations specified in shallow screening of normal track including through packing.

8.3.7 The work of shallow screening shall be done under traffic condition without block protection, but all safety precautions for train service to be observed for safety purpose.

8.3.8 Extra care should be taken while doing switch portion so that interlocking should not be failed and S&T staff to be informed for their presence during the work.

8.3.9 For screening, only inclined ballast screen of specified size shall be used. Use of wire baskets shall not be permitted.

8.3.10 Muck/spoils arising out of screening to be deposited on cess if low or on slopes of the bank as directed by Engineer or on spoil bank above the top of cutting, away from the track.

8.4 SUPPLY OF BALLAST

8.4.1 The supply of ballast should confirm to the **RDSO specifications** of track ballast issued **vide IRS-GE-1-2016** and with latest amendments and correction slips/ guidelines, if any from time to time

8.4.1.1 SCOPE: These specifications will be applicable for stone ballast to be used for all types of sleepers on normal track, turnouts, tunnels and deck slabs etc on all routes.

8.4.1.2 Specifications:

General

Basic Quality: Ballast should be hard durable and as far as possible angular along edges/corners, free from weathered portions of parent rock, organic impurities and inorganic residues.

Particle shape: Ballast should be cubical in shape as far as possible. Individual pieces should not be flaky and should have generally flat faces with not more than two rounded/sub rounded faces.

Mode of manufacture: Ballast for all BG main lines and running lines, except on ‘E’ routes but including ‘E’ special routes, shall be machine crushed. For other BG lines,

MG/NG routes and planned / sanctioned for conversion, the ballast shall preferably be machine crushed. Hand broken ballast can be used in exceptional cases with prior approval of Chief Track Engineer / CAO/C. Such approval shall be obtained prior to invitation of tenders.

On other MG and NG routes not planned/sanctioned for conversion hand broken ballast can be used for which no approval shall be required.

8.4.1.3 Physical Properties

Ballast sample should satisfy the following physical properties in accordance with IS:2386 Pt. IV when tested as per the procedure given in Annexure-I & II **RDSO specifications** of track ballast issued **vide IRS-GE-1-2016**.

Description	BG, MG & NG (planned/sanctioned for conversion)	NG & MG (other than those planned for conversion)
Aggregate Abrasion Value	30% Max.	35%Max.
Aggregate Impact Value	20% Max.	30%Max.

In exceptional cases, on technical and/or economic grounds relaxable up to 35%and 25%respectively by CTE in open line and CAO/C for construction projects. The relaxation in Abrasion and Impact values shall be given prior to invitation of tender and should be incorporated in the Tender document.

To carry out Impact Test on ballast, a test sample of ballast pieces (about 5 kg in weight) of size 10 mm to 12.5 mm will be required. Appropriate care should be taken by the railways that ballast selected for breaking down to 10mm to12.5mm size for Impact Test should be random from the ballast supply to avoid any subjectivity in selection of test sample. Alternatively, the test sample in the recommended range of size be got manufactured along with the ballast in sufficient quantity required for this test.

The '**Water Absorption'** tested as per IS 2386 Pt. III following the procedure given in Annexure III of **RDSO specifications** of track ballast issued **vide IRS-GE-1-2016** should not be more than 1%. This test, however, is to be prescribed at the discretion of CE/CTE in open line and CAO/Con. for construction projects.

The power of relaxing for water absorption limit should be delegated to CTE in open line / CAO on construction for specified areas. However, maximum water absorption in any case should not be allowed more than 2.5%.

8.4.1.4 Size And Gradation

Ballast should satisfy the following size and gradation:

a) Retained on 65mm Square mesh sieve 5%Maximum
b) Retained on 40mm Square mesh sieve* 40%-60%
c) Retained on 20mm Square mesh sieve *

* Not less than 98% for machine crushed ballast**.**Not less than 95% for hand broken ballast

In exceptional cases, where it is considered necessary on technical considerations, to reduce the maximum size of ballast for NG lines, CTE may modify the size & gradation of the ballast as defined above.

8.4.1.5 Oversize Ballast

i) Retention on65mmsquare mesh sieve.

A maximum of 5% ballast retained on 65mm sieve shall be allowed without deduction in payment. In case ballast retained on 65mm sieve exceeds 5% but does not exceed 10%, payment at 5% reduction in contracted rate shall be made for the full stack. Stacks having more than 10% retention of ballast on 65mm sieve shall be rejected.

ii) In case ballast retained on 40mm square mesh sieve (for machine crushed ballast only) exceeds 60% limit prescribed in 2.3.1 (b) of IRS Specifications GE: 1 - 2016, payment at the following reduced rates shall be made for the full stack in addition to the reduction worked out at above.

a) 5% reduction in contracted rates if retention on 40mm square mesh sieve is between 60% (excluding) and 65% (including).

b) 10% reduction in contracted rates if retention on 40mm square mesh sieve is between 65% (excluding) and 70% (including).

iii) In case retention on 40mm square mesh sieve exceeds 70%, the stack shall be rejected.

iv) In case of hand broken ballast supply, 40mm sieve analysis may not be carried out. The executive may however ensure that the ballast is well graded between 65mm and 20 mm size.

8.4.1.6 Under Size Ballast

The Ballast shall be treated as under size and shall be rejected if-

i) Retention on 40mm Sq. Mesh sieve is less than 40%.

ii) Retention on 20mm square mesh sieve is less than 98% (for machine crushed) or 95% (for hand broken).

8.4.1.7 Sieve Analysis of Ballast

The test sieves used for sieve analysis shall conform to the specifications given in

Annexure-IV **RDSO specifications** of track ballast issued **vide IRS-GE-1-2016**.

While carrying out sieve analysis, the screen shall not be kept inclined, but held horizontally and shaken vigorously. The pieces of ballast retained on the screen can be turned with hand to see if they pass through but should not be pushed through the sieve.

The percentage passing through or retained on the sieve shall be determined by weight. The weighing equipment used shall NOT have least count more than 100 grams.

8.5 METHOD OF MEASUREMENT

8.5.1 Stack Measurement

Stacking shall be done on a neat, plain and firm ground with good drainage. The height of stack shall not be less than 1m except in hilly areas where it may be 0.5m. The height shall not be more than 2.0m. Top width of stack shall not be less than 1.0m. Top of stack shall be kept parallel to the ground plane. The side slopes of stack should not be flatter than 1.5:1 (Horizontal: Vertical). Cubical content of each stack shall normally be not less than 30 cum in plain areas and 15 cumin hilly areas.

8.5.2 Wagon **Measurement**

In case of ballast supply taken by direct loading in to wagons, a continuous white line should be painted inside the wagon to indicate the level to which the ballast should be loaded. The cubical content in cubic meter corresponding to white line should also be painted on both sides outside the wagon.

In addition to painted line, short pieces of flats (cut pieces of tie bars or otherwise) with cubical contents punched shall be welded at the centre of all the four sides as permanent reference. In case the supply is taken in general service wagon, actual measurements shall be taken.

8.6 Shrinkage Allowance

Payment shall be made for the gross measurements either in stacks or in wagons without any deduction for shrinkage/voids. However, when ballast supply is made in wagons, shrinkage up to 8%shall be permitted at destination while verifying the booked quantities by the consignee.

8.7 SAMPLINGANDTESTING

8.7.1 The samples shall be drawn with due diligence and adequate precaution so that they represent the true nature and condition of the ballast.

8.7.2 Being a heterogeneous material, the gradation of ballast loaded in wagons and/or dumped/inserted in the track may not remain same as that initially checked in stacks, due to lifting, loading, transportation, unloading etc. Similarly in case of direct loading into wagons, the gradation of ballast at destination may not remain same as that at source, due to loading, transportation etc. Therefore, the samples from wagons

and track are not representative samples as far as gradation is concerned. Even in the same stack, results of two checks may not be same.

8.7.3 The samples from a stack taken after lapse of a long period of stacking are not representative samples of the ballast initially supplied in the stack, due to settling down of smaller size particles in voids underneath, dirt/dust getting accumulated in the stack, rains etc.

8.8 SAMPLING FREQUENCY

In order to ensure supply of uniform quality of ballast, the following norms shall be followed in respect of sampling, testing and acceptance:

8.8.1 On supply of the first 100cum, the tests for Size &Gradation, Abrasion Value, Impact Value and Water Absorption (if prescribed) shall be carried out by Railway. Further supply shall be accepted only after this ballast satisfies the specifications for these tests. Railway reserves the right to terminate the contract as per GCC at this stage itself in case the ballast supply fails to conform to any of these specifications.

8.8.2 Subsequent test shall be carried out as follows:

Type of Tests	**Supply in Stacks**	**Supply in Wagons**
(a)Size and Gradation Tests	One for each100 cum or part thereof in any stack	One for each100 cum or part there off or quantity to be loaded in wagons
(b)Abrasion Value, Impact Value and Water Absorption Value (*)	One Test for every 2000 cum	

(*) These tests shall be done for the purpose of monitoring quality during supply. In case of the test results not being as per the prescribed specifications at any stage, further supplies shall be suspended till suitable corrective action is taken and supplies ensured as per specifications.

The above tests may be carried out more frequently, at the discretion of Railway.

8.8.3 All tests of Abrasion Value, Impact Value and Water Absorption should be got done through approved laboratories or Railway's own laboratories (list of these laboratories shall be mentioned in the tender document). These tests, subsequent to award of contract, shall be done at Railway's cost.

8.9 SUPPLY OF BALLAST IN STACKS

8.9.1 Sampling Procedure

i) At the time of formation of stacks, sufficient care should be taken to ensure that there is sufficient space around the stack to facilitate movement of JCB/Power Equipments. The length and width of each stack shall be kept in such a way that every part of the stack is accessible to the JCB or Power Equipment, to be deployed for

drawing “Samples”.

ii) In case of ballast supply in stacks, three “Samples” each of 0.3 - 0.5cum volume, one sample each from two sides and one sample from top after removing outer layer (150-200 mm) should be collected from stack for every 100cum or part thereof, by JCB or other suitable Power Equipment.

iii) The location (in plan) and depths of sampling points shall be varied for different “Samples” and different stacks in a lot.

iv) “Gross Sample” should be prepared by thoroughly mixing the three “Samples” collected as in (ii) above, using JCB bucket or any other suitable Power Equipment, on a clean, flat and hard surface.

