

Chapter 1

Earth Work

1.1 EARTHWORK - GENERAL

1.1.1 Site Clearance : Before work is started, the whole area between the toes of banks or tops of cuttings plus 2m on both sides shall be properly and effectively cleared by the contractor of all small trees (of girth upto 30 cm), roots, bushes, heavy grass etc; The Contractor shall also clear the site of all buildings, abandoned structures etc as directed by the Engineer, for which extra will be made unless otherwise stated in the agreement. The Contractor shall arrange removal of rubbish and other excavated material excluding earth upto a distance of 50 the periphery of the area under site clearance. High portions of the ground shall be cut down and hollow depressions filled upto the required level with the excavated earth so as to give an even neat and tidy look. The work of this nature will be covered by the initial rate for earth work, unless stated to the contrary in the agreement.

1.1.1.1 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. The roots of trees and saplings shall be removed to a depth of 60 cm below ground level or 30 cm below formation level or 15 cm below subgrade level, whichever is lower. All holes or hollows formed due to removal of roots shall be filled up with earth rammed and levelled. Trees, shrubs, poles, fences, signs, monuments, pipe lines, cable, etc adjacent to the area which are not required to be disturbed during site clearance shall be properly protected by the contractor at his own cost and nothing extra shall be payable. In case any damage to the pipe lines, cables, etc is done due to negligence on part of the contractor the necessary damage charges will be recovered accordingly.

1.1.1.2 Any trees cut down or building materials released from dismantling of structures shall be stacked by the contractor within a distance of 100 metres outside the periphery of the area under site clearance as per instructions of the Engineer. 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 Demarcation and Profiles : The contractor, before starting work, is to demarcate with a deep furrow, at least 20 cm wide and 15 cm deep, 1m 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 and the top of the slopes of the borrow pits. 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 dag belling 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.

1.1.2.1 The centre line will be initially set out by the Railway. The contractor shall, at his own expense, provide all building materials 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 for marking out borrow pits and slopes and will be responsible to ensure that they are maintained in proper order. The costs of providing and maintaining the above including all materials and labour is included in the initial rate for earth-work.

1.1.2.2 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 should 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 level in consultation with the department.

1.1.3 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 it

in, and to further protect the place by turving, 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, and with the proper allowance for settlement as specified in **para 1.2.6.**

1.1.3.1 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 he shall have no claim for any extra work or payment on this account.

1.1.4 Spoil from cutting to bank : Up to the normal lead of 50 metres, 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 will 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. Dressing and compaction of the bank will, however, be paid for in addition.

1.1.5 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 :

1.1.5.1 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.

1.1.5.2 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.

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

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

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

1.1.5.6 Hard Rock (Blasting Prohibited) : Hard rock requiring blasting as described under **sub para 1.1.5.5**, but where blasting is prohibited for any reason and excavation has to be carried out by chiselling, wedging or any other agreed method.

1.1.6 Measurements : Cutting and banks are to be excavated and made up neatly to the lines shown in the cross section as per approved construction drawing. No payment will be made for excess work done outside these lines 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 will be made. Similar action will be taken in case of concave surfaces in the slopes of embankments, if permitted.

1.1.6.1 Should the Engineer so desire, 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 will be paid for in accordance with the specifications and the Schedule of Rates.

1.1.6.2 Unless otherwise specified the initial rate for Earth work is inclusive of an initial lead upto 50 metres and lift of 1.5 metres.

1.1.6.3 Additional lead for the purpose of payment will 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.

1.1.6.4 Additional lift for the purpose of payment will be estimated by dividing the cross section of the bank or cutting into successive stages of 1.5m high or deep respectively from the natural ground level and only the quantity contained in each strip shall be paid for at the rate pertaining to its height or depth above or below the natural ground level, respectively. Lift from the borrow-pit to the ground level or from ground level to the spoil bank shall not be taken into account in any payment for lift unless the depth of the borrow-pit or the height of the spoil bank has been made in excess of 1.5m under instructions from the Engineer, and in such cases, only the portion of the borrow-pit below 1.5m depth or of the spoil bank above 1.5m height as measured from the natural ground level, shall be, measured separately for payment of lift on the same basis as for cuttings or banks respectively. No extra payment will be made for descent, ascents, crossing of nullahs and ridges.

1.1.6.5 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 will 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 will be marked vertically on the cross section and the content of each type of soil will 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.

(b) For one sided cutting on a transversely sloping ground : Content of each type of soil will 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 will be made

(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.

(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.

1.1.6.6 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.

1.1.6.7 In computing the quantity of earth work in cuttings and side drains, no cognizance will 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 will only be made for the quantity as per cross sections required to be provided.

1.1.6.8 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 will 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 50 metres and lift upto 1.5 metres is covered by the initial rate of Earth work.

1.1.6.9 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 from borrow pits.

1.1.6.10 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 / bank profile shall be taken and plotted by the Authorised representative of the Engineer in the presence of contractor or his authorized agent before commencement of the work. The profile of the bank or the cutting required to be provided including allowance of settlement in case of embankment, 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 and plotted bank/ cutting shall like-wise be taken in the presence of the contractor or his authorised agent and super-imposed on the original ground profile. These profiles are to be taken at locations as directed by the Engineer, atleast 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. For the purpose of payment the gross quantity thus calculated shall be reduced by 10% towards shrinkage allowance for earth work in embankments only, but no such deductions shall be made for earth work in cuttings. Where the embankment has been compacted by heavy machinery as stipulated in subsequent **Para 1.9** 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. Irrespective of the type of soil, number of monsoons passed over the embankment, shrinkage / compaction which may be caused due to base settlement, wash out, mode of working, i.e. use of trucks, camel carts, donkeys etc, and other reasons, whatsoever and the actual shrinkage allowance provided in setting out the profiles in different sections.

As it may, at times, be difficult to measure by means of cross sections the quantity of rock excavated by blasting or chiselling, 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
(a) Rock spoil of different sizes	30 per cent
(b) Sandy materials	7 ½ per cent
(c) Black cotton soil	20 per cent

- (d) 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 levelled 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. If however, this is found to be uneconomical due to excessive lead or lift, the earth if available from the borrow pits in Railway land it may be used if permitted. If sufficient quantity of good earth fit for embankment is not available from the source of cut spoils and the source of borrow pits, Contractor's earth shall be utilised. 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 compaction done before earth from the next source is allowed to be dumped. 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 at the rate of 10%/5% as the case may be, depending upon the type of compaction done.

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.

1.1.6.11 At the end of final measurements, following certificate shall be recorded in the Measurement Book by Authorised representative of the Engineer.

"Certified that necessary allowance for shrinkage as prescribed was made while giving profiles to the contractor for doing earth work and the same has been provided by the Contractor".

1.1.6.12 Where, for any reason at the discretion of the Engineer, borrow-pit measurements are resorted to, all matams and roads and excess earth work, such as bulges in the slopes of the banks / cuttings, shall be excluded from the measurements.

1.1.6.13 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 not requiring pumping etc.
- (Note : Pumping out water caused by powerful springs, tidal or river seepage, broken water mains or drains and the like, shall be paid separately if provided for in the Agreement)
- (iv) Unauthorised 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.

1.1.7 Dressing Surface :

1.1.7.1 This specification is applicable to Surface dressing executed as a separate work for purposes other than Earthwork for Embankment or Cutting. In case of Earthwork for Embankment or cutting, provisions of **Para 1.1.1** will apply and the surface dressing will be covered by the initial rate of earthwork unless stated to the contrary in the Agreement. This specification shall also be applicable only to work involving Soft / Loose soil and Hard / Dense soil.

1.1.7.2 The terms "Dressing Surface" shall be taken to mean the cutting down of high portion of a specified area of ground and using the excavated earth to fill up the hollows and the depressions. The maximum depth of excavation or filling shall be restricted to 15 cms.

1.1.7.3 The levels to which the ground is to be dressed shall be such that the quantity filled is nearly equal to the quantity cut and the finished surface is even and tidy with

such slopes as may be necessary for proper drainage. Before the work is commenced the proposed levels shall be set up at regular intervals both for the cuts and for the fills, by suitable means as directed by the Engineer and these shall be got checked and approved by him.

1.1.7.4 Unless otherwise provided for in the Contract, the rates shall be inclusive of removal of rubbish upto a distance of 50m outside the periphery of the area cleared.

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 the rates to be paid, and will arrange for a special agreement for the same if necessary.

1.2.2 Selection of Earth : If due to non availability of adequate quantity of earth from Railway land, the contract provides for contractor's earth the contractor shall get the prior approval of the Engineer for the quality of earth and where Contract Conditions provide for lead based on the distance from the sources of supply to site, the lead to be paid. The disturbed / undisturbed soil samples along with the test results as per specifications will 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.

1.2.3 Formation Width : The formation widths are to be as shown in the drawings.

1.2.4 Side Slopes : The side slopes will ordinarily be 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 from the toes of the slope coming up simultaneously. The slopes of banks composed of sand shall, if directed by the Engineer be covered by a layer of not less than 30 cm thickness of Moorum or other good soil to facilitate turfing and extra payment will be made for the same.

1.2.5 Profiles : Profiles for banks shall be set out where-ever cross section has been taken. These profiles shall be set up atleast 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.

1.2.6 Allowance for settlement : In width of formation 50mm extra should be provided for each 30 cm of the height of the bank as shown on the section upto a maximum of 0.60m. This does not affect the width at the toes of the slopes, which will be set out from the height given on the section. In setting up profiles for bank, due allowance for settlement must be made and added to the height of the profile over and above the height of formation as shown in the approved drawing. As a guide the following shrinkage allowances per metre height are suggested for adoption with different classes of soil:- The additional earth has to be removed after final dressing and it can be used elsewhere after a stretch of the work is completed, dressed to final profile and taken over by the railways.

Shrinkage allowance for work done manually per metre height :

Bank made of rocky fills	0	to	2 cm
Bank made of moorum and sandy soils	8	to	12 cm
Bank made of fills with considerable clay content	16	to	20 cm

The Engineer will decide the scale of allowance for settlement for each section and shall be at liberty to vary the same during the progress of the work to suit the nature of soil met with, the method adopted for executing the earth work, the consolidation achieved during the progress of the work and any other factors affecting the earth work.

1.2.6.1 The above shrinkage allowances are only for the purpose of setting out of the work. For payment, the deduction for shrinkage shall be as specified in para **1.1.6.10**.

1.2.7 Borrow Pits : The Engineer concerned will direct from where material is to be obtained and has powers to refuse to allow any unsuitable material to be put into a

bank. As far as possible, Bank should be made of homogeneous material with no mix of rubble or boulders with soil. No excavation for borrow pits shall be made within 2m of the limits of the acquired land. Borrow pits shall not be dug close to level crossings, bridges or culverts, telegraph poles, electric poles, or close to inhabited areas, unless they can be properly drained to prevent water stagnating. Borrow pits within station limits shall be avoided as far as possible. The earth is to be excavated and thrown to such width, depth and height and in such places as may be from time to time decided.

1.2.7.1 During excavation, the contractor shall take particular care to avoid damage to drains, water mains, cables or other underground work. Should any damage be caused, the Engineer shall be notified immediately and the damage shall be made good at the contractor's expense.

1.2.7.2 Borrow pits shall be excavated within the limits of railway land as directed by the Engineer. The pits must be rectangular or conform to the land boundaries. The sides of the pits next to the toe of the bank are to be sloped down at 2:1, and elsewhere at a slope of 1:1 unless otherwise directed by the Engineer. Any pits wrongly excavated shall be refilled by the contractor at his own cost, and in such a manner as the Engineer directs.

1.2.7.3 Borrow pits are not to be made of uneven depth but the whole area of each pit is to be neatly excavated to the same level. The outer or the most distant half of the borrow-pits is to be excavated first, so that in the event of the pits being flooded by rain, there will still be ground available for work.

1.2.7.4 A berm 15m wide is to be left untouched initially at every 85m between edges of borrow-pits, and is not to be encroached upon for any excavation except under the instructions of the Engineer. If it is necessary for drainage purposes to cut through the berm, the channel will be made on the side remote from the Bank.

1.2.7.5 In side long ground, the borrow pits are to be dug on the upper side of the bank, and are to be continuous to serve as catch water drains; and, if so ordered, the contractor shall get the earth for the bank exclusively from such pits till the catch water drain is complete to the required length, section and level as prescribed by the Engineer.

1.2.7.6 When doing repair work to banks it is absolutely essential that diagonal bunds be

kept, when digging fresh borrow-pits in the old ones, as a precautionary measure for correct assessment of the work. Diagonal bunds are also to be kept in borrow-pits for new works where payments are to be made on borrow-pit measurements. When doing earthwork repairs, Authorised representative of the Engineer should bear this point in mind and refuse to measure up any pit in which a diagonal bund has not been kept. For repair works it would save a large amount of unnecessary detailed measurements if all pits were excavated to a uniform size as far as practicable.

1.2.8 Bank executed manually : All banks, if executed manually shall be made in successive layers, not more than 30 cm in depth, over the whole width and slightly concave in section so as to retain water for subsidence. The subsequent top layer shall be started only when the previous layer has been completed for a length not less than 30m along the embankment.

1.2.9 Clods:- All large clods (larger the 15 cm) shall be broken up in the borrow pits or bank by labour specially deputed for this work. This shall be strictly ensured.

1.2.10 Bunding of Bank Top : In banks executed manually/mechanically, before the commencement of monsoon, continuous longitudinal earth bunds, 25 cm high and 30 cm wide on the top with side slopes of 2:1, are to be made on the outer edges of the top of embankments, together with cross bunds of the same dimensions at every 15m, so as to impound rain water to expedite consolidation. This work shall be paid for separately at the rate for soft/loose soil and may be left uncompacted.

1.2.11 Benching : In widening an existing bank, steps 30cm in height and approximately 60 cm wide, shall be cut in the existing bank before any new earth is placed, to form a bond between the new and old earth work. Similar benching is to be provided in side-long ground of which the slope at right angles to the alignment of the banks is 3 Horizontal to 1 vertical or steeper or if ordered by the Engineer. The benching in side long ground will not be separately measured or paid for, but is deemed to be covered by the initial rate for earth work.

1.2.12 Stream diversions : When it has been decided to divert a stream adjoining the bank, the excavation for this work is to be undertaken and completed before any borrow pit work is done at site and all earth from such diversion is to be put into the main bank, if so ordered. If earth excavated from

the drain is led into the bank, payment will only be made for the quantity excavated including lead and lift if any and not for both cut and fill. In excavating for diversion of stream, care must be exercised by the Engineer that such diversion does not start a land slip.

1.2.13 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, in order that the filling may be well trodden down under the feet of the labourers; and in filling in foundations and backing to revetments, the earth work shall similarly be brought up level as the masonry proceeds. Filling for the backing of bridges or culverts will conform to specifications under **Para 1.6**, and subsequent sub paras, or as ordered by the Engineer. Cast iron rammers should be used to consolidate the earthwork where mechanical compaction can not be done due to practical constraints.

1.2.14 Dressing : After completion of earth work the slopes shall be neatly dressed to the correct profiles, and shall be made up where required during the maintenance period. The top 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.

1.2.15 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 will 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 and profiles. Contractor should be given permission in writing to this effect before starting the Turfing.

1.2.15.1 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.

1.2.15.2 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 it not doing so, he will returf 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 incharge depending upon the local conditions.

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

1.2.16 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 will be staggered for proper coverage of the area. For other types of plantation, the local practice shall be followed as directed by the Engineer. Where directed to be done, this item will be paid for extra.

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 :

The top width of each side drain will ordinarily be 120 cm at formation level and depth 30 cm, unless shown otherwise in the drawing. For longer drains specially designed sections will be adopted depending upon the catchment area, length and slope of the drain which should be finalized before completion of the cuttings.

1.3.2 Side Slopes : The side slopes will ordinarily be 1:1 unless otherwise ordered by the Engineer.

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 will not be started until the top portion is thus completed.

The necessity of excavating cuttings in this manner is evident as, in the event of heavy rain occurring with work partly completed, and the bottom of the excavation uneven and incapable of drainage, excessive delay might occur or excessive pumping might become necessary. The contractor is solely responsible for any such contingency and the railway will not be liable for any compensation.

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 oversight 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 will be excavated upto 15 cm (Max.) below the true formation and filled up to true level with cutting spoil to ensure that no lumps of solid rock project above formation level. The bottom sloping from centre towards side drains shall be as given in Sub **Para 1.3.3.3** below. Payment will, however be made for earth work in cutting up to the true formation level only.

1.3.3.3 In soft soil the excavation of cuttings shall, in the first instances be carried to about 15 cms short of the full depth, so much being left for dressing the bottom true to the formation. The side slopes shall be dressed true and straight and the bottom shall then be completed by sloping if from the centre line towards the side drains to a slope of 1 in 30 or any other slope as shown in the drawing.

1.3.4 Drainage of 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 will 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 will be made in such cuts or steps as may from time to time, be directed. Generally, in deep cuttings the first cut or step will approximately follow the surface of the ground, where this will secure the necessary

slope for drainage, and will 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. Excavation to the required cross section and longitudinal slope to form the side drain will be paid for at the same rates for cutting.

1.3.5 Catch-water drains : Where required, catch water drains cut to the section and profile prescribed, shall be constructed on the up hill side leaving a berm of one metre from the boundary of the railway land or as decided to suit the local conditions and shall be paid for at the same rates as for cutting. The cross sectional area of the catch water drain shall normally not exceed 0.75 sqm.

The spoil from the catch water drain will be deposited to make a uniform slope from the edge of the cutting towards the drain. The material derived from the catch water drain will 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 1 $\frac{1}{2}$: 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 up hill 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, as also 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 finds of archaeological interest such as relics of antiquity, coins, fossils or other articles of value shall be delivered 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 with the Contractor.

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 will be made for taking such measures unless otherwise specifically provided for in the Contract.

Excavation shall not be carried out below the foundation level of adjacent buildings until underpinning; shoring etc. is 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 upto date. Extracts from the Explosives Rules 1983 are kept at **Annexure 1.1** for strict adherence by the Contractor's staff as well as Railway employees engaged in blasting operations. For general guidance, the instructions contained in Chapter X of Indian Railways Works Manual may be referred to. The following specifications are supplementary to the above.

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 licence 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 upto date and the Explosive Rules, 1983. The contractor shall purchase the explosives fuses, detonators etc. only from a licenced 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 agent of the contractor (referred subsequently as agent 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 makeup 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 notch shall be cut in one piece of fuse about 2 cm deep from the end and the end of other piece inserted into the notch. 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 atleast 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 a 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, Safety code 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 WORK BY DEPARTMENTAL MATERIAL TRAINS ;

Normally earthwork is not done by DMT these days.

1.5 EXCAVATION OF FOUNDATIONS FOR BUILDINGS / TRENCHES FOR PIPELINES ETC.

1.5.1 Clearance of Site : The contractor will, at his own expense, clear the site of all obstructions to enable the setting out to be done, and will also provide all necessary labour, pegs, string, building materials including cement etc. required for the proper setting out of the work. If any huts or other structures, trees (girth 30 cm and above) etc. are to be removed they will be paid for separately.

1.5.2 Setting out : The centre longitudinal or face line and at least one main cross line shall be marked by means of small masonry pillars built clear of the point to which the slopes of the excavation will extend. On each pillar there shall be an accurate mark to enable a theodolite being set up over it for setting out purposes. These pillars shall be adequately protected from any possibility of damage during the course of the work. The provision and protection of the pillars shall be at the expense of the contractor, for which nothing extra shall be paid.

1.5.3 Size and Form of Excavation: The excavation for the foundations of bridges, culverts, columns and buildings and all other structures as well as trenches for sewers, drains and pipes, shall be executed to the depths shown on the drawings, or to such greater or lesser depth as the character of the ground necessitates to ensure a stable and solid foundation, and as directed by the Engineer. Should the trenches be excavated by the contractor by negligence or mistake to greater dimensions than are necessary, no payment shall be made for this extra excavation and the contractor will bear the cost of the concrete of the mix proportion stipulated for bed concrete and for levelling the concrete required to fill up the excess excavation.

1.5.4 Sides and Shoring : Excavations for foundations and trenches shall be executed with sloping sides, or shall be properly timbered with vertical sides as may be necessary and as directed by the Engineer. Whatever be the method adopted for the excavation, it shall be efficiently carried out to ensure its stability and safety of adjoining lands, railway line, pipes and other structures, as also the safety of the labourers employed on excavation work. No excavation shall be carried out below the foundation level of adjacent structures until adequate safety measures, as directed by the Engineer, have been taken. Any

measures as may be necessary or as directed by the Engineer for protection against risk of accidents to the public due to open excavation shall be provided by the Contractor. These may include temporary fencing, lighting of site etc.

1.5.5 Trenches for Sewers, Pipe lines or drains : The excavation of the trench shall be carried out accurately to the depths, gradients, lengths and directions shown in the drawing. All trenches which are to be with gradients, must be excavated commencing from the lowest point and advancing towards the highest point, the excavation of man-holes, chambers, etc. at the different points being completed before the excavation of the trench advances beyond those points. Trenches for laying of pipes shall be excavated wide enough to allow a space of 22.5cm unless otherwise directed by the Engineer, on either side of the collars, sockets or flanges of the pipes when laid, so as to provide walking space for workmen. No extra payment shall be made for making a trench to any special shape as may be specified in the case of drains, pipes bedded on earth etc.

1.5.6 Sight rails etc. : The Contractor shall supply and erect proper sight rails and supply boning rods, as necessary for the proper execution of the excavation work. Boning shall be done at intervals not exceeding 1.8m along the length of the trench. In the case of trenches for pipes and drains, where the boning rod is devised to show the invert level, a block of wood of height equal to the difference in level between the invert and the bottom of foundation should be used in boning the excavated trench.

1.5.7 Wet Excavation : All excavations in foundations shall be paid for as “dry”, except such as is actually below sub-soil water level and requiring continuous bailing or pumping. The contractor will be responsible that no work in excavation at the increased rate for “wet” excavation is commenced, until the work has been inspected by the Engineer or the Authorised representative of the Engineer, and approval obtained stating the point from which the “wet” excavation commences.

1.5.7.1 In all pumping and other operations, special care shall be taken to prevent “blowing” and to ensure that sand or other material is not withdrawn from the bottom or sides of the trenches and the adjoining ground. The contractor shall take adequate measures for bailing and / or pumping out

water from excavations and construct diversion channels, bunds, sumps, coffer dams etc. as may be required. Pumping shall be done directly from the foundation trenches or from a sump outside the excavation in such a manner as to preclude the possibility of movement of water through any fresh concrete or masonry and washing away parts of concrete or mortar. During laying of concrete or masonry and for a period of at least 24 hours thereafter, pumping shall be done from a suitable sump separated from concrete or masonry by effective means. Capacity and number of pumps, locations at which the pumps are to be installed, pumping hours etc. shall be decided from time to time in consultation with the Engineer.

Pumping shall be done in such a way as not to cause damage to the work or adjoining property by subsidence etc. Disposal of water shall not cause inconvenience or nuisance in the area or cause damage to the property and structures nearby.

1.5.7.2 The rate for dry excavation includes seepage water standing up to a maximum of 15 cm in depth in 3 hours when work is not in progress. The rate for wet excavation includes the cost of pumping or bailing out water with the contractor's tools, plants, fuel and labour.

1.5.7.3 Should it be necessary to do "Shoring" as approved by the Engineer the same will be paid for.

1.5.8 Bottom of foundations : The bottom of all foundations and trenches shall be accurately excavated to the form of the permanent work, and carefully levelled and cleaned, and if dry, shall be well watered and thoroughly rammed, and all loose or soft material of every kind shall be entirely removed before building work is started. Where the excavation is in rock, the sides of the trenches shall be properly sheared and cut, and the bottom shall be dressed and stepped for proper bearing as per plans or as directed by the Engineer, all without any extra payment beyond the contract rates.

1.5.9 Special measures : When a safe and solid foundation cannot be obtained at the depth shown in the plans, special measures (to be determined in all cases by the Engineer) may be necessary, and the carrying out of these must be made the matter of a special agreement before hand.

1.5.10 Disposal of soil : All spoil from excavation of foundations shall be neatly spread to make up the adjacent ground, or otherwise disposed of as directed by the

Engineer. Nothing extra shall be paid for the neat spreading of the spoil.

1.5.10.1 No excavated earth is to be heaped within 2 m of the edge of the trench or half the depth of the trench, whichever is more.

1.5.11 Inspection : Foundation trenches shall be passed by the Engineer or the Authorised representative of the Engineer before laying the concrete. The bottom of the excavation shall be carefully examined for any soft spots. Should any such places be found, all the soft earth must be removed and the hollow space filled with concrete with the same mix as the foundation concrete or as directed by the Engineer. If differences of level have to be provided for, it shall be done by means of vertical steps.

1.5.12 Measurements : The quantity of excavation to be paid for is to be the product of the area of the foundation trench as shown in the plan and the depth to which the trench has been carried, and is not to include slopes and slips due to the falling in of the sides or due to undermining, or any other cause whatsoever. Where shoring is considered necessary and approved by the Engineer, it shall be paid for at the rate as provided for in the Contract.

However, in case where excavations with sloping sides or with varying widths at different depths has been specifically permitted by the Engineer, the quantity of earth work in excavation will be paid for as actually executed.

1.6 EARTH FILLING IN FOUNDATION TRENCHES AND PLINTH, UNDER FLOORS AND BEHIND ABUTMENTS ETC.

1.6.1 Foundation Trenches : The space between the sides of the foundation trenches and the masonry is to be filled with sound impervious material such as moorum, chips, spawls, 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.

1.6.1.1 Where there is likelihood of rain, the earth filling may closely follow the masonry until ground level is reached, but the

contractor shall only do this after obtaining the written permission of the Engineer.