Note: In exceptional cases of site-specific constraints, approval of Competent Authority (Engineer-in-charge) shall be taken prior to invitation of tender, for using manual means for collection and mixing of “Samples”, and this should be incorporated in the Tender Document.

v) A “Test Sample” of volume 0.027 cum shall be drawn from each of the “Gross Sample”, by the method described in Para 5.3.1(vi) of IRS Specifications GE: 1 – 2016 for carrying out Size & Gradation tests.

vi) Method for drawing “Test Sample”: The ballast in “Gross Sample “shall be scooped into a cone shaped pile by taking care to drop each scoopful exactly over the same spot. After the cone is formed, it shall be flattened by pressing the top of cone with a smooth surface. Then it is cut into quarters by two lines which intersect at right angles at the centre of the cone. The bulk of the sample is reduced by rejecting any two diagonally opposite quarters. The remaining ballast shall be mixed and “test sample” shall be drawn for testing. After drawing “test sample”, the left-over ballast of “Gross Sample” shall be dumped back in the stack.

vii) In case clean, flat and hard surface is not available then a tarpaulin or any other suitable sheet may be used on a flat surface for mixing, drawing and sieve analysis of samples.

8.9.2 In case of stacks of volume more than 100 cum, more than one “Test Samples” shall be tested for Size & Gradation. In such cases, the sieve analysis results of all the “Test Samples” shall individually conform to following gradation, for acceptance/rejection of the whole stack:

(i) Retention on 20mm Square Mesh Sieve shall not be less than 98% for machine crushed ballast (not less than 95% for hand broken ballast).

(ii) Retentionon40mmSquare.MeshSieveshallbe between40to70%.

(iii) Retentionon65mm Square. Mesh Sieve shall not be morethan10%.

The full payment/reduced payment for the whole stack, as given in Para 2.3of IRS Specifications GE: 1 - 2016shall be decided based on the average of the sieve analysis results of all the “Test Samples” for a stack.

8.10 SUPPLY OF BALLAST IN HEAPS FOR LOADING DIRECTLY IN WAGONS

8.10.1 Sampling Procedure

Samples of ballast shall be collected from heaps of ballast proposed to be loaded into the wagons. For this, the contractor shall inform ADEN in-charge in writing sufficiently in advance before placement of rake, about the locations of ballast heaps from where it is to be loaded in to wagons. ADEN in-charge shall decide the location of heaps from which sampling is to be done, judiciously covering the entire quantity of ballast to be loaded in the rake.

8.11 Specification of Test Sieves used for Sieve Analysis of Ballast

8.11.1 The test sieves shall be perforated plate sieve type with square holes / apertures, mounted on a frame. The test sieves are designated by the nominal size of holes/apertures.

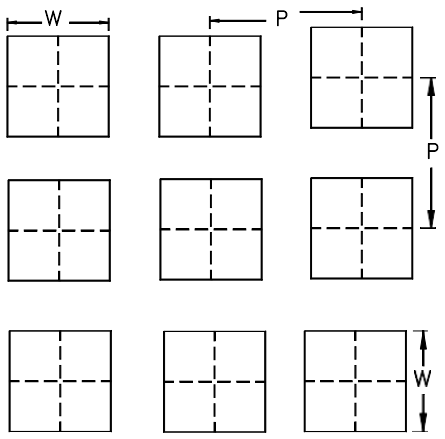
8.11.2 Material of Perforated Plate: The perforated plate for test sieves shall be manufactured from Brass Sheet or Steel Sheet or Stainless-Steel Sheet or Galvanized Steel Sheet or Electroplated Steel Sheet.

8.11.3 Plate Thickness: The thickness of plate used for making test sieve and the tolerance permitted for this shall be as following:

For 65mm Square Mesh Sieve - 3mm (Plus 1.0mm Minus 0.5mm) For 40mm Square Mesh Sieve - 2mm (Plus Minus 0.5mm)

For20mmSquareMesh Sieve-2mm (PlusMinus0.5mm)

8.11.4 Arrangement of Holes/Apertures: The square holes/apertures of size “W” in the perforated plate shall be arranged at Pitch “P” as per the sketch given below:



8.11.5 Sieve Opening Size, Pitch of Openings and tolerances: The nominal size of individual hole/aperture at mid-section (W), the Pitch of holes/apertures (P) and permissible tolerance for them shall be as under:

Test Sieve of Square Mesh Size	W		P	
	Nominal Size	Tolerance	Distance	Tolerance
65mm	65 mm	(±)1.5mm	80mm	(+)12.0 mm (-)8.0mm
40mm	40 mm	(±)1.5mm	50mm	(+)7.5 mm (-)5.0mm
20mm	20 mm	14(±)1.0mm	25mm	(+)4.0 mm (-)2.5mm

8.11.6 Sieve Frame: The frame of test sieves shall be manufactured from Hardwood or Steel sheet or Brass sheet. The internal size of the frame (i.e. clear size of perforated plate mounted on frame) shall not be less than100cm in length, 70cm in breadth and10cm in height on sides.

8.11.7 Marking on test sieves: A label shall be fixed to the frame of each sieve, legibly marked with following information:

Nominal Aperture Size, Material of perforated plate, Material of sieve frame, Maker's Name or Trade mark, and An Identification Number for the sieve.

8.12 LEADING AND DUMPING BALLAST

8.12.1 The item of the work shall be done as stipulated in IRPWM.

8.12.2 The work includes boxing neatly as directed by Engineer in charge and as per the standard profile stipulated in latest IRPWM prescribed for SWR/LWR track.

8.13 LOADING OF BALLAST INTO RAILWAY WAGONS

8.13.1 The contractor shall be intimated by the Railway 24 hrs in advance of the expected arrival of empty wagons.

8.13.2 The contractor should arrange for loading within a stipulated time as per the commercial code and delay on contract account shall attract demurrage charges.

8.13.3 The ballast should be spread evenly with manual/mechanical means with adequate precautions as given below:

a) Care must be taken during ballasting that signal installations are not damaged.

b) When spreading ballast, care must be taken to ensure that check rail flange-way clearance, switch points, guard rails are free of ballast

c) It must be ensured that ballast is kept clear of rail seats.

d) Ballast profile in shoulders is to be ensured and any deficiency in shoulder ballast must be adjusted from crib portion.

e) After unloading ballast wagons along the line, care should be taken that the heaps at the sides and at the centre are clear of prescribed running dimensions.

Chapter - 9
Welding Activities

9.1 WELDING OF RAIL JOINTS

9.1.1 The work shall be done as specified in IRPWM and Manual for Fusion Welding of Rails by Alumino – Thermic Process -2022.

9.1.2 The ends of the rails to be welded should be true to vertical and full cutting.

9.1.3 Only Hydraulic weld trimmer shall be used for stripping the weld.

9.1.4 Welding Temperature measuring devices and stop watch should be available at work spot arranged by contractor.

9.1.5 The work shall be done under full block protection and under minimum direct supervision of JE/P. Way.

9.1.6 Finishing Tolerances after welding shall be as specified in Manual for Fusion Welding of Rails by Alumino – Thermic Process -2022

Sl. No.	Parameter	Value
1	Vertical misalignment	At the centre of a 1 m straight edge +1.0 mm - 0.0 mm
2	Lateral misalignment	± 0.5 mm at the centre of a 1 m straight edge
3	Head finishing (in width)	Side of rail head should be finished to ± 0.3 mm on gauge side at the centre of 10 cm straight edge
4	Finishing of top table surface	At the centre of 10 cm straight edge + 0.4 mm - 0.0 mm
5	Web zone (under side of head web, top of base, both fillet each side	+ 3.0 mm of the parent contour - 0.0 mm
6	Upper sides, under surfaces shall be ground smooth. The edges of foot should be rounded.	

9.1.7 A Thermit welding done in-situ shall be joggled fish plated with two clamps and supported on wooden blocks of length 300-450 mm until tested as good by USFD.

9.1.8 Joggled fishplates with far end bolts shall be provided on AT welds, which have undertaken traffic equal to or more than 50% of stipulated fatigue life (GMT) of the rail.

9.1.9 Joggled fishplate with clamps or two far end bolts on good AT welds shall be provided on banks having height 5 m or more.

9.1.10 Joggled fish plate with clamps or two far end bolts on good AT welds shall be provided on bridges (having length of waterway as 100 m or more) and on approaches upto100 m length.

9.1.11 Joggled fishplate with clamps or two far end bolts on good AT welds shall be provided on curves of 3° or sharper.

9.2 Use of Second-hand rails: For conversion of existing single rails/short welded panels into SWP/LWR/CWR or during secondary rail renewal, old serviceable rails may be welded subject to the following conditions:

a) Obsolete rail sections and rails older than 50 years shall normally not be welded. Specific approval of the CTE may, however, be obtained in special cases.

b) The Chief Track Engineer shall satisfy himself that second hand rails have a substantial rail life to make it a safe and economical proposal.

c) Rails shall be free from corrosion or excessive wear. The height of rail and width of railhead shall not be less than the values as indicated below.

Rail section	Normal height of new rail (mm)	Minimum height of old rail (mm)	Width of head of new rail (mm)	Minimum width of head of old rail (as measured at the gauge corner) (mm)
60 kg/m	172	163	72	66
52 kg/m	156	150	67	61

The limit of lateral wear in the rail head as mentioned in table above may be followed subject to uniform gauge without any abrupt change.

d) Rails shall be tested before welding with Ultrasonic Flaw Detector apart from visual inspection, so that rails having cracks and internal flaws are not welded. In order to achieve satisfactory running on welded rail panels, rails with excessive scabbing, wheel burns, corrugations and wear of rail seats are not to be welded. The rail flange bottom is to be visually inspected to ensure freedom from defects like dent, notch, corrosion, etc.

e) Even where cracks/flaws are not detected during visual/USFD examination before welding, the ends of second-hand rails should be suitably cropped so as to eliminate fish bolt holes. The rail ends shall be cut by sawing or using abrasive disc cutter and not by flame cutting. Second hand rails shall be match-marked before releasing from

track to enable matching of the rail ends at the time of welding. Kinks, if any, in the rails shall be removed before welding.

f) The rolling marks on the web of rails shall be checked before welding to ensure that generally rails of different Grades of rails are not welded together. However, in unavoidable circumstances, where rails of Grade 710 (72 UTS) rail chemistry and that of Grade 880 (90 UTS) chemistry are to be welded, the portion of Grade 880 (90 UTS) chemistry shall be utilized for welding

Chapter - 10
Reconditioning of Points and Crossings

10.1 RESURFACING OF WORN-OUT TONGUE RAILS & CROSSINGS

10.1.1 The work shall be done as specified in Manual for Reconditioning of Medium Manganese (MM) Steel Points and Crossings, SEJs and Work Procedure for Reconditioning of Cupped AT Welding Joints and Wheel Burn/Scabs Using "Robotic Welding Machine" (Provisional) 2019.

10.1.2 Worn out tongue rails and crossings fabricated by using Medium Manganese Rails and CMS crossings are resurfaced/ reconditioned by welding process using specified types of electrodes.

10.1.3 The item of the work envisages electric Arc welding of worn-out Crossing including wing rails/ Tongue rails using contractor's electrodes, welding equipment and power at locations as per Railway's requirements and/or as directed by the Engineer or his Representative complete including all incidental works.

10.1.4 The measurement for payment shall be in terms of numbers for tongue rails as well as crossings as specified in Schedule. The exact depth of vertical wear for crossings shall be measured at a distance of 150mm from the actual nose by the Engineer or his Representative. His decision in this regard shall be treated as final and binding.

10.1.5 The work shall be carried out as per the Railway's standard drawings, provisions in Indian Railways Permanent Way Manual and extant instructions.

10.2 RE-SURFACING OF BUILT-UP CROSSING OF MM RAILS:

10.2.1 The electrodes shall be from amongst the approved brands having valid and current approval as issued by RDSO. The Contractor shall have to submit documentary proof for having procured the approved brand of electrodes from authorized stockiest duly supported by necessary test certificates issued by the manufacturers of electrodes.

10.2.2 The surface of the crossings to be resurfaced should be thoroughly cleaned by means of kerosene oil and wire brush. Slight heating by means of oxy-acetylene flame prior to cleaning with the wire brush can be resorted for facilitating the removal of oil, dirt or rust from the crossings/tongue rails.

10.2.3 The fatigued and work hardened areas should be removed by light grinding ensuring that cracks are not formed during grinding process. Cracks, if any formed, should be removed by grinding and the surface should be checked by Visual/Dye-penetration to ensure freedom from cracks. In case, deep cracks are formed/present, the same may be removed first either by cutting electrodes or by gouging.

10.2.4 Prior to resurfacing, the assembly of the crack free crossings may be opened out and areas to be welded be marked by chalk to follow proper sequence during welding. The areas to be welded should be heated to about 250^0 C (two hundred fifty

degree centigrade) by oxy-acetylene gas flame. This temperature should be maintained during welding.

10.2.5 The crossings should be resurfaced in flat position. Short and string beads should be deposited longitudinally covering some portion of the previous bead and the manipulation of electrodes should be such that the built-up layers are uniform. The sequence of weld followed should be depositing bead on the left-wing rail, then on nose and thereafter on the right-wing rail and so on.

10.2.6 Welding defects, if any, formed during welding should be removed prior to deposition of subsequent bead.

10.2.7 After welding, the built-up areas should be closely examined for non-welded / less built-up spots and such areas should be repaired immediately while the crossing is still hot. The weld metal should be allowed to cool slowly.

10.2.8 It should be ensured that the weld metal is sufficient so as to ensure the proper profile after grinding.

10.2.9 The resurfaced crossings should then be grinded and filed to final finished profile.

10.2.10 To ensure crack-free weld deposits, the crossing should be subjected to the die-penetration test.

10.3 RESURFACING OF CAST MANGANESE STEEL (CMS) CROSSINGS.

10.3.1 The electrodes shall have to be procured by the contractor from amongst the RDSO approved brands from one of the authorized stockiest. Contractor shall have to produce documentary evidence in this regard with necessary test certificate. The following additional precautions should be taken.

10.3.2 The worn-out crossing shall be placed in a trough containing water so that only surface table is left open to the atmosphere.

10.3.3 Welding should be done with DC power source using reverse polarity.

10.3.4 No preheating should be done on CMS crossings.

10.3.5 Current as low as possible should be used to avoid rise in temperature. At no time, the temperature should be allowed to rise above 250^0 Centigrade.

10.3.6 Short and string beads should be deposited longitudinally following proper welding sequence. The width of the bead should be twice the electrode diameter. Care should be taken to fill the crater by moving the electrode in backward direction before breaking the arc.

10.3.7 Adequate precautions should be taken to avoid welding defects.

10.3.8 The weld metal should be cooled very fast – if required by pouring water over the weld metal.

10.3.9 Light peening with the help of a ball-peen hammer should be done after depositing each bead to relieve stresses due to welding. The point where arc is broken

should be peened first and then the remainder of the bead. Just after peening, the welded portion should be water quenched or quenched by compressed air to retain austenitic structure of the base metal.

10.3.10 After completion of welding, the resurfaced areas should be finished by light grinding ensuring that cracks do not form.

10.3.11 In case of grinding CMS crossings, special precautions are to be taken and small pieces of gunny bags soaked in water should be placed over the areas ground to avoid formation of cracks. Continuous grinding of one spot should not be resorted to, in order to avoid overheating.

Chapter - 11
Formation Rehabilitation.

11.1 Formation Rehabilitation by Providing Blanket Layer

11.1.1 In case of rehabilitation of poor formation in running line by replacement of upper layers of poor soil with blanketing material, only mechanically manufactured blanketing material shall be used.

11.1.2 In laying of blanketing material, procedure specified in IRS Specification No. RDSO/2020/GE: IRS-0004- September -2020 shall be followed. Record of prescribed checks/tests shall be maintained accordingly.

11.1.3 In no case thickness of loose layer of blanket material shall exceed 300 mm. Use of Motor Graders with hydraulic control system, in spreading layers of blanketing material uniformly, is mandatory.

11.1.4 Since, it may not be possible to give additional width on either side required for compaction of different layers of blanketing material, slope vibratory roller shall be used simultaneously to compact loose layers on either side.

11.1.5 Before start of the work, availability of required material, machinery, tools, plants & equipment must be ensured at site and a certificate shall be obtained from the Engineer about adequacy and proper working condition.

11.1.6 Apart from prescribed test reports, video graphic records of all tests i.e., collection of samples, transportation, testing etc. shall be maintained and submitted.

11.1.7 After completion of work, all the disturbances due to construction of ramps, moving of different heavy machinery, dumping of new/waste materials etc., should be repaired and embankment shall be restored to standard profile.

11.1.8 Before starting the work, all relevant parameters like cutting depth, thickness of blanketing material, number of layers etc. should be designed and proper reference benchmarks indicating existing formation level, cutting level, final blanketing level, rail level etc. should be established in the field to work as a reference point during working.

11.1.9 Efforts should be made to obtain closure of track for long duration with traffic diversion in place of daily blocks as far as possible.

11.2 Other methods of Formation Rehabilitation:

Other methods of formation rehabilitation other than blanketing viz. by laying Geogrid & Non-woven Geotextile, by cess widening, by rehabilitation of unstable slopes can also be planned/adopted as per site condition as mentioned in Para 10.5 of RDSO's "Comprehensive Guidelines and Specifications for Railway Formation" Specification No. RDSO/2020/GE: IRS-0004, September 2020 with latest correction slips & latest revision.

Chapter - 12
Activities at Construction Sites

12.1 COLLECTING/LEADING/ASSEMBLING OF TRACK

12.1.1 The work includes Collecting/leading Railway's Material s like Rails, Sleepers Points crossing rails, SEJs, Glued Joints etc., including chairs brackets, bolts and nuts, screws spikes, rubber pads, tie angles etc. as specified in the schedule, to the actual location of work.

12.1.2 The work includes Collecting/leading Railway's special PSC sleepers from station/depot to actual location of work.

12.1.3 The work of assembling and insertion in to track shall be carried out as per the standard drawings, provisions contained in the IRPWM -2020 and latest correction slips and guidelines.

12.1.4 The work shall be done under full block protection and under the personal supervision and satisfaction of Railway's representative not lower than the grade of JE/P. Way and work shall be completed within block period.

12.1.5 The measurements for payment shall be as mentioned in the schedule.

12.1.6 Wherever the road vehicles and/or machinery are required to work in the close vicinity of railway line, the work shall be so carried out that there is no infringement to the Railway's Schedule of Dimensions. For this purpose, the area where road vehicles and/or machinery are required to ply, shall be demarcated and acknowledged by the contractor. Special care shall be taken for turning/reversal of road vehicles/machinery without infringing the running track. Barricading shall be provided wherever justified and feasible as per site conditions

12.1.7 A large number of men and machinery are deployed by the contractors for track renewals, gauge conversions, doublings, bridge rebuilding etc. It is therefore essential that adequate safety measures are taken for safety of the trains as well as the work force.

12.1.8 The supervisor/workmen should be counseled about safety measures. A competency certificate to the contractor's supervisor as per pro-forma prescribed shall be issued by ADEN which shall be valid only for the work for which it has been issued. (Annexure -8/5 of IRPWM-2020).

12.1.9 The ballast/rails/sleepers/other P. Way Materials after unloading along track should be kept clear off moving dimensions and stacked as per the specified heights and distance from the running track.

12.1.10 Supplementary site-specific instructions, wherever considered necessary, shall be issued by the Engineer in-charge.

12.1.11 The Engineer in-charge shall approve the methodology proposed to be adopted by the contractor, with a view to ensure safety of trains, passengers and workers and he shall also ensure that the methods and arrangements are actually

available at site before start of the work and the contractor's supervisors and the workers have clearly understood the safety aspects and requirements to be adopted/ followed while executing the work.