1.6.1.2 Where concrete foundations are brought up in reducing off-sets, it will 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.

1.6.2 Plinth filling or filling under floors

: After allowing 7 days / 14 days setting time respectively for Cement / Lime masonry, filling in plinth or under floors shall be similarly done with earth in layers not exceeding 15 cm, watered and consolidated by ramming with iron rammers and with butt ends of crow bars / wooden ballies. Only sandy soil, free from salts, organic or other foreign matter and white ants shall be used for such filling. Where there is black cotton soil, this shall be removed to a depth of 60 cm as it is liable to absorb moisture and expand and thus ruin a floor. The top 30 cm immediately below or as shown in the drawings the floor shall be filled with sand or cinder. If earth of good quality fit for this filling is not available from earth generated by excavation for foundation etc, or from borrow pits from within the Railway land, good contractor's earth should be used.

1.6.2.1 To prevent future sinkage, and damage to the floor it is necessary, when convenient to do so, that the plinth area be flooded with water for minimum 3 days so as to enable the earth filling to consolidate thoroughly. In this case, however, the earth filling shall be allowed to dry and then rammed and consolidated, before the pucca flooring is laid.

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

1.6.2.3 The filling shall not be commenced until the recording of levels, measurements etc as maybe 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.

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

1.6.3 Filling behind abutments etc. : Unless otherwise specified, the space next to the masonry at the back of all bridge abutments, wing walls and return walls is to

be "Backed" or filled by hand packed graded coarse material such as boulders and cobbles, quarry rubbish, chips, spawls, hand packed dry rubble or other hard and drainable materials for a thickness of at least 60 cm. or to such thickness as may be shown in the drawings, or as directed by the Engineer with the smaller size material towards the back.

1.6.3.1 The space at the back of this packing is to be filled with granular material such as moorum, sand or sandy oil, well watered and rammed in layers 15 cm or less thick. Under no circumstances is black cotton soil or any clayey or silty soil to be used for backing. Each layer shall have a slope of about 45° towards the ground level, toe slope to commence from immediately behind the abutments. Compactions of the layers shall be done by vibratory plate compactors or as directed by the Engineer.

1.6.4 Dressing of surrounding ground :

On the completion of a building, the ground all round up to a distance of 15m is to be carefully dressed, and when practicable, given a gentle slope outwards. This dressing will be paid for separately.

1.6.5 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.

1.6.6 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 upto 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 will be made.

1.6.7 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.

1.6.8 Rates : The rate for each type of filling shall include the cost of all the operations as described above for each, except that in cases where the excavated earth available within the initial lead and lift is not adequate for the filling, the procurement of the extra earth required will be a matter of special agreement.

1.7 SHORING OR TIMBERING FOR TRENCHES

1.7.1 General : In case of deep trenches, exceeding 2 metres or where the soil is soft or slushy, the sides of trenches shall be prevented from collapsing by stepping, sloping and / or shoring or timbering as may be decided by the Engineer or the Authorized representative of the Engineer. Timbering shall be “Close” or “Open” depending on the nature of soil and the depth of the trench and the type of timbering shall be determined by the Authorised representative of the Engineer or the Engineer. It shall be the responsibility of the contractor to take all necessary steps to prevent the sides of trenches from collapsing. Guidance may be taken from IS 3764 for designing the shoring and strutting arrangements.

1.7.2 Close Timbering : Close timbering shall be done by completely covering the sides of the trench generally with short, upright members called ‘polling boards’. These shall be 25 cm x 4cm section or as directed by the Engineer. The boards shall generally be placed in position vertically in pairs, one board on each side of cutting, and shall be kept apart by horizontal walings of strong wood at 1.0 to 1.2m spacings, cross strutted with ballies or as directed by the Engineer. The length of the ballies shall depend upon the width of the trench. Typical sketch of close timbering is given in **Figures 1.5A & 1.5B**.

1.7.2.1 In case the soil is very soft and loose, the boards shall be placed horizontally against the sides of the excavation and

supported by vertical walings, which shall be strutted to similar timber pieces on the opposite face of the trench. The lowest boards supporting the sides shall be taken into the ground. No portion of the vertical side of the trench shall remain exposed, so that earth is not liable to slip out.

1.7.2.2 The withdrawal of the timber shall be done very carefully to prevent the collapse of the trench. It shall be started at one end and proceed systematically to the other end. Concrete or masonry shall not be damaged in the removal of timber. Where planking and strutting are required to be left permanently in position as directed by the Engineer, extra payment will be made under the relevant schedule item. In cases where there is no such specific directive of the Engineer no claim shall be entertained for any timber, which cannot be withdrawn and is lost, damaged or buried.

1.7.3 Open Timbering : In case of open timbering, the entire side of the trench is not required to be covered. The vertical boards of 25 cm width shall be spaced sufficiently apart to leave unsupported strips of 50 cm average width. The detailed arrangement, sizes of the timber and the distances apart shall be subject to the approval of the Engineer. In all other respects, specifications for close timbering shall apply to open timbering. A typical sketch of open timbering is given in **Figures 1.5A & 1.5B**.

1.7.4 Measurements : The area of longitudinal section of the timbered trench shall be measured for the purpose of payment. This shall be the area of one side of the trench timbered on both sides. In case of basements, where the opposite sides, are not connected by struts but, each side is supported by slanting struts and toe supports, the measurements for timbering shall be taken for the area of all the walls supported by timbering. The dimensions shall be measured correct to a cm.

1.8 PUDDLE

1.8.1 Composition : Puddle shall consist of good adhesive and stiff clay containing nearly 20% sand by weight. So called ‘Sodium Clays’, containing sodium carbonate shall generally be preferred. If adequate quantity of sand is not present in the clay, suitable amount of sand may be mixed with the clay after it has been weathered and pulverised. The clay shall be free from roots, turf, shale and other injurious materials, and should be approved by the Engineer.

1.8.2 Preparation : The clay should be dry and exposed to the sun and pulverised with rammers. Additional sand if necessary shall be uniformly mixed with the powdered clay two days previous to that on which the clay is required for use. The clay and sand mixture shall be wetted and thoroughly worked up into a plastic homogeneous mass of the toughest consistency, in a pug mill or under men's feet.

1.8.3 Laying As soon as possible after it has been worked up into puddle it shall be deposited in place, spread in even layers 15 cm thick, each layer laid out to its full extent, rammed, trodden and if necessary, cross cut and made perfectly water-tight.

1.8.3.1 The puddle shall be carried in baskets or wheel-borrow as convenient. Each batch shall be well consolidated with rammers or trodden under feet until it is thoroughly integrated with the batch already in place. Stones, bricks, roots, grass, etc. shall not be allowed to remain in the puddle.

1.8.3.2 If at any time the puddle surface should become dry/hard or soft, it shall be excavated and removed from the work before another layer is laid. Puddle walls must be supported on each side by selected material.

1.8.4 Protection : All puddle after placing shall be protected from the strong rays of the sun by covering with wet gunny bags or mats.

1.8.4.1 Contractor's liability and maintenance : The contractor shall make good at his own expense any defect that may occur either in the puddle or in its junction with the ground or walls whether during the construction stage or during the period of maintenance.

1.9 MECHANICAL COMPACTION OF EARTHWORK

Note : Based on RDSO's "Guidelines for Earthwork in Railway Projects" (July 2003 – Guideline No.GE:G-1 to which reference may be made for further details.)

1.9.1 Orders for compaction : Depending upon the height of the embankment the type of the soil, time available for completing the embankment, the importance of the line and other relevant factors such as axle load, permitting higher speeds within a limited time etc, the Engineer shall decide whether Mechanical compaction is to be done for the full or part height of the embankment.

1.9.2 Advantages of Compaction :

1.9.2.1 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:

- Helps soils to acquire increase in strength in both bearing resistance and shear strength.
- Reduces compressibility, thus minimising uneven settlement during services.
- Increased density and reduces permeability, thereby reducing susceptibility to change in moisture content.
- Reduction in erodibility
- Results in homogeneous uniform soil mass of known properties.
- Reduction in frost susceptibility in cold regions.

1.9.3 Factors affecting Compaction in the filed :

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 upto 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 which will be arranged by the Engineer for which the Contractor shall make all arrangements and bear the cost of test / tests as required.

1.9.4 Compaction procedure for Different soils

The embankments are constructed with locally available soil provided it fulfils 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 will be decided by the Engineer for strict adherence by the Contractor.

1.9.4.1 Compaction of Cohesion less gravelly and Sandy soil

i) Sandy & gravelly 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 gravelly 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.

ii) Poorly graded sand and gravel with $C_u < 2.0$, should not be used in earthwork for the banks to safeguard against liquefaction under moving loads or especially due to earthquake tremor. Generally, fine sand is prone to liquefaction. This aspect should be specifically examined to prevent possibility of any liquefaction.

1.9.4.2 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.

1.9.4.3 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-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. Pad foot vibratory roller with drum module weight of 7 tonne (total static weight of 11 tons) for a lift thickness of 30 cm is found quite effective for compaction of clays. For better results, initial rolling with static pad foot roller followed by 15 tons vibratory roller can be tried.

iii) 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 for which the Contractor shall make all arrangements and bear the cost of field trials as required.

1.9.5 Selection of Compacting Equipment :

The performance of roller is dependent mainly on type of soil used in construction. Guidelines on selection of compacting equipment are given in **Annexure 1.2**. Vibratory rollers which can be used in static as well as dynamic mode with plain and pad drum, are now being manufactured by reputed Indian Companies also. Salient features of some of models are given in **Annexure 1.3**. The Contractor should get the Engineer's approval for the type of equipment to be deployed for compaction.

1.9.6 General aspects of Mechanical Compaction

a) The spreading of material in layers of desired thickness over the entire width of embankment should be done by mechanical means and finished by a motor grader. 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, as a good practice thickness of layer should be generally kept as 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 $OMC \pm 2\%$ 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. The earth so cut in final stages will not be paid but can be used at other places by the contractor.

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 on 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 will be carried out if directed by the Engineer for which extra rate will be paid.

1.9.7 Quality Control of Compacted Earth / Blanket layer

1.9.7.1 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 check of in-situ dry density are in vogue. The sampling adopted has to be such that effectiveness of proper compaction having been done for the entire area under consideration can be judged. For this, the Engineer will lay down in detail the method to be adopted in detail depending on site conditions and accordingly records of checks done are to be properly maintained. However, in absence of such procedure laid down, following method should be adopted.

Suggested Method of Sampling : For each layer, a minimum of one sample at a predetermined interval (in compliance with the requirement stated in next para) 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 sub para "b" below. 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. Additional sampling points can be taken, as considered necessary.

ii) In case of bank widening, sampling should be done at an interval of minimum 25 metres on widened side(s) of embankment.

b) 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 check for every 200 sqm. for blanket layers and top one metre of sub-grade.

ii) Atleast one density check for every 100 sqm. for other than blanket and one metre of sub-grade.

In case of bridge approaches or special locations closer frequency may be adopted.

c) Method of In-situ Dry Density Measurements

Any of the following methods could be adopted as per the requirements at site. RDSO's guidance may be taken for adoption of other methods such as by use of Nuclear Moisture Density gauge and Compact Meter fitted on rollers.

Method Of Measurement	Procedure Of Test	Parameters To Be Measured	Remarks
i) Sand Replace-ment Method	As per IS-2720 (Part 28) 1974	a) In-situ Dry Density b) Moisture content	May be adopted for all type of soils
ii) Core Cutter Method	As per IS-2720 (Part 29) 1975	a) In-situ Dry Density b) Moisture content	In some of the coarse grained soils (with little fines) taking core cutter samples is difficult. In such cases, sand replacement method may be used for density measurement.

d) Acceptance Criteria :

i) Coarse grained soils which contains fines passing 75 micron IS Sieve, upto 5 percent should have the Density Index (Relative Density) a minimum of 70% as obtained in accordance with IS:2720 (Part-14)-1983.

ii) For other soils, field dry density should not be less than maximum attainable dry density obtained in field compaction trial. However, in field compaction trial, the maximum attainable dry density should not be less than 98% of MDD values as

obtained by Heavy Compaction Test (IS 2720 (part 8) – 1983) 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 upto 95% of MDD with the specific approval of the Engineer, recording reasons of such relaxation.

iii) During widening of bank 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) – 1983) or 70% Relative Density for cohesion less soil (IS:2720 (Part 14) –1983).

1.9.7.2 Formation Level : Finished top of sub-grade level may have variation from design level by ± 25 mm and finished top of blanket layer may also be permitted to have variation from design level by plus 25mm. The ballast should be placed only on level formation without ruts or low pockets.

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

1.9.7.4 Side Slopes : Side slope should in no case be steeper than designed side slope. Provision of berm width should not be less than the designed width.

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

1.10 BLANKETING

Note : Based on RDSO's Specification no. GE.IRS.2 (Final) dated July 2005 on "Mechanically produced Blanketing Material for Railway formation including Guidelines for Laying" to which reference may be made for further details.

1.10.1 Scope : 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 formation earthwork and for consolidation as detailed below. The thickness of blanketing layer shall be fixed in light of the Guidelines dated July 2005 of RDSO referred to in the Note above.

1.10.2 Sample for Material : The successful contractor should submit for

approval by the Engineer samples of the Blanketing material in three wide mouth sealed glass jars of a quantity of 0.035 Cum. each. The material to be used by the contractor for blanketing should strictly adhere to the quality of material as approved by the Engineer.

1.10.3 Specifications of Blanket Material

Blanket material produced in a plant should generally conform to following specifications :

- It should be coarse, granular and well graded.
- Skip graded material is not permitted.
- Non -plastic fines (particles of size less than 75 micron) are limited maximum to 12%, whereas plastic fines are limited maximum to 5%.
- The blanket material should have particle size distribution curve within one of the bands of enveloping curves shown in **Figure 1.6** or the percent passing of the material through each IS sieves should lie between the upper and lower limit of blanket material as given in the **Table 1.1**
- The material should be well graded with C_u & C_c as under :

Uniformity coefficient, $C_u = D_{60}/D_{10} > 7$

Coefficient of curvature,

$$C_c = \frac{D_{30}^2}{D_{60} \times D_{10}} \text{ between 1 and 3}$$

- Particle size distribution must follow one of the gradation ranges tabulated below :

Table 1.1 : Particle size distribution ranges for different grades of blanket material

	Headings	Headings	Headings	Headings
1.	40 mm	100	95-100	95-100
2.	20 mm	100	93-100	80-100
3.	10 mm	95-100	85-95	65-85
4.	4.75 mm	92-99	70-92	43-70
5.	2 mm	65-90	46-65	22-46
6.	600 micron	33-50	22-33	08-22
7.	425 micron	28-40	18-28	05-18
8.	212 micron	16-27	10-16	00-10
9.	75 micron	00-12	00-10	00-08

1.10.4 Selection of Blanket Material

Depending on the source of material, the blanket material can be categorized in the following categories:

- Natural material
- Machine manufactured material
- Crushed material
- Blended material

1.10.4.1 Proper survey of area close to projects needs to be carried out to identify suitable sources of blanket material required for the project. Aim of such source identification survey is to use naturally available material, or select alternatives of machine manufactured blanket material through crushing, blending or a combination, which is cheap and conforms to the specifications laid down.

1.10.4.2 The parent material of the blanket material so chosen should be chemically inactive and sturdy in normal working environment. Brickbats, factory slag, weak dissolvable stones like lime, shale, laterite etc. need not be selected as blanket material.

1.10.4.3 The choice of gradation as provided in 1.10.3 (f), above, may be exercised judiciously, based on the availability of material. It may be advisable to choose the grade A for finest subgrade soils (requiring 1.0m thick layer of blanket), and grade B or C for coarser subgrades (requiring less thickness of blanket).

1.10.5 Mechanical Production :

The Blanket can be produced by adopting either crushing methodology or Blending Methodology as described in Paras 6.1 and 6.2 respectively of RDSO's Specification No.GE.IRS.2 (Final) dated July 2005 and to which reference can be made for any details. Crushing Methodology is resorted to in the event of non availability of natural source of blanket materials and involves crushing the rock / boulder to produce crushed blanket material. Blending methodology involves proper blending of two or more soils or in combination with soils crushed material like stone chips or quarry dust.

1.10.6 Quality Control on Blanket Material at Production site

1.10.6.1 The source of blanket material, detailed in para 1.10.4, needs to be identified based on tests & studies conducted and conformity of the material to the Specification as laid down in para 1.10.3.

1.10.6.2 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 complication at a later stage.

1.10.6.3 The frequency of such test could be laid down by the engineer in-charge, if need be. In the absence of any other instructions, at least one test may be performed per day to check the particle size gradation at the point of loading into the trucks. However, the final acceptance of the blanket material should be at the site where it is laid, as per para 1.10.6.6.

1.10.6.4 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.

1.10.6.5 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).

1.10.6.6 Acceptance Criteria :

The material should generally conform to specification as given at para 1.10.3.

1.10.7 Transportation:

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

1.10.8 Laying, Spreading and Compacting

1.10.8.1 The blanket material must be spread with a tractor mounted grader or a paver-finisher in layers of uniform thickness, before allowing compaction.

1.10.8.2 Compaction to specified levels of RD or percentage of MDD (para **1.10.10.3**) will be carried out through a number of passes of vibratory rollers of 100-120 kN static weight or equivalent capacity. A combination of vibrating rolling initially and static finishing rolling may be established through trials. Speed of roller shall not exceed 5 km/hr.

1.10.8.3 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 by sprinkling at the plant or at site as per the requirement.

1.10.8.4 Rolling is to be carried out in layers of not more than 300 mm each, following the same camber profile as provided in the subgrade layer and to be maintained upto the top layer.

1.10.8.5 No provision for uncompacted portion may be made on the edges of embankment. The sides may be hand rammed with a suitable rammer.

Note : The engineer should generally expect to get MDD above 2.1 gm/cc, and OMC in the range of 5-9%, as matter of guidance.

1.10.9 Quality Control Checks on Finished blanket work :

1.10.9.1 Degree of compaction of each layer of compacted blanket 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.

1.10.9.2 Method of Sampling :

(a) The sampling adopted has to be such that effectiveness of proper compaction having been done for the entire area under consideration can be judged. For this, the Engineer in-charge should lay down the method adopted in detail depending on site conditions and accordingly records of checks done are properly maintained. However, in absence of such procedure laid down, following method should be adopted:

(b) Suggested method of sampling : For each layer, a minimum of one sample at a predetermined interval (in compliance with the requirement stated in next para) along the centre line of the alignment would be taken. The checking points may be staggered to the extent possible.

(c) Frequency of Tests : Density check would be done for every layer of blanket material as per following min. frequency :

At least one density check for every 200 sqm of blanket layer. (say, every 18 to 30 m for single line, or doubling work and every 12 to 16 m for a double line construction.)

1.10.9.3 Method of in-situ dry density measurements :

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

Method of measurement	Procedure of test	Parameters to be measured	Remarks
i) Sand Replacement Method	As per IS-2720 (Part 28) 1974	a) In-situ Dry Density b) Moisture content	May be adopted for all type of material
ii) Core Cutter Method	As per IS-2720 (Part 29) 1975	c) In-situ Dry Density d) Moisture content	In some of the coarse-grained soils (with little fines) taking core cutter samples is difficult. In such cases, sand replacement method may be used for density measurement.
iii) Nuclear Moisture Density Gauge	As issued by RDSO	a) Bulk density b) Moisture content c) Dry density d) Degree of compaction	May be used in consultation with RDSO
iv) Compaction meters fitted on roller (On roller continuous compaction control)	As issued by RDSO	As issued by RDSO	May be used in consultation with RDSO

1.10.10 Acceptance Criteria :

1.10.10.1 1.10.1 to 1.10.4 above.

1.10.10.2 The blanket material, which contains fines passing 75 micron IS Sieve, upto 5 percent should have the Density Index (Relative Density) a minimum of 70% as obtained in accordance with IS: 2720 (Part 14) – 1983.

1.10.10.3 For other materials, field dry density should not be less than maximum attainable dry density obtained in field compaction trial. However, in field compaction trial, the maximum attainable dry density should not be less than 98% of MDD values as obtained by Heavy Compaction Test (IS: 2720 (part 8) – 1983) 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 upto 95% of MDD with the specific approval of Chief Engineer, recording reasons of such relaxation.

1.10.10.4 During widening of bank in case of gauge conversion and rehabilitation of unstable formation, compaction of blanket layer should be minimum 95% of MDD as obtained by Laboratory test as per Heavy Compaction Test (IS: 2720 (part 8) – 1983) or 70% Relative Density for cohesionless soil (IS: 2720 (Part 14) – 1983).

1.10.11 Measurement :

1.10.11.1 Measurement of blanket material should be done on the basis of finished cross section after the material and workmanship have been accepted as per the above criteria. No deduction is to be made towards voids.

1.10.11.2 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.

1.10.11.3 Method of measurement in case of stack measurement may be the same as in case of ballast incorporated in "Specification for track ballast-1999".

1.10.11.4 It is advisable to tally the quantity and quality measured at site with the 'Incoming Materials Register' maintained at plant (para 1.10.6.4) as a means of double check.

1.11 SPECIFICATIONS OF BIAXIAL GEOGRIDS FOR TRACKBED STABILIZATION

Biaxial Geogrids of Punched & oriented type with large aperture with below mentioned specifications are to be used for trackbed stabilization application.

Biaxial Geogrids shall be manufactured from carefully selected polypropylene (PP). Grade of PP used shall in manufacturing of Geogrids shall combine optimum values of strength, stiffness, toughness and durability. Biaxial Geogrids shall be made by extruding a sheet of PP to very precise tolerances, punching an accurate pattern of holes, then stretching the sheet under controlled temperature, firstly in longitudinal direction, then in transverse direction. Process shall create a geogrid with square or almost square apertures by stretching in two orthogonal directions.

The polymers long chain molecules shall be orientated in the direction of stretching resulting in a dramatic increase in both strength and stiffness. This orientation shall pass through both the narrower ribs and the thicker nodes. The resulting product shall be monolithic grid with square edged ribs and integral junctions which possesses both geometrical and molecular symmetry; critical for consistency in manufacture and efficient load transfer in service.

The geogrid shall be supplied in standard width of 3.8m and roll length of minimum 40m.

SL	Property	Test Method	Values	Testing Facilities At
General Properties :				
1.	Polymer	Polypropylene / HDPE or similar polymer		IIT-Chennai, IIT-Delhi, IIT-Bombay, BTRA-Mumbai, BICS-Hyderabad, BTTG-Ahmedabad, SASMIRA-Mumbai, CBRI-Roorkee, CIPET-Chennai
2.	Carbon Black	BS 2782 Part-4 Method 452B:1993	2% (min.)	
3.	Mass Per Unit Area	IS:14716 / ASTM	320 g/m ² (min.)	

		D : 3776		Bombay, BTRA-Mumbai, BICS-Hyderabad, BTTG-Ahmedabad, SASMIRA-Mumbai, CBRI-Roorkee
4.	Aperture Size	Square opening of suitable size with tolerance of ±10% : Size of 60mm to 70mm at the interface of ballast & blanket, i.e. for ballast reinforcement application, such that effective interlocking takes place with existing ballast particles.		
5.	Rib Profile & Thickness	Rectangular with 1.5mm rib depth (min.)		
6.	Roll Width	3.8m to 4.0m, as per site requirement and width attachment to BCM		Not Applicable
7.	Roll Length	40m to 50m (<i>However, it has to be ensured that final roll dia does not exceed 350mm or else geo-grids may get struck underneath the sleepers during installation on existing tracks</i>)		Not Applicable
Mechanical Properties :				
8.	Ultimate Tensile Strength (CD & MD)	IS:13162 Part-5 & IS:13325 And ASTM D 6637/ BS EN ISO 10319:1996	30 kN/m (min.)	IIT-Chennai, IIT-Delhi, IIT-Bombay, BTRA-Mumbai, BICS-Hyderabad, BTTG-Ahmedabad, SASMIRA-Mumbai, CBRI-Roorkee
9.	Strain at Ultimate Tensile Strength (CD & MD)		8% To 12%	
10.	Load at 5% Strain (CD & MD)		21.0 kN/m (min.)	
11.	Junction Efficiency (CD & MD)	GRI-GG2-87 and GRI-GG1-87	95 %	IIT-Chennai, IIT-Delhi, IIT-Bombay, BTRA-Mumbai, BICS-Hyderabad, BTTG-Ahmedabad, CBRI-Roorkee
12.	Radial Stiffness at low strain, (@ 0.5% strain)	ISO 10319:1996	350 kN/m (min.)	IIT-Chennai, IIT-Delhi, IIT-Bombay, BTRA-Mumbai, BICS-Hyderabad, BTTG-Ahmedabad, SASMIRA-Mumbai, CBRI-Roorkee
13.	Aperture Stability	U.S. Army Corps of Engineers Methodology for measurement of Torsional Rigidity	3.5 Kg-cm/deg (min.)	BICS-Hyderabad, BTTG-Ahmedabad, Tensar – UK
14.	Resistance to Installation Damage	BS 8006:1995 & ISO 10319:1996	> 90 %	IIT-Chennai, IIT-Delhi, IIT-Bombay, BICS-Hyderabad, BTTG-Ahmedabad, CBRI-Roorkee
15.	Resistance to Chemical Degradation	EPA 9090	100 %	IIT-Chennai, IIT-Delhi, IIT-Bombay, BTRA-Mumbai, BICS-Hyderabad, BTTG-Ahmedabad, SASMIRA-Mumbai, CBRI-Roorkee, CIPET-Chennai
16.	Resistance to UV Light Weathering	ASTM D4355	100 %	



1.11.1 Installation Methodology

The formation shall be prepared as per Indian Railway standards. It shall be free

from stumps, stones or other large protrusions which could cause damage to the grids.