12.2 TRACK PARAMETERS TO BE MAINTAINED AFTER TRACK RENEWAL WORKS. (MANUAL / MACHINE)

Track Parameter	Items for measurement	Value
Gauge	Sleeper to sleeper variation	2mm
Expansion gap at joint	Average gap worked out by recording 20 successive gaps	+/- 2mm
joints	Low joints not permitted. High joints not more than	+/- 2mm
	Squareness of joints on straight	+/- 10mm
Spacing of sleeper	With respect to theoretical spacing	+/- 20mm
Cross level	To be recorded in every 4^{th} sleeper	+/- 3mm
Alignment	ON straight on 10m chord	+/- 2mm
	On curves of radius > 600m on 20m chord variation over theoretical versine	5 mm
	On curves of radius < 600m on 20m chord variation over theoretical versine	10mm
Longitudinal level	Variation in longitudinal level with reference to approved longitudinal sections	50mm

Chapter - 13
Maintenance Activities

13.1 THROUGH PACKING

13.1.1 The above item of work envisages packing/through packing of sleepers as per the Railway's requirement and/or as per extant instructions.

13.1.2 The work of packing/through packing etc. is incidental to other items of track works such as deep screening/TSR/TRR/CTR etc. and the track standards as prescribed herein shall be attained.

13.1.3 The work shall be carried out as per provisions contained in Indian Railways Permanent Way Manual and/or Railway drawings and extant instructions.

13.1.4 The packing of sleeper shall be as specified for conventional maintenance by and as enumerated in Para 607of Indian Railways Permanent Way Manual-2020 or latest.

13.1.5 It is preferable to use approved type of tampers on large stretches to achieve better quality. In case of packing of stretches exceeding 20 continuous sleepers this work shall also include all operations of through packing as specified in Indian Railways Permanent Way Manual. But in case of concrete sleeper track, packing shall preferably be done by mechanical means.

13.2 LIFTING OF TRACK

13.2.1 The above item of work envisages lifting of track on ballast so as to ensure that the desired clean ballast cushion below bottom of sleeper and to have good drainage to the track is achieved. Lifting of track shall be done in accordance with Indian Railways Permanent Way Manual.

13.2.2 The measurement for payment shall be as per Track metre of the track lifted and accepted by the Engineer or his representative whose decision in this regard shall be final and conclusive.

13.2.3 The work would envisage lifting of track on ballast so as to result into raising up to prescribed rail level. The extent of raising will be indicated in the relevant item of schedule. The extent of rising would be specified for the various stretches by the Engineer-in-charge.

13.2.4 The work shall be carried out as per provisions contained in Indian Railways Permanent Way Manual and/or Railway drawings and the extant instructions.

13.2.5 The work of lifting is to be carried out under a speed restriction of 20 km/h without a traffic block and under supervision of Engineer in charge

13.2.6 The work of lifting should be carried out as per procedure described in Indian Railways Permanent Way Manual. The schedule of relaxation of speed restrictions shall be as given in Indian Railways Permanent Way Manual. Any deviations from this

procedure should have the approval of the Engineer which should be recorded in the site order book.

13.2.7 The track shall be surveyed in advance and pegs indicating the final level shall be provided at 30m interval by the Railways' Engineer. The Contractor shall maintain the rail level after lifting to the level as indicated on the pegs or as directed by the Engineer.

13.2.8 The rate includes all lead and lift and also contractor's labour, tools and plant, materials consumables etc.

13.2.9 Measurement shall be taken to nearest mm.

13.2.10 Lifting to be done in stages of 50 mm up to the required level. And proper packing to be ensured after each stage of lifting.

13.2.11 Slacks to be picked on the next day of the work at every stage of lifting for which no extra payment shall be made.

13.2.12 The track should made fit always to that Speed restriction available in view of safety.

13.2.13 Location like Bridge/P&C/LC etc. approaches, where lift is restricted, and payment shall be made as per pro-rata basis.

13.3 LIFTING OF TRACK

13.3.1 Lifting of track will become necessary during re-grading and for elimination of minor sags, which develop through improper maintenance or yielding soil, to keep a good top.

13.3.2 Correct level pegs should be fixed at suitable intervals, before lifting is commenced.

13.3.3 Heavy lifting should always be carried out under suitable speed restriction and under the protection of corresponding engineering signals.

13.3.4 The lifting should not exceed 50 mm at a time so as to allow proper consolidation. The easement gradient for the passage of trains should not be steeper than 25 mm in one rail length of 13 metres.

13.3.5 The operation should be repeated until the required level is attained when the track should be finally ballasted, through packed and boxed, the cess being made up to proper level.

13.3.6 Lifting should commence from the downhill end carried out in the direction of rising grade in case of single line. It should proceed in the opposite direction to traffic, in case of double line, care being taken not to exceed the easement grade.

13.3.7 While lifting track under bridges and overhead structures and in tunnels, it should be ensured that there is no infringement of standard dimensions.

13.3.8 In case of curves, it is usual to set the inner rail to the correct level and grade and to raise the outer rail to give the required super elevation, care being taken to see that the cant gradient is within the permissible limit.

13.4 Lowering of Track

13.4.1 Lowering of the track should not be resorted to except where it cannot be avoided and if resorted to, it should be done under suitable speed restriction and under the protection of Engineering signals.

13.4.2 When lowering is to be done, trenches should be made across the track at every 30m to the final level in order to give a continuous indication, while the work is in progress. The ballast should be removed sufficiently far away from the track to prevent it getting mixed up with excavated Material.

13.4.3 The procedure is to clear the spaces between the sleepers, then slightly lift the track break the packing beneath and level it in to the space between sleepers. This material is then removed and the operation repeated until the final level is reached. The road should then be ballasted, through packed and boxed, the cess to be cut down to proper level.

13.5 PICIKING UP SLACKS

13.5.1 The work shall be done as specified in IRPWM-2020 and as per correction slips/ guidelines issued from time to time if any.

13.5.2 The person in charge of the work shall give written advice indicating stretches and extent of defects in alignment, gauge, cross level and unevenness.

13.6 PULLING BACK CREEP

13.6.1 The above work shall be done as stipulated in IRPWM-2020 or latest

13.6.2 The work shall be done under speed restriction. Protection of track shall be as specified in latest IRPWM and G & SR

13.6.3 Works of Short Duration

Protection in block section and procedure for passing of trains – Before commencing any work of such category the JE/SSE/P.Way or authorized Railway servant should issue a notice to the Station Master/Block-hut in-charge at each end of the Block section and obtain their acknowledgment. Depending as to whether the train is to be passed through the work site after stopping or at a restricted speed, the line should be protected in the following manner –

(1) When the train is required to stop at the site of work (in Block section) –

a) Post a flagman with hand signals at a distance of 30 metres in rear of the place of obstruction, to show stop hand signals.

b) Post a flagman with hand signals and place a banner flag across the track at a distance of 600 metres in rear of the work. The flagman shall show stop hand signals.

c) Post a flagman with hand signals and detonators at a distance of 1200 metres in rear of the work. The flagman shall fix three detonators on the line 10 metres apart and stand at a place not less than 45 metres from the three detonators, from where he can obtain a clear view of the approaching train. He shall show stop hand signals.

d) The man at the site of obstruction shall give proceed hand signal to indicate to the Driver, when he may resume normal speed after the train has been hand signaled past the obstruction **(Annexure - 8/1 of IRPWM-2020).**

(2) When the train can pass over the work spot at restricted speed in Block section

The following protections should be adopted in the above cases –

(a) Post a flagman exhibiting caution hand signals at a distance of 30 metres from the place of obstruction.

(b) Post a flagman exhibiting caution hand signals at a distance of 1200 metres for Broad Gauge from the place of obstruction.

(c) Post an intermediate flagman with hand signals at a distance of 600 metres for Broad Gauge from the place of obstruction. He shall also place a banner flag across the track. The intermediate banner flag must be kept across the line until the speed of the train has been reduced, after which the banner flag shall be removed and the train hand signaled forward.

(d) The railway servant at the site of work should give proceed hand signals to indicate to the Driver, that he may resume normal speed after the train has been hand signaled past the site of work- **(Annexure - 8/2 of IRPWM-2020).**

(3) The following points should be kept in view, while protecting the track in the cases mentioned in Sub-Para (1) and (2) above –

(a) On single line, the line must be so protected on both sides of the work.

(b) At places where there are curves or falling gradients and at times of poor visibility the distances laid down in Sub-Para (1) and (2) above may be suitably increased wherever necessary and intermediate flagman posted to relay hand signals.

(c) The location of the banner flag, detonators and hand signals should be so selected as to avoid stopping of trains, as far as possible, on continuous steep rising gradients.

(d) If in an emergency, it becomes necessary to carry out such works at night, the provisions for protection of line as detailed in above Sub-Para (1) and (2) must be complied with except that red light must be exhibited in the direction of approaching trains in place of red hand signaling flags and banner flags.

(e) In an Emergency, when it is necessary on considerations of safety, the JE/SSE/P. Way, or authorized railway servant may commence such work after protecting the line as per GR 15.08 and 15.09, before issuing notice to the Station Master. If the work is likely to be prolonged, he should notify the Station Master as soon as possible.

13.6.3.1 The work shall include re-fixing/providing anchors as directed by Engineer-in-charge and squaring of sleepers and slack packing.

13.7 SCRAPPING AND PAINTING OF RAILS

13.7.1 The work shall be done as per the provisions of latest IRPWM and procedural orders issued from time to time.

13.7.2 The work includes scrapping of rail surfaces with contractor's wire brushes.

13.7.3 Paints used shall be of approved quality as per guidelines issued by railways from time to time.

13.8 DESTRESSING OF LWR PANELS

13.8.1 The work shall be as specified in latest IRPWM (2020) and latest guidelines issued from time to time. The contractor should engage sufficient men to complete the work within block period and as specified in the schedule.

13.8.2 The work shall be done under block protection and under the direct supervision of JE/SSE/ P.WAY.

13.8.3 The de-stressing operation shall be done at the temperatures as stipulated in IRPWM with latest correction slips.

13.8.4 Rollers of prescribed size and spacing shall be used as while de-stressing on Plain track and also on curved track.

13.8.5 The work shall preferably be done at rail temperature lower than t_d using rail tensor.

13.9 PATROLLING OF RAILWAY TRACK:

13.9.1 The men deployed for patrolling work should be trained in Railway's training school and should possess valid competency certificate. All charges for initial as well as refresher courses shall be borne by the contractor.