Biaxial Geogrids shall be placed over the formation just below the ballast.

Adjacent rolls are secured along both the longitudinal and transverse edges by forming 300mm overlaps. Ballast must be placed over Geogrid so that it is able to fully interlock with the grid to ensure continuity of strength between adjacent rolls.

1.12 WOVEN GEOTEXTILE AS SEPERATOR TO SUBGRADE AND BLANKET LAYER

The geotextile shall be made from polypropylene multifilament yarns, woven together into a stable fabric structure with a superior combination of mechanical and hydraulic properties. Finished product shall have excellent resistance to biological and chemical environments normally found in soils and shall be stable against short-term exposure to ultraviolet radiation.

The woven geotextile shall conform to property values listed below :

Specifications of Multifilament Woven Geotextile

SL	Property	Test Method	Value (MARV)
I	Polymer Composition, Structure and Physical Properties		
1	Polymer	Polypropylene	
2	Structure	Woven with multifilament yarn in both warp and weft directions	
3	Mass per unit area	ASTM D 5261	240 g/m ²
II	Mechanical Properties		
1	Tensile strength	Warp	55 kN/m
		Weft	40 kN/m
2	Elongation at specified Tensile Strength	Warp	25 %
		Weft	25 %
3	Trapezoid tearing strength	Warp	1100 N
		Weft	750 N
4	Puncture strength	ASTM D 4833	600 N
III	Hydraulic Properties		
1	Apparent opening size	ASTM D 4751	150 microns
2	Water flow rate normal to the plane	ASTM D 4491	32 l/m ² /s
Roll Dimensions		Standard roll length : 100m, Standard roll width : 5m	

1. Values listed are minimum average roll values except for II-2 and III-1, which are maximum average roll values.

2. The elongations reported are the actual fabric elongations at the specified

tensile strength measured over a gauge length of 100mm marked at the center of specimen.

3. Roll length and Roll width may vary as per requirement.



1.12.1 Installation of Woven Geotextile as Separator

The woven geotextile shall be laid directly on the site, having removed major protrusions such as rocks and bush stumps and also having filled local hollows and depressions with the approved fill.

The geotextile rolls of specified width shall be laid in the longitudinal direction (parallel to the track) on the prepared subgrade. A 300mm overlap shall be provided between any joint of two geotextile rolls (transversely or longitudinally).

After laying the geotextile, first layer of blanket layer as per drawing is to be constructed and compacted.

1.13 Jute Geotextile

Jute Geotextile improves performance of soil. It imparts strength to soil by not allowing soil particles to migrate on one hand and by easing out water through its pores on the other. Jute Geotextile is capable of performing functions of separating drainage and initial reinforcement.

The application of Jute Geotextile in slopes of Railway embankment is to be done in accordance with RDSO's guidelines for application of jute geotextile in Railway embankments and hill slopes vide RDSO's report no. RDSO/2007/GE:G-0008 or its subsequent versions including earth work and fixing arrangement.

The guidelines for application of jute geotextile for Rain water erosion control in Road & Railway embankment and hill slopes have also been issued by Bureau of Indian Standard (BIS) vide (IS-14986-2001) and woven geotextile Specifications (IS-14715: 2000 under revision), these may be referred to for further guidance and application.

Tests

The sample of jute geotextile may be got tested at Institute of Jute Technology (IJT) Kolkata or Indian Jute Industries Research Association (IJIRA) or any authorized jute testing laboratory.



ANNEXURE 1.1**EXTRACTS FROM THE EXPLOSIVES RULES, 1983****4. Safety distance categories of explosives**

(1) Explosives are divided into four categories according to the risks which they present when initiated, namely-

(i) Category X — those explosives which have a fire or a slight explosion risk or both but the effect of which will be local.

(ii) Category Y — Those explosives which have a mass fire risk or a moderate explosion risk, but not the risk of mass explosion.

(iii) Category Z — Those explosives which have a mass explosion risk and major missile effect.

(iv) Category ZZ. — Those explosives which have a mass explosion risk and minor missile effect.

(2) If any question arises as to whether any explosive belongs to Category X, Category Y, Category Z or Category ZZ, the matter shall be referred to the Chief Controller whose decision shall be final.

General Provisions**7. Restriction on delivery and dispatch of explosives —**

(1) No person shall deliver or dispatch any explosive to any one other than a person who —

(a) is the holder of a licence, to possess the explosives or the agent of a holder of such a licence duly authorised by him in writing in this behalf; or

(b) is entitled under these rules to possess the explosives without a licence.

(2) The explosives so delivered or dispatched shall in no case exceed the quantity which the person to whom they are delivered or dispatched is authorised to possess with or without a licence under these rules.

(3) (i) No person shall receive explosives from any person other than the holder of a licence granted under these rules.

(ii) No person shall receive from or transfer explosives to any person for a temporary storage or safe custody in a licensed premises, unless prior approval is obtained from the Chief Controller.

11. Competent person to be Incharge of operations — Every person holding or

acting under a licence granted under these rules shall, whenever explosives are loaded, unloaded or handled, depute a competent person experienced in the handling of explosives to be present at and to conduct the operations in accordance with these rules.

12. Precautions to be observed in handling explosives —

(1) The floor of any place or any carriage or vessel in which any explosive is or is to be laid and the ground gangway, decks and other places over which the explosive is to be conveyed during loading or unloading shall be —

(i) Carefully examined to ensure that there is nothing thereon in contravention of these rules or likely to endanger the safety of the consignment;

(ii) Thoroughly cleaned and swept before and after use,

(2) The packages containing the explosives shall not be thrown or dropped down or rolled or pulled along the ground or floor but shall be passed from hand to hand and carefully deposited and stored.

(3) Where a package is to be slung, due precaution shall be taken to slung it in such a manner as effectively to prevent the possibility of a fall.

(4) After the handling of explosives has commenced, the operations shall proceed with due diligence and without unnecessary stoppage.

13. Restriction on handling of explosives after sunset — No person shall handle or cause to be handled any explosive between the hours of sunset and sunrise:

Provided that nothing in this rule shall apply to handling of explosives during the dark hours if proper illumination is provided in the area and the place is guarded,

14. Prohibition of smoking, fires, lights and dangerous substances — No person shall smoke, and no fires, lights or articles or substances of a flammable nature or liable to spontaneous ignition, or to cause or communicate fire or explosion such as acids, petroleum, carbide of calcium, compressed gases or such other hazardous substances, shall be allowed-

(a) at any time within 15 metres from a place where an explosive is stored; or

(b) at any place where an explosive is handled, during transport, one hour before and during such handling:

Provided that nothing in this rule shall apply to the use on a ship of —

- (i) an engine room fire, if such fire has been previously carefully banked up or
- (ii) any artificial light or ship's signal lights or of a type approved in writing by the Chief Controller in areas outside port limits and by the Conservator of the Port within port limits.

15. Prohibition of matches etc. — No person on, in, or near any place where explosives are stored or handled or on any carriage conveying explosives shall —

- (a) have in his possession any matches, fuses or other appliances for producing ignition or explosion or any knives or other articles made of iron or steel; or
- (b) wear boots or shoes with iron nails or shod or strengthened with iron, unless such boots or shoes are covered with leather, rubber, felt or other material, in the form of overshoes or other.

41. Protection from fire or explosion —

(1) No carriage or aircraft or vessel shall be used for transporting explosives unless all iron or steel therein with which a package containing any explosive is likely to come in contact is effectually covered with lead, leather, wood, cloth or other suitable material.

(2) Where the weight of the explosives transported in any carriage exceeds 1000 kg, they shall be placed in the interior of the carriage which shall be enclosed on all sides with wood or metal so as effectually to protect the explosives from communication of fire and the carriage shall be locked.

(3) Where the weight of explosives transported in any vessel exceeds 1000 kg, they shall be placed in the hold of the vessel which shall have a closed deck and closely fitting hatches and double water-tight bulk heads shall be provided at each end of the hold where the explosives are stowed and the hatches shall be locked.

(4) Where the explosives carried in carriage or vessel do not exceed 1000 kg in weight, the explosives shall, unless they are conveyed in the manner specified in sub-rule (2) or sub-rule (3), as the case may be, be completely covered with fireproof cloth tarpaulin or any other suitable material as effectually to protect the explosives from communication of fire.

(5) All doors, hatches and coverings of every compartments or hold containing explosives in or on any carriage or vessel shall be kept closed and secured except when explosives are being loaded or unloaded into, onto or from it.

(6) When explosives are being carried in or on a carriage or aircraft or vessel, they shall be kept away from anything whether in the carriage or vessel or elsewhere that would be liable to cause them to ignite or explode.

42. Delay in transit to be avoided — If the quantity of explosives transported in any carriage or vessel exceeds 2.5 kg, the person or persons in charge of such carriage or vessel shall not stop or delay at any place for a longer time than may be reasonably necessary, nor stop unnecessarily at any place where such stopping would be attended with danger to public.

44. Small quantities of fireworks exempted — Nothing contained in Rules 35, 40 and 41 shall apply to the transport of manufactured fireworks in the custody of a person entitled to possess them without a licence under Rule 14 provided that not more than 2.5 kg of manufactured fireworks, securely packed, shall be so transported in any motor vehicle licensed for conveyance of more than six passengers.

113. Licence for possession, sale and use —

(1) No person shall possess, sell or use any explosive except under and in accordance with a licence granted under these rules.

(2) The licensee shall be responsible for all operations in connection with the possession, sale or use of explosives which may be conducted in the premises covered by the licence.

114. No licence needed for possession and sale in certain cases -

(i) notwithstanding anything contained in Rule 113, no licence shall be necessary for the possession.

(a) of any explosive by a carrier or other person for the purpose of (transport, when the same is being kept or transported in accordance with the provisions of Chapter IV regulating transport of such explosives: or

(b) by any person of manufactured fireworks in any quantity not exceeding 25 kg Provided that the fireworks -

(i) are obtained and intended by such person for immediate use and not for sale

and are possessed by him for a period not exceeding 14 days; and

(ii) are kept in substantial receptacle which is exclusively appropriated to the keeping of explosives and is closed and secured so as to prevent unauthorised person from having access to the explosives; or

(c) by any person for his own private use and not for sale of gunpowder not exceeding 5 kg and 50 metres of safety fuse for blasting in any State, other than Bihar, Kerala, Tamil Nadu and West Bengal, and of small arm nitre-compound not exceeding 5 kg except in the State of Kerala and Tamil Nadu;

(d) by Railway Administration for flare lights or other explosives for its own use and not for sale to any other person by transfer or otherwise for maintaining railways, tracks, tunnels, provided that the provisions of the Act and these rules or otherwise complied with;

(e) of any explosive, which is not for sale and is required solely for the navigation of aircraft, when kept in an aircraft for use therein, or for distribution to other aircraft or to aerodromes or at an aerodrome for use there or for distribution to aircraft or to other aerodromes, provided that the maximum quantity so possessed shall not exceed 25 kg when carried in an aircraft and 50 kg, when kept at an aerodrome;

(f) and sale from a shop of amorces (an explosive of Class 7 and division 2) in quantity not exceeding 12.5 kg Provided that in respect of clauses (b) and (c) the Central Government may prohibit the possession of any explosive or prescribe any conditions under which the explosives can be possessed without a licence when considered necessary for the security of public peace.

(2) Notwithstanding anything contained in Rule 113, no licence shall be necessary for the sale of such explosives manufactured by the Armed Forces of the Union and Ordnance Factories or other establishment of such Forces as are sold or delivered to any person who is in possession of a valid licence issued under these rules for the class and quantity of the explosives so sold or delivered.

116. Protection from lightning —

(1) Every magazine shall have attached thereto one or more efficient lightning, conductors designed and erected in accordance with the specification laid down

in Indian Standard Specification No. 2309 as amended from time to time.

(2) The connections to various parts of earth resistance of the lightning conductor terminal on the building to the earth shall be tested at least once in every year by a qualified electrical engineer or any other competent person holding a certificate of competency in this behalf from the State Electricity Department. A certificate showing the results of such test and the date of the last test shall be hung up in conspicuous place in the building -

117. Precautions during thunderstorm

- Whenever a thunderstorm appears to be imminent in the vicinity of a magazine or store house every person engaged in or about such magazine or store house shall be withdrawn to a safe distance from such magazine and store house and the magazine and the store house shall be kept closed and locked until the thunderstorm has ceased or the threat of it has passed.

119. Maintenance of records — Every person holding a licence granted under these rules for possession, sale or use of explosives shall maintain records in the prescribed Forms and shall produce such records on demand to an inspecting officer.

120. Repairing of licensed magazine or store house — Before repairs are done to any magazine or store house or part thereof used for storage of explosives, that magazine or Store house shall be cleaned by removal of all explosives and by thorough washing.

122. Premises to be kept locked —

(1) Any licensed magazine or store house shall be kept securely closed or locked at all times except when goods, are being placed in or taken from it or when it must be kept open for some other purpose in connection with the management of such premises.

(2) The keys of the licensed magazine shall, at all times be kept secured in licensee's, own custody or of his authorised agent and shall be produced for opening the magazine or store house whenever so required by an inspecting officer. The name and address of the person with whom the keys will be kept shall be intimated to the licensing authority and the controller of Explosives having Jurisdiction.

123. Guards to be provided —

(1) The licensee shall at his own expenses provide for round the clock safe custody of the magazine or store house a guard which shall be of such strength as the

District Authority may consider it to be sufficient.

(2) The licensee, shall provide a shelter for the watchman on duty near the magazine or store house,

124. Repacking or opening of packages —

(1) No packages containing explosives shall be opened in magazine or store house.

(2) Repacking of explosives shall be done, where the necessary in an approved open sided shed having smoothly finished cemented floor at a distance as approved by licensing authority.

125. Explosives not to be kept in damaged boxes — The licensee of every magazine or store house shall ensure that the explosives are always kept in their original outer package. In case the outer package gets damaged so that the explosives contained therein cannot be stored or transported, such explosives shall be repacked only after the same are examined by a Cont

126. Storage of explosives In excess of licensed quantity —

(1) The quantity of any kind of explosives kept in any licensed magazine or store house shall not exceed the quantity entered in the licence against such kind of explosives,

(2) Notwithstanding anything contained in sub-rule (1), the Chief Controller may issue a permit, on payment of the prescribed fee to a holder of licence in Form 22 and such holders of licence in Form 21 who also have licence in Form 20 (for the class of explosives) for keeping of explosives in excess of the licensed quantity entered in the licence when he is satisfied that such excess storage is essential and unavoidable due to circumstances beyond the control of the licensee. The validity of such permit shall not exceed 30 days

(i) the licensing authority shall not issue any permit for excess storage of explosives if the magazine or store house cannot observe the requisite safety distances for the total quantity entered in the licence plus the additional quantity of the explosives so permitted.

(ii) no permit for storage of explosives in excess of the licensed capacity shall be

granted if the specified distances on the licence around the magazine or store house or the floor space in the specified rooms for storage of each kind of explosives is not adequate for keeping of the total quantity of explosives, including the excess quantity applied for.

(iii) The licensing authority may refuse to grant a permit for excess storage of explosives if such excess storage is of a repeated nature.

(iv) No explosive in excess of the licensed quantity shall be stored in the magazine or store house unless a permit in this behalf is obtained from the licensing authority by a letter or telegram.

129. Storage in a magazine — An explosive if stored in a magazine shall be stored either in Mode 'A' or Mode 'B' magazine as specified in Schedule VII.

130. Restriction, on use of Mode 'B' magazine — Mode 'B' magazine shall be used for storage of explosive required (or use for a temporary period for a specific purpose and such magazine shall not be used for sale of explosives.

131. Mound of magazines — A substantial mound shall be provided near a magazine, if so required by the licensing authority. Such mound shall be of a type approved by the licensing authority and shall always be maintained in good condition to provide effective protection.

135. Construction of premises :

(1) All explosives on the premises shall be kept in a brick, stone or concrete building which is closed and secured so as to prevent unauthorized person from having access thereto.

(2) The premises shall have a floor area of minimum nine square metres.

(3) The premises shall have independent entry and exit.

(4) If the premises are situated in a building used for other purposes also, such premises shall not be situated under a staircase and shall be so located as not to obstruct any passage in from or to the building in case of fire or accident.

(5) The premises shall be situated at ground level.

ANNEXURE 1.2**Typical Compaction Characteristics for natural soils, rocks and artificial materials****(Ref: BS: 6031-1981, Table 4)**

Material	Major Divisions	Subgroups	Suitable type of compaction plant	Maximum number of passes for satisfactory compaction	Maximum thickness of compacted layer (mm)	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Rock-like materials	Natural rocks	All rock fill (except chalk)	Heavy vibratory roller not less than 180 kg per 100mm of roll Grid roller not less 180 kg per 100mm of roll	4 to 12	500 to 1500 depending on plant used	If well graded or easily broken down then this can be classified as a coarse-grained soil for the purpose of compaction. The maximum diameter of the rock fragment should not exceed two third of the later thickness.
		Chalk	See remarks	3	500	This material can be very sensitive to weight and operation of compacting effort and spreading plant. Less compactive effort is needed than with other rocks
Artificial	Waste material	Burnt and unburnt colliery shale	Vibratory roller Smooth wheeled roller Self-propelled tamping roller	4 to 12 depending on weight of plant	300	
		Pulverized fuel ash	Vibratory roller Self - propelled tamping roller Smooth wheeled roller Pneumatic tired roller			Includes lagoon and furnace bottom ash
		Broken concrete, bricks, steel works, slag,	Heavy vibratory roller Self- propelled tamping roller			Non-processed sulphide brick slag should be use with caution

		etc.	Smooth wheeled roller			
Coarse-grained soils	Gravel sand, gravelly soils	Well graded gravel and gravel/ sand mixture: little or no fines Well graded gravel / sand mixtures with excellent clay binder Uniform gravel: little or no fines Poorly graded gravel and gravel / sand mixtures: little or no fines. Gravel with excess fines, silty gravel, clayey gravel, poorly graded gravel / sand / clay mixtures	Grid roller over 540 kg per 100mm of roll. Pneumatic tired over 2000 kg per wheel Vibratory plate compactor over 1100 kg /Sq.m. of base plate Smooth wheel roller Vibratory roller Vibro rammer Self-propelled temping roller	3 to 12 depending on type of plant	75 to 275 depending on type of plant	
	Sand and sandy soils	Well graded gravel and gravel/ sand mixture: little or no fines Well graded gravel / sand mixtures with excellent clay binder Uniform gravel: little or no fines Poorly graded gravel and gravel / sand mixtures: little or no fines. Gravel with excess fines				
	Uniform sands and gravels	Uniform gravels; little or no fines. Uniform sands; little or no fines. Poorly graded sands; little or no fines. Sands with	Smooth wheeled roller below 500 kg per 100mm of roll. Grid roller below 540 kg per 100mm of rolling. Pneumatic tired roller	3 to 16 depending on type of plant	75 to 300 depending on type of plant	

		finer, silty sands, clayey sands, poorly graded sand / clay mixtures	below 1500 kg per wheel. Vibratory roller. Vibrating plate compactor Vibro-tamper			
Fines soils	Soils having low plasticity	Silts (inorganic) and very fine sands, rock flour, silty or clayey fine sands with slight plasticity Clayey silts (inorganic) Organic silts of low plasticity	Sheepsfoot roller Smooth wheeled roller Pneumatic tired roller Vibratory roller over 70 kg per 100 mm of roll Vibratory plate compactor over 1400 kgs./sqm. of base plate Vibro tamper Power rammer	4 to 8 depending on type of plant	100 to 450 depending on type of plant	If water content is low, it may be preferable to use vibratory roller. Sheeps foot rollers are best suited to soils at water contents below their plastic limit.
	Soils having medium plasticity	Silty and sandy clays (inorganic) of medium plasticity Clays (inorganic) of medium plasticity Organic clays of medium plasticity				Generally unsuitable for Earthworks
	Soils having high plasticity	Micaceous or diatomaceous fine sandy and silty soils, plastic silts Clay (inorganic) of high plasticity, fat clays Organic clays of high plasticity				Should only be used when circumstances are favourable Should not be used for earthworks

Note: The information in this table should be taken only as a general guide. Field trials for compaction should be conducted for working out optimum layer thickness and number of roller passes for the type of compaction equipment being used. Compaction of mixed soils should be based on that subgrade requiring most compactive effort.

ANNEXURE 1.3**SALIENT FEATURES OF VIBRATORY ROLLERS MANUFACTURED IN INDIA**

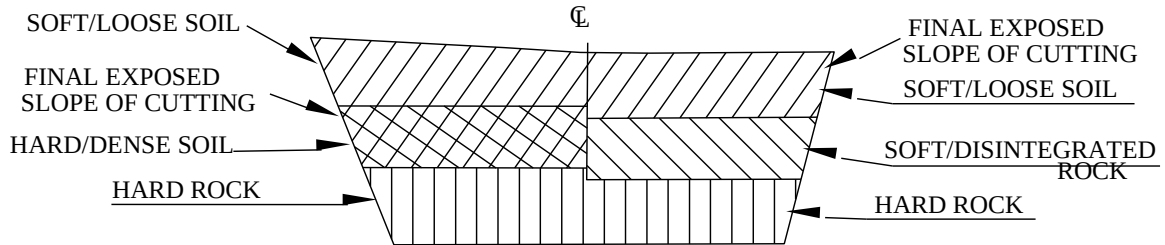
MAKE	MODEL No.	Operati ng Weight (Kg.)	Drum Detail			Normal Amplitu de (Mm)	Vibrati ng Freque ncy (Hz)	REMARKS
			DRUM WIDTH (Mm)	AXLE LOAD (T)				
				Front	Rear			
ESCORTS	EC 5250 STD	9350	2130	5.050	4.300	1.72	30	
		9550	2130	5.250	4.300	1.72	30	It is used for better gradeability
		10500	2130	6.650	4.300	1.53	30	It is used for better gradeability & breaking clods
		9300	1680	4.650	4.300	1.27/0.7 5	0- 30/42	
GREAVES BOMAG	BW 212- D-2 (2A)	10424	2100	6.463	3.961	1.67	40/31	It is used for better gradeability
	BW 212- PD-2	10879	2100	6.201	4.678	1.5	30	It is used for better gradeability & breaking clods
L&T	1104 STD	11150	2330	5.770	5.380	1.6/0.6	28/36	
	1104 D	11150	2330	5.900	5.535	1.6/0.6	28/36	It is used for better gradeability
	1104 PD	11835	2330	6.300	5.535	1.6	28	It is used for better gradeability & breaking clods
INGERSOL LRAND	ISD-100 STD	10740	2135	6.210	4.535	1.7	0-30	
	ISD-100 D	10830	2135	6.295	4.535	1.7	0-30	It is used for better gradeability
	ISD-100F	11740	2135	7.205	4.535	1.41	0-30	

NOTE : The rollers indicated above can also be used in Static mode. The list includes rollers manufactured by reputed firms only.

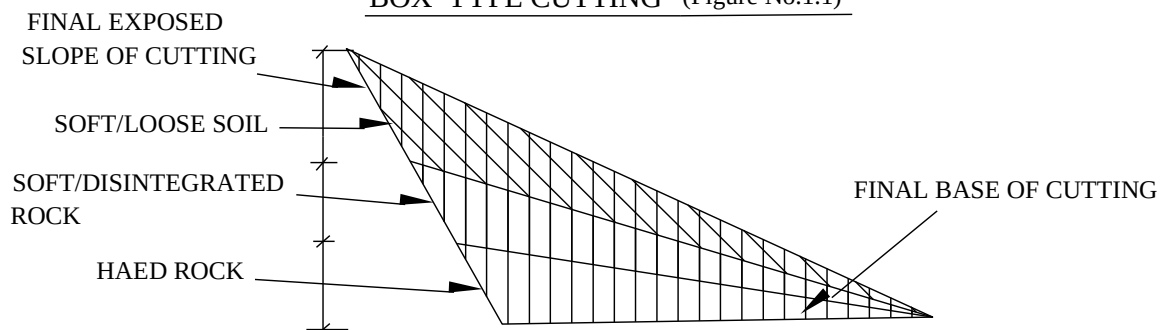
LEGEND : STD- Standard Type, D- Drum Type & PD - Pads + Drum Type

SKETCHES SHOWING MANNER OF COMPUTATION OF QUANTITIES OF
VARIOUS CLASSIFICATIONS OF SOIL

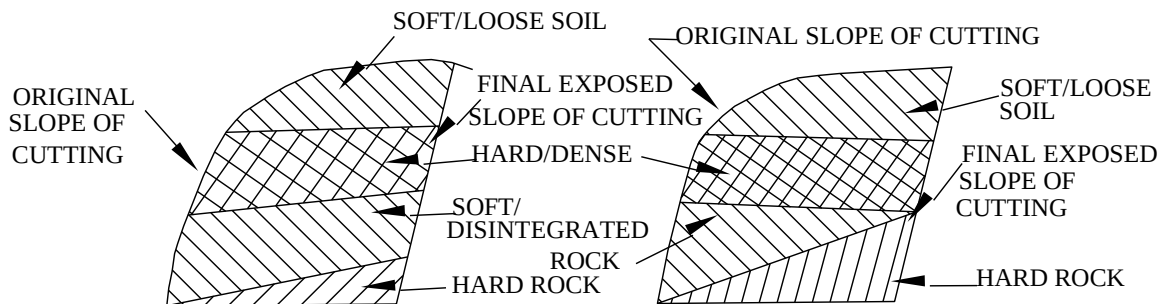
(FIG. NOS.1.1 TO1.4)