13.9.2 The men deployed for patrolling should have police clearance so as to ensure that the men deployed are reliable and trustworthy.

13.9.3 Any untoward incident due to negligence of the patrolman shall result in to penalty as envisaged in contract agreement and the Railway's decision in this regard shall be final.

Chapter -14

Testing of Rails and other Components

14.1 The working ultrasonic testing of rails and welds to be carried out as per the specifications and guidelines mentioned in latest version of "**Manual & Specifications for Ultrasonic Testing of Rails and Welds" & related instructions**, guidelines issued from time to time on this subject.

The outsourcing work of USFD testing of rails and welds to be carried out as per the Indian Railway Standard Specification for Ultrasonic Testing of Rails/Welds, Revised-2020- (IRS- T-53) issued by RDSO and latest correction slips and guidelines from time to time.

14.1.1 Scope:

This specification applies to the through ultrasonic testing of rails/welds manually by SRT/DRT with B-Scan and ultrasonic testing by hand probing of Alumino Thermit (A.T), Flash butt (F.B) &Gas Pressure (G.P) rail welds in service by weld tester, to identify, locate and evaluate internal defects for track of Indian Railway. The specification is to be used for outsourcing of ultrasonic testing of rails/welds.

14.1.2 Definition of terms

The terms and definitions used in this specification are placed in Annexure-1 of IRS T-53. The list is indicative and not exhaustive.

14.1.3 Technical Representative

The Principal Chief Engineer (PCE) or his nominated technical representative shall be responsible for resolving technical issues, including interpretation or points of doubt with respect to the specification, which may arise from time to time. The decision of Principal Chief Engineer in such matters shall be final and binding.

14.1.4 Standards

“Manual for Ultrasonic Testing of Rails and Welds – Revised, 2022” along with its latest revision and updated correction slips at the time of opening of the tender shall be the reference standard for classification of defects in rail/weld, detected during through ultrasonic testing manually by SRT/DRT with B-Scan and defects detected in A.T/ F.B/G.P rail welds during ultrasonic testing by hand probing. Wherever other standard(s) is/are referred in this specification, the revision of that standard current at the time of calling tenders shall be used. In case additional correction slips are issued to the Manual, during the pendency of the tender/contract, the test procedure/criteria shall have to be suitably updated.

14.1.5 USFD testing of rails &welds

Rail defect definition: Rail and weld defects are classified and coded as per “Manual for Ultrasonic Testing of Rails and Welds – Revised, 2022” along with its latest revision and updated correction slips.

14.1.6 Rail and Weld Defect testing

Through Rail and Weld testing (Manually by SRT/DRT)

Frequency: The agency/firm shall test the rails and welds during through Rail testing manually using SRT / DRT, in the track at locations and at intervals as directed by the Railway.

Scanned Area: The equipment shall be capable of detecting defects originating with in the area specified in “Manual for Ultrasonic Testing of Rails and Welds – Revised,2022” along with its latest revision and updated correction slips for Through Rail and Weld testing manually by SRT/DRT**.**

14.1.7 Alumino Thermit (AT) welds testing by Hand Probing

Frequency: The agency / firm shall test Alumino Thermit welds by hand probing using weld tester in the track at locations and at intervals as directed by the Railway.

Scanned Area: The testing system shall be capable to detect the defects originating within the area specified in “Manual for Ultrasonic Testing of Rails and Welds – Revised 2022” along with its latest revision and updated correction slips.

14.1.8 Flash-Butt (FB)/Gas Pressure welds testing (by hand probing)

Frequency of testing of Flash Butt / Gas Pressure Welds: The agency/firm shall do ultrasonic test of the Flash Butt / Gas Pressure welds in the track at locations and at intervals as directed by the Railway.

Scanned Area: The equipment shall be capable to detect the defects originating with in the area specified in “Manual for Ultrasonic Testing of Rails and Welds – Revised, 2022” along with its latest revision and updated correction slips**.**

14.1.9 Sensitivity setting and Rail/Weld defect classification

For through rail testing manually by SRT/DRT:

Sensitivity Setting: The sensitivity setting of the USFD equipment shall be done with the help of standard test pieces as given in “Manual for Ultrasonic Testing of Rails and Welds– Revised-2012” along with its latest revision and updated correction slips.

Rail/ Weld defect classification: The defects in the rails/welds shall be classified as per the criteria given in “Manual for Ultrasonic Testing of Rails and Welds – Revised, 2022” along with its latest revision and updated correction slips.

14.1.10 For AT/FB/GP Weld defect classification (By hand probing)

Sensitivity setting: The sensitivity setting of the USFD equipment shall be done with the help of standard test pieces as given in “Manual for Ultrasonic Testing of Rails and Welds– Revised,2022” along with its latest revision and updated correction slips.

Weld defect classification: The defects in welds shall be classified as per the criteria given in “Manual for Ultrasonic Testing of Rails and Welds – Revised, 2022” along with its latest revision and updated correction slips.

Rail/Weld defect action requirements:

14.1.11 Rail and Weld defects (For through Rail testing manually by SRT / DRT): The action to be taken in respect of defective rails / welds detected during through pedestrian USFD testing shall be as per “Manual for Ultrasonic Testing of Rails and Welds –Revised,2022” along with its latest revision and updated correction slips.

14.1.12 Weld defects (by hand probing): The action to be taken for AT welds classified as defective (DFWO/DFWR) shall be as per “Manual for Ultrasonic Testing of Rails and Welds– Revised, 2022” along with its latest revision and updated correction slips.

14.1.13 Defect identification requirements

14.1.14 Rail and welds defects (For through Rail testing manually by SRT / DRT): Defect identification for Rail and weld defects by through rail testing manually by SRT/DRT shall be as per “Manual for Ultrasonic Testing of Rails and Welds– Revised, 2022” along with its latest revision and updated correction slips.

14.1.15 Weld defects (By hand probing): Defect identification for weld defects by Hand probing shall be as per “Manual for Ultrasonic Testing of Rails and Welds – Revised, 2022” along with its latest revision and updated correction slips.

14.1.16 Defect identification: Rail defects with respect to chainage of rails, GPS co-ordinates (Latitude & Longitude) and weld defects with respect to weld number shall be recorded. The defect shall also be marked and painted on both faces of rail/welds as per “Manual for Ultrasonic Testing of Rails and Welds – Revised, 2022” along with its latest revision and updated correction slips.

14.1.17 Paint Quality: Paints used to mark defects shall be of the line marking type to meet the required colour density and adherence (to be durable in service). Paint used must remain adherent for a period of at least 3 months and painting technique used must ensure high visibility from a distance of thirty (30) meters. Paint used should be resistant to bubbling after application on rail that may be still wet with ultrasonic testing couplant.

14.1.18 Ultrasonic Testing Equipment and its Performance requirement

Ultrasonic Testing Equipment: The agency /firm shall offer Ultrasonic Testing equipment for performance evaluation by RDSO as per Para 6.2 of specification IRS-T-53. M&C directorate shall only verify the performance of the equipment as per Para 6.2 of IRS T – 53.

Note:

a) Single Rail Tester (SRT) and Double Rail Tester (DRT) offered by agency / firm for performance evaluation by RDSO shall be capable of B-Scan recording with facility of location stamping in km/m/cm by digital encoder (odometer), GPS coordinates (latitude and longitude) recording. Equipment shall also have time stamping facility

duly synchronized with GPS satellite clock on at least half hourly basis. Record of synchronization is to be stored in the equipment. In case signal is missing from satellite, real time clock in equipment shall record the time.

b) The agency / firm have to submit the declaration that the echo pattern of their ultra-sonic equipment shall not get disturbed under Electrified section of Indian Railways. The existing SRT / DRT without having B-Scan recording facility with remaining service life and having valid verification certificate shall be included in the QAP in a separate list.

14.1.19 Ultrasonic Testing Equipment Performance requirement

14.1.20 Testing Equipment: The equipment offered by the agency/firm shall meet the minimum detection levels commensurate with the provision of Para 5.1 to 5.4 specification IRS-T-53 as well as provisions of Para 9 of IRS T - 53.

The performance of each equipment shall be verified by Metallurgical & Chemical (M&C) Directorate of RDSO. After verification by performance evaluation, the verification certificate with unique number for each equipment will be issued by RDSO. This verification certificate will be valid for four years from the date of issue and after which, the equipment shall be offered for recertification before expiry of validity date. After re-verification of the equipment the validity will be assigned for the rest of the period of service life of USFD equipment which is 8 years. The service life i.e. 8 years is taken from the date of manufacture of the equipment.

The equipment offered by agency/firm and RDSO approved equipment available at M&C Directorate will be calibrated to the same level of sensitivity on simulated flaws in the rail as prescribed in the “Manual for Ultrasonic Testing of Rails and Welds – Revised, 2022” along with its latest revision and updated correction slips for evaluation of performance. The equipment shall also be tested for coverage of rail section as per provisions mentioned

(a) The equipment under test shall exhibit equal or better coverage of rail/weld sections in detection of flaw as compared to the provisions of clause 5.2.1(b)/ 5.2.2(b)/5.2.3(b) of IRS -53 specifications

(b) While testing rail pieces having natural defects, the equipment under test shall exhibit variation in echo vertical height and horizontal movement up to ±10%, when results are compared with signals of approved equipment available at M&C Directorate.

M&C directorate will also check the B-Scan recording capability with facility of location stamping in km/m/cm by digital encoder (odometer), GPS coordinate (latitude and longitude) recording and time stamping facility (duly synchronized with GPS satellite clock) for Single Rail Tester (SRT)and Double Rail Tester (DRT).

14.1.21 Standard Test Piece: The standard test pieces (as per Para 5.3 of specification IRS-T-53meant for sensitivity setting of testing equipment should be verified by M&C Directorate of RDSO before the same is taken to field for sensitivity

setting purpose. The validity of calibration certificate shall be 4 years from the date of issue, there after standard test pieces shall be offered subsequently for re-verification in every 4 years by the agency/firm. The validity after re-verification shall be assigned for next 4 years. The certificate of authenticity shall be issued with RDSO Stamp (Seal) to each standard test piece and the same stamp (Seal) shall be punched on each standard test piece Reliability of Defect Detection:

14.1.22 The reliability of detection of defects shall be verified by the Zonal Railways.

14.1.23 The reliability of detection of defects shall be 100%. However, due to variation in echo vertical height and horizontal movement up to specified level of ± 10 % (Para 6.2.1.2 (b)of specification IRS-T-53**)**, the defect classification of defect may change accordingly.