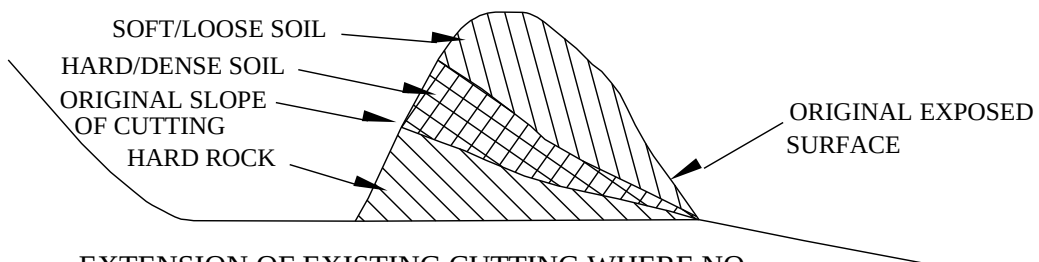
BOX TYPE CUTTING (Figure No.1.1)



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



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



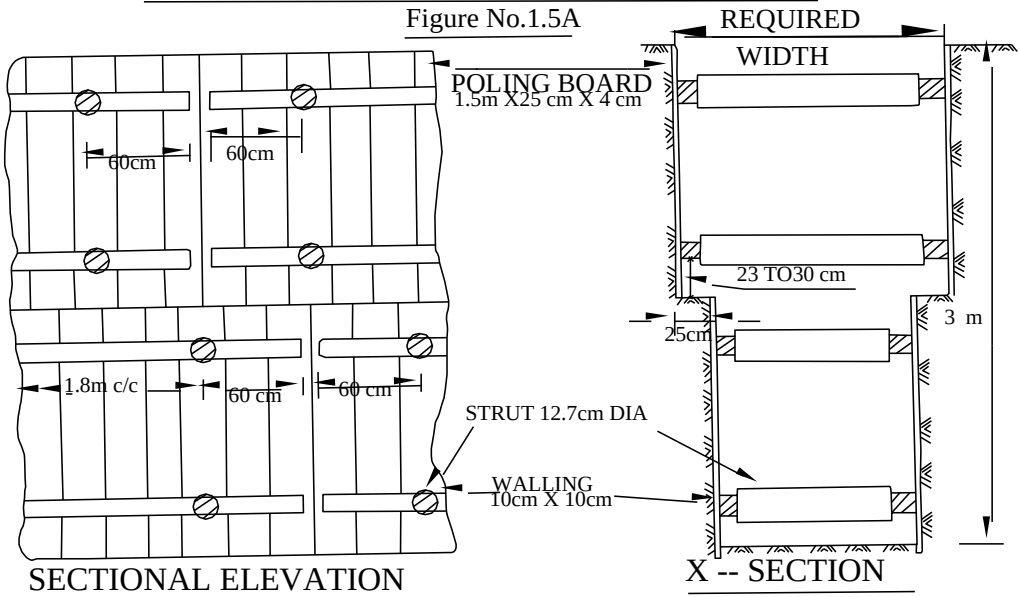
EXTENSION OF EXISTING CUTTING WHERE NO
FRESH CUTTING SLOPE IS AVAILABLE AFTER THE WORK. (Figure No.1.4)

DETAILS OF CLOSE AND OPEN TIMBERING
(SECTIONAL ELEVATION & CROSS SECTION)

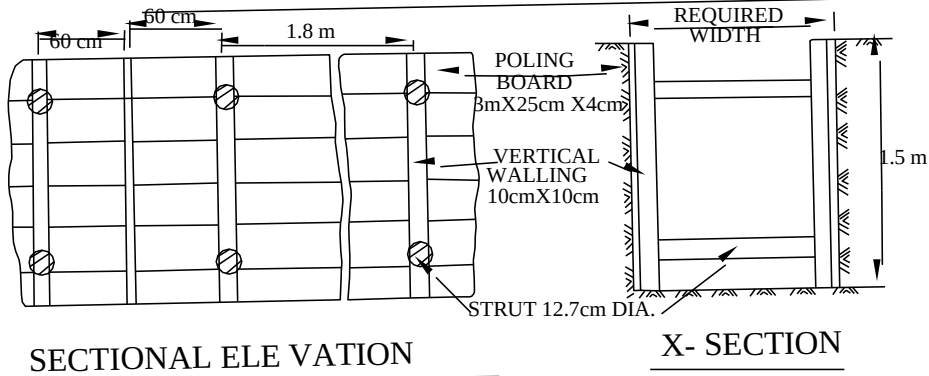
NOT TO SCALE

DETAILS OF CLOSE & OPEN TIMBERING

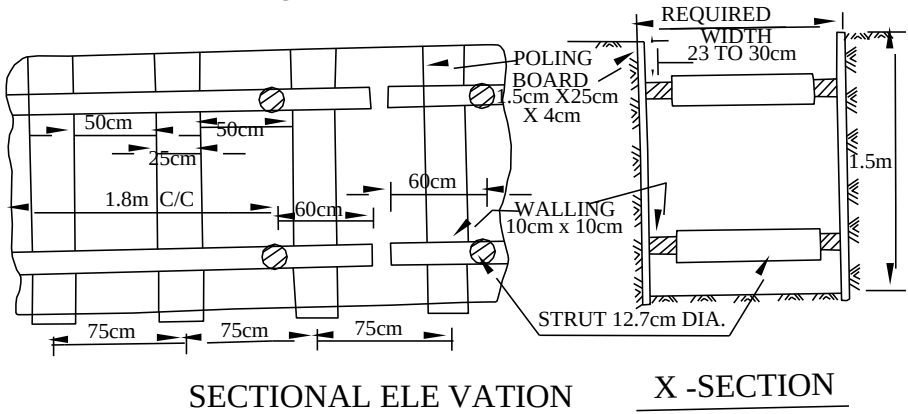
CLOSE TIMBERING (With vertical poling boards)



CLOSE TIMBERING (WITH LONGITUDINAL POLING BOARD)



OPEN TIMBERING



DETAILS OF CLOSE AND OPEN TIMBERING
(ISOMETRIC VIEW)

Figure No.1.5B

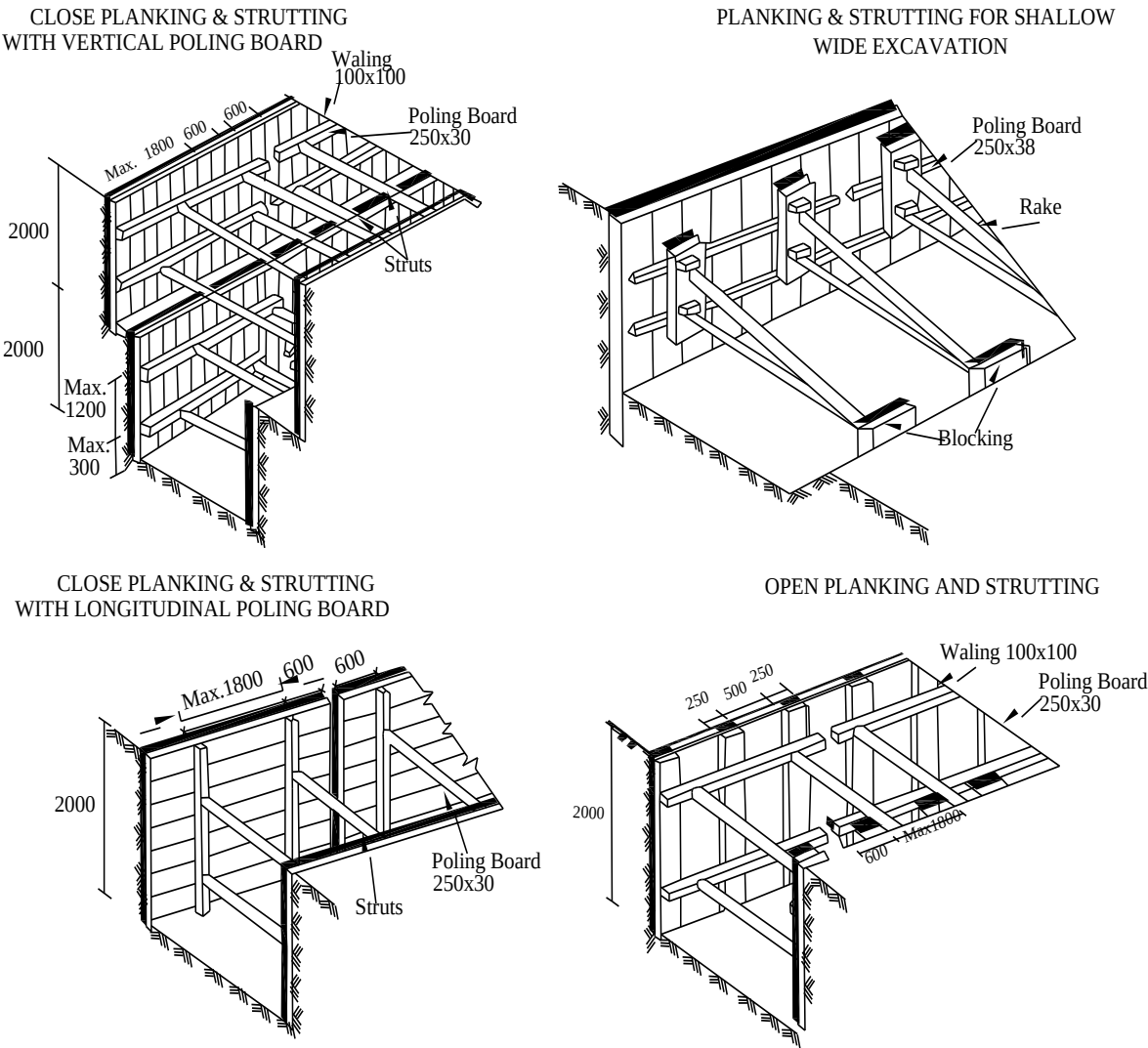
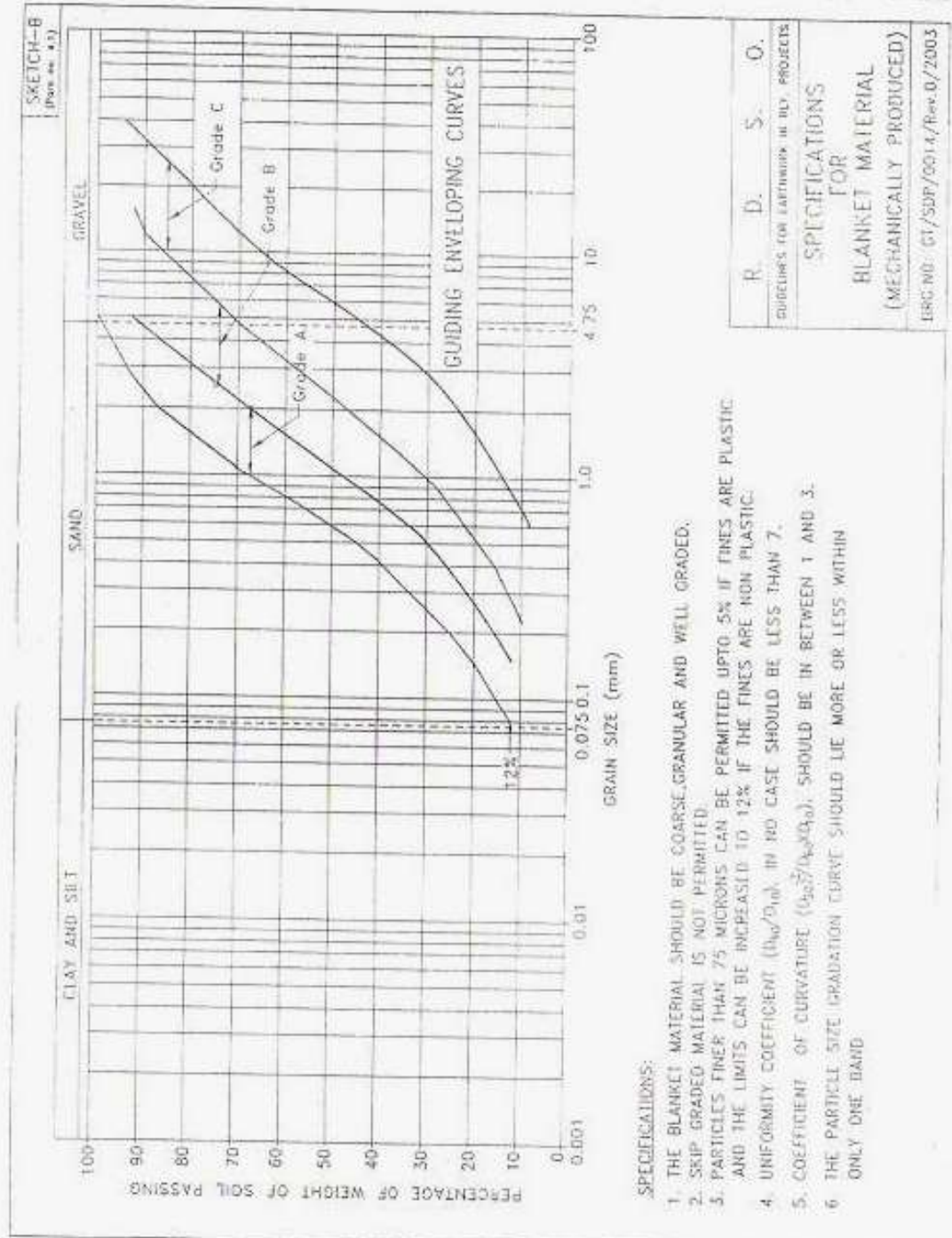


Figure No.1.6
(Para No.1.10.3)

SPECIFICATIONS FOR BLANKET MATERIAL



Chapter 2

Carriage Of Materials

SUPPLY OF QUARRY PRODUCTS TO RAILWAYS

The Contractor shall arrange at his own cost all labour, explosives, tools, baskets, carts, lorries and other conveyance required for excavation, quarrying, leading, stacking, loading etc. When blasting is necessary, it shall be carried out in accordance with the statutory rules in force. The rate payable to the contractor is inclusive of all charges, royalty, compensation to land owners for right of passage, sales tax, octroi etc.