14.1.24 This verification can be undertaken by use of either a rail containing artificial defects (if such a rail is available) or on a stretch of rail length containing OBS/OBSW/IMR/IMRW/DFWO/DFWR/DFWN defects. The testing shall be repeated at least three times to assess the reliability.

14.1.25 For reliability of defect detection, the probes of the equipment used by the agency /firm shall be set to the same level of sensitivity as that of the approved ultrasonic equipment (make and model approved by RDSO).

14.1.26 The equipment of agency/firm shall detect all those defects which are detected by approved ultrasonic equipment (make and model approved by RDSO) in each round of testing. Any over reporting by agency/firm's equipment shall also be confirmed by Zonal Railways by either testing at higher gain or alternative methods such as side probing, pitch catch method, breaking open the defect etc.

14.2 OPERATOR CERTIFICATION AND OTHER REQUIREMENTS

14.2.1 Agency/firm shall not employ any Ultrasonic operator, who does not hold valid competency certificate issued by RDSO as per Para 7.2 of specification IRS-T-53. The operator shall possess original copy of the valid Competency Certificate issued by RDSO while performing through testing of rails &welds and /or USFD testing of welds by hand probing in the field and produce the same to railway officials when demanded. Railways shall put in place a mechanism to maintain day today records of operators employed by the agency/firm along with equipment used (Sr. No. of machine etc.). Sectional ADEN/DEN/Sr. DEN (where testing is being done) shall verify the competency certificate of the USFD operator by matching with the one uploaded on relevant TMS application during their inspection.

14.2.2 Competency certificate issued by the RDSO:M&C directorate of RDSO issues competency certificate in following categories:

a) Provisional competency certificate valid for 6 months for

i) Through Rail and Weld testing manually by SRT and DRT.
ii) USFD testing of welds by Hand probing only.

b) Regular competency certificate valid for 2 years for

i) Through Rail and Weld testing manually by SRT and DRT.
ii) USFD testing of welds by Hand probing only.

Note:

1.The competency certificate (Provisional/Regular) shall be uploaded on TMS by RDSO (Track Design Directorate) against the approved QAP of the agency/firm.

2. The existing competency certificate issued to the USFD operator by the M&C directorate for the A-Scan testing shall remain valid and shall be included in the QAP

14.3 QUALITY ASSURANCE PLAN (QAP)

14.3.1 The agency/firm who wish to submit Quality Assurance Plan (QAP) for Ultrasonic Testing of Rail and welds or/and welds for outsourcing of USFD testing shall furnish the following information in the QAP, while submitting QAP to Track Design Directorate.

(i) Name of agency/ firm, registered address along with contact number &mailing address.

(ii) Registration certificate, details of GST registration, PAN number and ISO certificate.

(iii) Total Number of USFD machines:

(a) For rail testing-SRT/DRT
(b) For weld testing-weld tester.

(iv) Total number of operators:
(a) For rail testing.
(b) For weld testing.
(c) For rail and weld testing both.

(v) QAP In-charge.

(vi) Details of IIW (V1) Blocks for calibration and standard test piece.

(vii) Self-assessed capacity: The self-assessed capacity shall be calculated as per following criteria

a) For total no. of welds in a year: One weld tester, two operators, 25 days of working in a month and 30welds per day.

b) For total Track Km in a year for SRT: One SRT, two operators, 25 days of working in a month and 2Track Km per day.

c) For total Track Km in a year for DRT: One DRT, two operators, 25 days of working in a month and 4 Track Km per day.

14.3.2 The agency/ firm shall prepare & submit QAP in four copies along with proof of charges deposited to RDSO for scrutiny of the QAP.

14.3.3 QAP shall be approved on the basis of verification of USFD machines, Certification of USFD operators & Quality Control In-charge and other information

given by the agency/firm in Quality Assurance Plan. The details of USFD operator, verified USFD machines and standard test pieces mentioned in the QAP shall be examined by M&C Directorate. The list of approved QAP will be maintained by Track Design Directorate which will be uploaded at RDSO website and TMS. The validity of QAP shall be 3years. After this period QAP shall be renewed based on the machines available with firms, operators qualified, performance of operators and other relevant factors.

14.4 RECORDING OF DATA

14.4.1 The testing system of the agency /firm shall have minimum memory provision along with facility to entering and recording data as under

(a) For SRT

(i) 04 number Calibration Sets
(ii) 200 A-Scan storage memory
(iii) B-Scan recording facility

(b) For DRT

(i) 04 number Calibration Sets
(ii) 400 A-Scan storage memory
(iii) B-Scan recording facility

(c) For Weld Tester

(i) 04 number Calibration Sets

14.4.2 In order to overcome the problems associated with the long and short kilometers the defect location report shall indicate location references with respect to kilometer point and chainage as indicated below.

The location of defect shall be reported manually in14 digit code comprising of

i) First four digits for Km Post encountered first
ii) next four digits for Km post encountered next
iii) last six digits for chainage in meters

14.4.3 Location of the defect shall also be indicated with reference to telegraph post/OHE mast numbers/ chainage. For SRT/DRT, location of defect in GPS coordinate (latitude and longitude) along with time stamping (equipment clock shall be duly synchronized with GPS satellite clock on at least half hourly basis, record of synchronization is to be stored in the equipment. Incase signal is missing from satellite, real time clock on the equipment shall record the time) shall also be recorded.

14.4.4 For SRT/DRT, the backup of ultrasonic testing data in electronic format shall be possible to be downloaded on desktop computer to allow analysis by suitable post processing software. Suitable post processing software shall be provided to Railway free of cost by the outsourcing agency/firm for analyzing recorded A-Scan, B-Scan data and recreation of A-Scan defect echo envelop display from B-Scan.

14.4.5 In case of ultrasonic testing of rails/welds by SRT/DRT, when a defect location is identified by the agency/firm's ultrasonic operators, the A-Scan defect echo envelope shall be recorded. Defect is marked in accordance with Para 5.5 of IRS Specification T-53. Rails that have not been tested on turnouts and similar locations shall be recorded and reported.

14.4.6 If such circumstances arise in the test work (where the limitation on the capacity of the agency / firm's testing system to identify defects in specific common track situations actually prevents reliable testing), then the start and end points of these conditions which prevent reliable testing should be identified clearly in the test exception report and be annotated to the overall comments to field on the daily test report.

14.5 DOCUMENTATION

14.5.1 The agency/firm shall determine and record all information as specified below pertaining to Recording of Data with respect to the detection of rail flaw.

14.5.2 Daily test report gives a summary of the day's testing.

a) Date of the inspection.
b) Name of the operator.
c) Name of Railway
d) Name of Division
e) Name of Block section
f) The line tested: UP/DN/Single Line/NL/SL/3L/4L
g) Chainage of start and finish of USFD testing as per Para 9.2 of IRS Specification T-53.
h) Section of Rail tested.
i) Log of operating ultrasonic parameters for each run along with any changes
j) And reasons e.g. change in gain due to temperature recalibration etc.
k) Railways employee present during testing.
l) Summary of all defects found during testing with chainage, defect classification and
m) Classification during the previous round of USFD testing if any.
n) Comments field for notes on particular defects e.g.
a. The type, category, length and recommended action (e.g. paints).
b. In the case of flaws in welds whether Thermit (TW), flash butt (FB), gas pressure (GP) and whether the defect in the weld is in the head (H), web (W) or foot (F) of the Rail.

c. The length and location of any rail/weld that could not be tested for a particular reason.

o) Location of defect as per Para 9.2 of IRS Specification T-53.

14.5.3 Rail/weld defect report listing all defects found during a test run.
a) Running log of defects detected, peak pattern, category and defect echo envelope.

b) Date of the inspection.
c) Name of the operator.
d) Name of Railway
e) Name of Division
f) Name of Block section
g) The line tested: UP/DN/Single Line/NL/SL/3L/4L
h) Chainage of start and finish of USFD testing as per Para 9.2 of IRS Specification T-53.
i) Location of defect as per Para 9.2 of IRS Specification T-53.
j) Classification of defect as per 'Manual for Ultrasonic Testing of Rails and Welds Revised,2012'along with its latest revision and updated correction slips.
k) In addition to above complete daily USFD test result shall be provided in the format matching with TMS for direct uploading of USFD test data on TMS (Track Management System). Format is provided at Annexure -2.

14.5.4 Priority defect list detailing rail defects requiring immediate action.

A priority defect report is to be communicated to the JE/SSE (P Way), immediately upon detecting IMR, IMRW and DFWO/DFWR/DFWN rail defects requiring a speed restriction and removal.

14.5.5 Movement log detailing the daily location and hours spent testing.

Movement Reports shall contain sufficient information to enable identification of the actual kilometers tested during the course of the day, the railway corridor tested and all other information required to ascertain hours of testing involved, and any other performance issues deemed relevant for contract administration purposes.

This information must include the following:

a) Time of scheduled meeting of staff at test start point.

b) Time of commencement of test.

c) Location and chainage of commencement of test as per Para 9.2 of IRS Specification T-53.

d) Name of Block Section to be tested.

e) The line tested: UP/DN/Single Line/NL/SL/3L/4L.

f) Kilometers tested in each session.

g) Time at which daily testing ceased.

h) Location and chainage at which testing ceased as per Para 9.2 of IRS Specification T-53.

i) A comments field must indicate any areas by kilometer readings that could not be tested and the testing limitation which led to the lack of testing in this area.

14.5.6 Comparison report listing defects reported on consecutive test runs.

14.5.7 Rail/weld test exception report which lists the sections of rail/weld that are omitted from the test programmed due to rail/weld and track conditions.

14.5.8 The above reports shall be prepared in hard copy and shall be forwarded to the Junior Engineer (JE)/Sr. Section Engineer (SSE) (P. Way), AEN and DEN/ Sr. DEN. The report indicated in Para10.1.1 and 10.1.2 of IRS Specification T-53shall be forwarded daily while the report indicated shall be communicated immediately to the above-mentioned officials. All other reports shall be forwarded to JE /SSE (P. Way), AEN and DEN/Sr. DEN at the frequency decided by the DEN/Sr. DEN of the section.

14.5.9 The electronic report (Soft copy) shall also be provided by the agency/firm in Micro soft Word/Excel/Access format at the frequency decided by the DEN/Sr. DEN of the section.

14.5.10 The B-Scan data recorded by SRT/DRT (in electronic format) shall also be provided by the firm along with suitable software for viewing the results in the office of AEN, DEN/Sr. DEN of the section as mentioned in specifications.

Chapter - 15
Heavy Track Machines

15.1 GENERAL

15.1.1 The Inventory of the existing track components to be jointly recorded and signed by contractor or his representative and SE/SSE-P.WAY and Account's Representative before taking up the work and released materials/left over materials to be stacked/handed over item wise/class wise at the nominated location.

15.1.2 The works are to be carried out under traffic conditions. It is the responsibility of the contractor to see that there is no detention and/or interruption to the movement of trains. No claim shall be admissible towards loss of time, wastage of labour, employed etc. that may be incurred by the contractor due to movement of trains. The rate quoted should cover all such contingencies.

15.1.3 Necessary speed restriction for the trains shall be imposed by the Railway and look out man shall be made available by the contractors to warn his labours for safety purpose.

15.1.4 Work shall be taken up only in the presence of the Engineer/Railways supervision nominated for the work.

15.1.5 The contractor should engage a qualified Engineering P. Way Inspector conversant with similar P. Way work to supervise at his cost. In the event at any accident at the work spot and it is established during the departmental enquiry by the Railways that the accident occurred wholly or partly due to any act of tantamount to negligence on the part of the contractor or his labour in not adhering to the instructions of the Engineer-in-charge. The contractor shall render himself liable for damages and also legal prosecution if loss of life is involved.

15.1.6 It is the responsibility of the contractor to arrange for watchman to guard against the theft / pilferage etc., till such time the released materials are handed over to the Engineer-in-charge.

15.1.7 The payment shall be released only after carting and stacking the released materials item wise and classification wise at nominated locations indicated by the Engineer-in-charge.

15.1.8 Post inventory of the laid track components to be jointly recorded and if any deficiency is noticed it should be made good at contractors cost after completion of the entire work.

15.1.9 Where ever required greasing and oiling to be done by the contractor.

15.1.10 PQRS portals, its maintenance, consumables etc. along with operators shall be provided by Railways.

15.2 SPECIFICATION OF SERVICE PANELS IN PQRS DEPOTS.

15.2.1 The above item of work envisages fabrication of service panels of nominal length of 9/13 m of concrete sleepers & rail sections as specified in the schedule in PQRS depots and at locations as per Railway's requirements and/or as directed by the Engineer or his Representative complete with all lifts, descent complete and all incidental works.

Besides fabricating the panels in 9 to 13 m approximate length depending on capacity of portal cranes in use, a small quantity of panels of nominal length 6 m may also be required for use in closing of work or at bridge approaches/level crossings etc.

15.2.2 The measurements for payment shall be per track metre& measured to nearest centimeter fabricated and accepted by the Engineer or his Representative.

15.2.3 The work shall be carried out as per the Railway's standard drawings, provisions contained in Indian Railways Permanent Way Manual and the extant instructions issued from time to time.

15.2.4 The concrete sleepers shall be provided at Railway's PQRS depot/locations and the work of fabrication of panels shall include: -

i) Placing the sleepers to the density (1540/1660 per km.) as required.

ii) Providing and fixing of 90R/52kg/60kg USFD tested service rails on the concrete sleepers correctly spaced including provision of rubber pads, liners and elastic rail clips as per standard assembly drawings and as per extant instructions. USFD testing of rails shall be done by the Railways.

iii) The sleeper position shall be paint marked on the rail and the sleeper shall be inserted exactly at these locations.

iv) Standard and prescribed tools shall only be used for driving elastic rail clips and other fittings.

v) Rail-sleeper fastenings and the service rails shall be supplied by the Railways within a lead of 100m.

vi) To prevent seizure of elastic rail clips (ERC) in MCI inserts it is essential that all ERCs and MCI inserts are thoroughly cleaned. Grease to IS:408(Specification for Grease No. "**O"** Graphite) or any other approved grease should be applied on the central leg of the ERC and eye of MCI insert and then the clip should be driven at the time of making the panels. The grease or the approved material shall be supplied free by the Railway otherwise specified in the item of work.

15.2.5 The panels on fabrication shall satisfy the following quality standards in regard to gauge and spacing:

Parameter	Details	Limiting Value
Gauge	Sleeper to sleeper variation	+2 mm
Spacing of Sleepers	with respect to theoretical spacing	+10mm

15.3 LAYING OF AUXILIARY TRACK

15.3.1 The above item of work envisages laying and fixing rails and rail-sleeper fastening and fittings etc. including all incidental works.

15.3.2 The measurement for payment shall be per track meter laid, measured to the nearest centimeter, and accepted by the Engineer or his representative.

15.3.3 The works shall be carried as per the Railway's standard drawings, provisions contained in Indian Railways permanent Way Manual and the extant instructions.

15.3.4 The rails shall be provided on the formation at site and the work shall include:

i) Placing Cast Iron plates/wooden blocks on the formation at 2 metre centre to centre.

ii) Linking rails on Cast Iron plates/wooden block to proper alignment so that gauge face is at 1.70 m. from centre line of existing track or at any other specified distance.

iii) Fixing fish plates and fish bolts and other rail and rail sleeper fastenings and M.S keys and dog spike etc. as per Railway's drawings and/or as per extant instructions.

iv) The rail and sleeper fastening shall be supplied by the Railway within a lead of100 m.

v) The rail height of auxiliary track shall be 50mm above the top of existing track rail level.

vi) The necessary lifting of cast iron plate/wooden block to achieve the desired level with locally available Railways packing material available at site.

vii) Packing of the track to render auxiliary track fit for movement of PQRS cranes.

15.4 TRACK RENEWALS WITH PQRS MACHINE

15.4.1 During this work, Railway will arrange PQRS cranes with fuel for unloading and laying of prefabricated panels from BFRs and removing of existing panels and loading into BFRs.

15.4.2 Contractor should arrange sufficient men for completing the other works viz: leveling of ballast, squaring of sleepers, gauging, aligning, initial packing boxing of ballast with in the period of traffic block including renewals of rails.

15.4.3 Contractor should also arrange sufficient gas cylinders and cutters with spares for flame cutting of rails at appropriate locations as instructed by Engineer-in-Charge.

15.4.4 The track parameters which should be attained on a relaying work with new materials and deep screening works should conform to stipulations of Indian Railways Permanent Way Manual and as per extant instructions.

Track Parameters to be maintained after Track renewal works. (Manual/Machine)

Track Parameter	Items for measurement	Value
Gauge	Sleeper to sleeper variation	2mm
Expansion gap at joint	Average gap worked out by recording 20 successive gaps	+/- 2mm
joints	Low joints not permitted. High joints not more than	+/- 2mm
joints	Squareness of joints on straight	+/- 10mm
Spacing of sleeper	With respect to theoretical spacing	+/- 20mm
Cross level	To be recorded in every 4^{th} sleeper	=/- 3mm
Alignment	ON straight on 10m chord On curves of radius > 600m on 20m chord variation over theoretical versine On curves of radius < 600m on 20m chord variation over theoretical versine	+/- 2mm 5 mm 10mm
Longitudinal level	Variation in longitudinal level with reference to approved longitudinal sections	50mm

15.5 REAR WORK OF BCM

15.5.1 The work includes filling up of 5 sleeper spaces with ballast, which the BCM leaves at the end of each days' work and closing spot.

15.5.2 Left over ballast shall be screened and spread in the crib and shoulders.

15.5.3 Boxing and sectioning should be done to correct profile as specified in latest IRPWM and as per instructions of Engineer-in-Charge at site.

15.5.4 Muck released from BCM shall be evenly leveled so that the height of the cess is as per standards laid down in IRPWM and it shall not obstruct track drainage.

15.6 PRE AND POST TAMPING OPERATIONS

This work should be carried out as per guidelines mentioned in latest IRPWM and IRTMM and the work to be done by the contractor is briefly mentioned hereunder:

PRE-TAMPING OPERATION:

15.6.1 Rail head ballast to be cleared for free rolling of lifting rollers/clamps

15.6.2 Heaping up of ballast in tamping zone to be done.

15.6.3 Squaring of sleepers for the correct spacing to be done. Deficient fittings and fastenings to be made good, and all fittings to be properly tightened to be done by Contractor

15.6.4 Worn out and damaged fittings to be replaced by the contractor.

15.6.5 Low/pumping joints to be packed properly by manually before tamping.

15.6.6 Removing of wooden blocks which were provided for supporting the rail/welds temporarily for tamping purpose.

15.6.7 Removing of wooden blocks provided for supporting rail/welds/check rails on curves/LC including opening gate, guard rails and tie angles provided at SEJ and OHE/S&T bonds etc. temporarily for tamping purposes.

DURING TAMPING OPERATION:

15.6.8 Work to be carried out only in traffic block period and sufficient man power to be engaged as directed by engineer at site.

15.6.9 Contractor to collect any machine parts fallen, if any, and hand over to Railways and all the loosed fittings while tamping to be tightened by contractor men.

15.6.10 Shoulders ballast should be compacted by manually if required.

POST TAMPING OPERATION:

15.6.11 Rear portion to be checked the gauge, cross levels, alignment and however under the supervision of Railway's representative. If any differences more than the tolerances to be attended as per Engineer in charge at site.

15.6.12 Re-fixing of wooden blocks, fish plates, check rails on curve/LC guard rails, and tie angles, OHE and S&T bonds etc. at original places/position.

15.6.13 While re-fixing the greasing/oiling to be done as required.

15.6.14 In case of level crossing road surface to be made good.

15.6.15 Voids left by tamping tools to be filled with ballast.

15.7 REMOVING AND STACKING OF POINTS AND CROSSINGS AND INSERTION OF PRE-ASSEMBLED FAN SHAPED LAYOUTS WITH PSC SLEEPERS WITH RAILWAY'S RELAYING MACHINE.

15.7.1 The above works are interconnected and shall be done under the personal supervision of Railway's representative.

15.7.2 Contractor should engage sufficient men for completing the work within block period.

15.7.3 Work includes renewals of approach rails i.e., a head of SRJ and behind crossing.

15.7.4 Only relaying machine with fuel shall be supplied by the Railway free of cost for lifting the pre-assembled points and crossings and keep it in position. All the other balance works in the schedule shall be done by the contractor with his men and material including initial packing leveling, aligning, profiling and boxing of ballast etc. to make the track fit for passing the trains at restricted speed.

Chapter - 16
Small Track Machines

16.1 The work has to be carried out as per the guidelines mentioned in Latest version of IRPWM and latest version of IRSTMM (Indian railway small track machine manual) and correction slips/ instructions issued from time to time by railway authorities, RDSO specifications and also as instructed by Engineer- in-charge at site .

Chapter - 17
Handling of Materials

17.1 LOADING/UNLOADING OF RAILS/SLEEPERS/P.WAY FITTINGS

17.1.1 The collecting/loading/unloading/stacking rails/sleepers/P. Way fittings etc. into/from Railway wagons/trucks at stations or movement on material lorries/dip lorry in block section as specified in the schedule and at locations as per Railway's requirements and/or as directed by the Engineer or his Representative complete with all lifts/descents and lead as specified in the schedule and all incidental works.

17.1.2 Labour and tools & plants etc. to be kept ready as and when traffic block is permitted.

17.1.3 If contractor fails to load as per the instructions of the Engineer-in-charge during the traffic block, sufficient quantity of the material, penalty shall be imposed as per terms & conditions.

17.1.4 No other adjacent lines to infringe during work for the movement of trains.

17.1.5 The measurements for payment shall be:

i) Weight in Metric Tons (**measured to the nearest to Kilogram**) of rails and sleepers loaded/unloaded.

ii) Weight in Metric tons (worked out to the nearest kilogram) of the P. Way fittings loaded/unloaded.

iii) For new materials, weight of material shall be reckoned with respect to nominal weight as per drawing/laid down, if drawing is not available.

iv) For class II material average weight of each unit to be taken.

v) For released materials, reduction from nominal weight shall be as prescribed by Railway Administration.

17.1.6 The work shall be carried out as per relevant provisions of the Indian Railways Permanent Way Manual and the extant instructions.

17.1.7 Procedure for moving materials in mid-section by Dip Lorry/material lorry on track is to be executed as per the guidelines laid down in IRPWM. It would be necessary that the movement be permitted strictly under the control of a Railway's representative who has the necessary lorry/trolley certificate. When materials are moved on material lorry without block protection, unloading/loading the material lorry in the mid-section may become necessary to permit movement of trains. Such incidental loading(s)/unloading(s) in the mid-section do not entail measurements for payment.

17.1.8 The wagon/truck shall be loaded in a safe and proper manner not exceeding their carrying capacity. No uneven loading shall be done.

17.1.9 Unloading of materials shall be done in a safe and proper manner so as not to damage existing structures/installations. It shall be ensured that unloaded materials do not infringe the Railway's Schedule of Dimensions.

17.1.10 All materials after unloading shall be properly stacked in material wise and classification wise as per directions of the Engineer and as per provisions of Indian Railways Permanent Way Manual.

17.1.11 In case of loading/unloading in block working the availability of adequate strength of workmen so as to complete the work in the block time granted shall be ensured.

17.1.12 While loading/unloading materials, adequate care shall be taken as per extant instructions for handling the material so that material itself is not damaged/adversely affected.

17.1.13 Whenever concrete sleepers are loaded into wagons/trucks, wooden battens of specified size shall be placed between the tiers of sleepers (including below the bottom most tiers) to facilitate convenient handling.

17.1.14 Stacking the sleepers at the nominated Deport/Stacks/Locations, as specified in the schedule, all lifts and descents and incidental works.

17.1.15 Sleepers shall be handled carefully so as to avoid any damages rendering them unsuitable for use. Concrete sleeper shall preferably be handled by mechanical equipment.

17.1.16 The sleepers are stacked on reasonably level ground where adequate drainage exists.

17.1.17 In case of wooden sleepers, stacking should be in accordance to the stipulation of Indian Railways Permanent Way Manual.

17.2 COLLECTING/LEADING/STACKING OF CROSSING ASSEMBLIES/ TONGUE RAILS

17.2.1 Collecting/leading/stacking Railway's crossing assemblies consisting of one Vee(V) and two wing rails including all blocks, their nuts and bolts etc. but excluding check rails and sleepers of the rail section as specified in the schedule from the nominated depots/stacks/locations

17.2.2 Collecting/leading/stacking tongue rails of the rail section as specified in the schedule from the nominated depots/stacks/locations within specified lead or and including all lifts/descents etc. as directed by the Engineer with all incidental works.

17.2.3 The measurements for payment shall be on the weight in metric tons (MT) nearest to kilogram.

17.2.4 The work shall be carried out as per the standard drawings, provisions contained in Indian Railways Permanent Way Manual and the extant instructions.

17.2.5 The work shall conform to the following:

i) Crossings/tongue rails should not be dragged on the ground/track. For handling, slings, rail tongs, rail dollies, rollers etc. or other prescribed equipment shall only be used.

ii) While stacking/collecting, care shall be taken to ensure that the crossings/tongue rails are sorted rail-section wise and/or class wise, and they are stacked/spread on level ground and stacked in a manner directed by the Engineer or his representative.

17.2.6 While working in the vicinity of track, it shall be ensured that the Railway's Schedule of Dimensions are not infringed with.

17.2.7 Use of rail lorries/Dip Lorries for leading/hauling on track can be resorted on only with the approval of the Engineer and it should be carried out under the supervision of the Engineer or his authorized representative.

17.3 TRANSPORTATION OF P.WAY MATERIALS

17.3.1 Loading/unloading of P. Way materials shall be done with utmost care without damaging and stacked at locations as instructed by Engineer neatly, class-wise and material-wise.

17.3.2 All logistics required for loading/unloading and stacking at the location as directed by Engineer-in-charge shall be arranged by the contractor.

Chapter - 18
Level Crossings

18.1 BENDING OF CHECK/GUARD RAILS

18.1.1 Bending of check rails and guard rails shall be as per standard drawing and to latest alterations if any.

18.1.2 Bending of check rails and Guard rails for level crossings and Bridges includes Gas flame cutting if required. Bending should be done as per Railways Standard drawings.

18.1.3 In case of cutting of flange/web of rail either by cutting machine of flame cutting; the cut surface should be properly grinded to give even finish and profile without leaving any uneven marks on the exterior surface.

18.2 OVERHAULING OF LEVEL CROSSINGS

18.2.1 Digging out ballast up to 50mm below sleeper, screening of ballast, making up of good ballast, replacing worn-out track fittings, worn-out sleepers, check rails etc.

i) The work includes scrapping of rails and painting with approved quality of anti-corrosive paint 2 coats (R/M Bituminous black, lead free, acid, alkali, water resisting to IS:9862-81).

ii) The work shall be done under speed restriction without block protection.

iii) Railway shall arrange for diverting the Road traffic in consultation with local authorities.

iv) The work shall be done under direct supervision and satisfaction of Railway's representative not lower than the grade of JE/P. Way and as stipulated in latest version of IRPWM and latest CS/ guidelines issued from time to time

v) After refilling the ballast, the surface shall be made good with available material or re-fixing RCC slabs for smooth movement of traffic.

18.3 The material/ Equipment supplied by contractor towards assembling / Erection of Level crossing gate should confirm to RDSO specifications and Drawings and to be fixed as per the specified drawings, and the concrete work carried for erection of LC equipment should confirm to railway specifications and work to be carried out as per instructions of engineer at site.

Chapter - 19
Bridge Related Activities

19.1 RENEWAL OF BRIDGE SLEEPERS

19.1.1 The work shall be done as stipulated in latest IRPWM (2020), latest IRBM and guidelines issued from time to time.

19.1.2 The work shall include removing of guard rails and foot path sheets& fittings.

19.1.3 Creep should be adjusted before taking up the work of re-sleepering.

19.1.4 The contact surface of steel work between the sleeper and girder (top flange under sleeper seat) should be painted with approved quality of paint after thorough scrapping

19.1.5 Care should be taken to ensure that the rails are fixed in correct alignment and gauge.

19.1.6 The hook bolts should be fixed in such a way that the arrow grooved on the top end of the bolt should be perpendicular to the rail and pointed towards the rail.

19.1.7 Foot path sheet also should be re-fixed.

19.1.8 The material supplied towards bridge works i.e., Steel channel sleepers and relevant fittings should be as per the RDSO specifications and drawings.

19.1.9 The work has to be carried out under the supervision of railway officials not less than the rank of JE/ P. way/Bridges.

19.1.10 The Renewal work has to be carried out under suitable speed restriction / Traffic block.

Chapter - 20
Supply of P. Way Materials

20.1 The P. way material/ Fittings/ Equipment etc., Supplied should be as per the RDSO Specifications and drawings.

20.1.1 The LC indicator boards/ Engineering Indicator boards/ Trolley refuge indicator boards/ Curve indicator boards / Bridge indicator boards supplied should be as per the RDSO Specifications and drawings and also as per latest version of IRPWM and Correction slips/ guidelines issued from time to time in this matter.

Chapter - 21
Miscellaneous Items

21.1 The work has to be carried out as per the RDSO specifications, instructions laid down in latest IRPWM, and guidelines issued by railways from time to time.

21.2 The work has to be carried out as per the prescribed drawings and Instructions of engineer at site.

21.3 The work of galvanization to be carried out as per the specifications issued by RDSO with latest correction slips/guidelines if any.

21.4 The work of providing of Kilometer/Gradient posts - These may preferably be of RCC of suitable dimensions and fixed at right angles to the track on the cess so as to be distinctly visible. The figures, arrows and letters should be painted in a black on a white background.