2.1.1 Site for stacking

Sites for stacking materials shall be located within the railway boundaries and close to the place of use and as directed by the Engineer. The sites for stacking of materials should be got approved before collection is commenced. The collection of materials made on stacking grounds not approved by the Engineer will be liable for rejection. The stacking grounds shall be levelled. The Engineer shall direct the contractor to level the ground where required and for this purpose no payment will be made.

2.1.2 Deductions

Payment shall be made for the materials on the actual measurements of the stacks with such deductions as are laid down in the relevant chapter of the specifications for each type of material.

2.1.3 Opening out

At any time required by the Engineer or his authorised representative while stacking is in progress and at the time measurement is taken, the contractor shall supply at his own cost, labour, tools and other facilities to open out all or any of the stacks for the purpose of inspection or measurement.

Nonconforming materials

Materials not conforming to the detailed specifications shall be removed from the Railway's premises by the Contractor within the time specified by the Engineer. Failing such removal after issue of notice, the Railway shall be at liberty to dispose of the materials at the risk and cost of Contractor. No compensation shall be payable to the Contractor for the materials so disposed of by the Administration.

Samples

When calling for tenders for supply of materials, samples of the materials should be called for along with each tender. No materials should be accepted which are inferior to the approved samples under any circumstances. In all cases of dispute about the quality of the materials whether conforming to accepted sample or not, the decision of the Engineer shall be final and binding.

SUPPLY OF MISCELLANEOUS MATERIALS TO RAILWAYS

2.5.1 BAMBOOS

2.5.1.1 General : The bamboos to be supplied or to be used on works shall be sound and shall be free from attacks of weevils or other boring insects. They shall be sufficiently seasoned.

2.5.1.2 Size : The bamboos shall be of the specified girth, the measurement of girth being taken at the centre of the length of each bamboo. The Engineer's representative may, at his discretion, exclude from the length of the bamboos any tapered end which is too thin to be of use.

2.5.2 CASUARINA POSTS

2.5.2.1 Quality : The posts shall be reasonably straight and sound, and free from projecting knots, remnants of branches, splits, hollows, rot or any other defect which may affect their strength or usefulness to any appreciable extent, in the opinion of the Engineer's representative.

2.5.2.2 Size : The provisions of Para 2.4.1.2 will apply, substituting the word "casuarinas posts" in place of "bamboos".

2.5.3 BAMBOO MATTING

2.5.3.1 Mats : The bamboo mats shall be of the specified type, viz. "Ordinary" or "double", the latter meaning the thicker variety, with the outer skin of bamboos covering one face of the mat. The quality of mats to be supplied or used on works shall invariably be got approved by the Engineer in advance. All edges shall be properly bound, in weaving, to prevent fraying. The bamboo strips used shall be reasonably uniform in width and thickness and shall be closely woven.

2.5.3.2 Size : When using bamboo matting in claddings, partitions, etc, side and end laps of at least 15 cm shall be provided between individual mats. The matting shall be fixed to

the supports in an approved manner. When fillets of wood or bamboo are used for securing the matting, the fixing shall be done with nails driven through the fillets. Any cut edges shall be properly bound to prevent fraying.

2.2.4CHICKS

2.2.4.2Bamboo Chicks : The chick shall be formed out of bamboo laths of width 6 to 10mm, thickness not less than 3mm and length equal to the full width of the chick, split out of good mature bamboo. The laths shall be planed smooth with knife to be of fairly uniform size and free from projecting knots and fibres. They shall then be arranged on the ground and closely bound together by country twine, with the spacing between laths kept to a minimum and the spacing between consecutive twines not exceeding 20 cm. The binding shall be such that the laths are held fast, while at the same time there is freedom for rolling. Two straight solid bamboos of diameter not less than 5 cm shall be tied to the top and bottom edges of the chick so formed,

2.2.4.2

2.2.4.2Cane Chicks : Where cane chicks are prescribed, the chicks shall be formed out of mature cane of diameter from 6 to 10mm instead of bamboo laths. In other respects, the constructional details shall be the same as given in para 2.4.4.1.

2.2.4.3 Binding : Blue dungry cloth of the best quality, formed to the required size, shall be spread over the chick so as to cover the whole of the chick and folded back at the edges for a width of 4 cm on both sides and 7.5cm at the top and bottom, and well stitched on. Best white tape, 8 cm wide, shall then be stitched securely along both the sides, covering approximately 4 cm on either face of the chick. Additional tapes 4 cm wide shall also be stitched on, either diagonally, or in vertical bands of spacing not exceeding 1.2m as may be directed by the Engineer, to prevent flapping of the cloth.

2.2.4.4 All chicks shall be provided with 2 nos. of endless cotton ropes 12mm dia for the full depth so as to enable their being

secured to the floor and prevented from flapping in the lowered position. In addition, slip rings and wooden plugs shall be provided for holding the chick when rolled up to any desired height. For chicks of height exceeding 3m and in other cases where specified, two wooden / steel pulleys of approved quality shall also be supplied, along with an adequate extra length of 12 mm cotton rope to enable the chick being raised or lowered.

2.2.4.5 Rate : Unless otherwise stipulated, the rate for supply of chicks shall be all inclusive and nothing extra shall be payable for pulleys, ropes, rings etc.

2.2.5 POLYETHYLENE CANE – Should be as per IS:-2828:1964

2.2.5.1 TYPES

- Type 1 – Produced from high density polyethylene; and
- Type 2 – Produced from blends of high and low density polyethylene.

2.2.5.2 High Density Polyethylene

High density polyethylene used for manufacturing cane shall be of grade designation. PE TGN A 50 T 022 or PE TGN A 57 T 022 as per IS 7328 : 1992. But density, in any case, shall not be less than 0.950 g/ml and melt flow index (is) shall not exceed 2.0 g/10 Min.

2.2.5.3 Low Density Polyethylene

Low density polyethylene used for manufacturing cane shall be of grade designation LDPE 23 Y 00 or LDPE 33 Y 00 as per IS 3395 : 1984. But density, in any case shall not be less than 0.92 g/ml and melt flow index (is) shall not exceed 3.0 g/10/Min.

2.2.5.4 The material shall be smooth and glossy and its edges shall be free from sharp cuts. It shall not split while weaving.

2.2.5.5 Tolerance on Width and Thickness

The polyethylene cane shall be supplied in two sizes, one for seat and back and the other for border. The permissible tolerance on width and thickness for the two sizes shall be as follows :

	Width	Thickness
For the seat and back	± 0.10 mm	± 0.02 mm
For border	± 0.15 mm	± 0.03 mm

Notes :

- Following sizes of polyethylene cane are most suitable and are used in furniture trade :

	Width	Thickness
For the seat and back	2.00 mm	0.02 mm
For border	3.50 mm	0.03 mm

- The thickness may be determined by a micro meter in mm.

CARRIAGE OF MATERIALS

General

The carriage and stacking of materials shall be done as directed by the Engineer. Any tools and plants required for the work shall be arranged by the Contractor. The carriage of materials includes loading within a lead of 50 metres, unloading and stacking within a lead of 50 metres.

Responsibility for Loss or Damage

Loading, carriage, unloading and stacking shall be done carefully to avoid loss or damage to the materials. In case of any loss or damage, recovery shall be affected from the contractor at twice the Departmental issue rates of the materials. If the departmental issue rates of the materials are not available, then the recovery shall be affected at twice the prevailing market rates as determined by the Engineer.

Mode of Carriage

Depending upon the feasibility and economy, the Engineer shall determine the mode of carriage viz. whether by mechanical or animal transport or manual labour.

Lead

2.3.3.1 All distances shall be measured over the shortest practical route and not necessarily the route actually taken.

2.3.3.2 Carriage by manual labour shall be reckoned in units of 50 metres.

2.3.4.3 Carriage by animal and mechanical transport shall be reckoned in one km unit. Distances of 0.5km or more shall be taken as 1 km and distance of less than 0.5 km shall be ignored. However, when the total lead is less than 0.5 km., it will not be ignored but paid for separately in successive stages of 50 metres subject to the condition that the rate worked on this basis does not exceed the rate for initial lead of 1 km. by mechanical / animal transport.

2.3.4 Stacking - IS 4082:1996 may be seen for further details

2.4.0 Material shall be stacked in such a manner as to ensure the preservation of their quality and fitness for the work. Different types of materials shall be stacked separately and in such a way that counting and measurements can be done without disturbing the stacks.

2.3.4.1 Earth, dismantled materials, malba and other similar materials shall be stacked as directed by the Engineer.

2.3.4.2 Cement bags, steel bars, structural steel sections, bricks and timber and other similar materials shall be stacked in regular tiers.

2.3.4.3 Pipes of RCC, SW, GI, CI etc. shall be stacked in rows.

2.3.5.5 Lime, stone, metal, sand and such similar materials shall be stacked as directed by the Engineer.

2.3.5 Measurements

Length, breadth and height of stacks shall be measured correct to a cm. The quantity shall be worked out in cubic metre correct to two places of decimal. The volume of stacks, shall be reduced by percentages as shown against each for looseness in stacking to arrive at the net quantity for payment. No reduction shall be made in respect of articles or materials for which mode of payment is by length or weight or number.

2.3.5.1 Earth

i) In loose stacks such as cart loads, lorry loads etc- 20%

ii) In fills consolidated by light mechanical machinery or manually – 10% (Refer Para 1.1.6.11)

iii) In fills consolidated by heavy mechanical machinery at or near OMC – 5% (Refer Para 1.1.6.11)

iv) Consolidated fills in confined situation such as under floors etc. Nil

Manure or sludge – 8% (Refer Para 16.2.1.1 & 16.2.4.2)

Moorum, building rubbish, Lime – 7.5 %

Sand / Sandy Material – 7.5% (Refer Para 1.1.6.11)

Stone material, 40mm nominal size and above 10.0%

Coarse aggregate / stone metal below 40mm nominal size – 7.5 %

2.3.5.7 Soling Stone / Boulder 100mm and above – 15%

Excavated rocks – 30%

2.3.6 Rate : The rate for carriage of materials is inclusive of all the operations described above.

STORAGE OF MATERIALS

Para 17.9 of Chapter 17 may be referred to.

FLOOR AND LEVELS

Buildings :

2.5.1.1 Floor 1 is the lowest floor above the ground level in the building unless otherwise

specified in a particular case. The floors above floor 1 shall be numbered in sequence as floor 2, floor 3 and so on. The number shall increase upwards.

2.5.1.2 Floor level : For floor 1 top level of finished floor shall be the floor level and for all other floors above floor 1, top level of the structural slabs shall be the floor level.

2.5.1.3 Plinth level : Floor 1 level or 1.2m above the ground level whichever is lower shall be the plinth level.

2.5.1.4 Plinth level - For abutments piers & return walls of culverts and bridges, walls of water reservoirs and basements - Floor level

2.5.1.5 Plinth level - For retaining walls where floor level is not determinate 1.2 metres above average ground level or bed level whichever is lower.

2.5.1.6 Plinth level - For breast walls Formation level

2.5.1.7 Plinth level - For platform walls Formation level of track

2.5.5 Special Structures

For all other structures like chimneys, over head reservoirs/ tanks and other elevated structures, where elevations/ height above a defined datum level have not been specified and identification of floors cannot be done 1.2m above the ground level shall be the plinth level.

2.6 MEASUREMENTS

2.1 In booking dimensions, the order shall be consistent and in the sequence of length, width and height or depth or thickness.

2.6.2 Rounding Off

Rounding off where required shall be done in accordance with IS : 2. The number of significant places rounded in the rounded off value should be as specified.

2.72.7 SAFETY IN CONSTRUCTION

2.7.1 The Contractor shall employ only such methods of construction, tools and plant as are appropriate for the type of work or as approved by Engineer in writing.

2.7.2 The Contractor shall take all precautions and measures to ensure safety of works and workman and shall be fully responsible for the same. Safety pertaining to construction works such as excavation, centring and shuttering, trenching, blasting demolition, electric connections, scaffolds, ladders, working platforms gangway, mixing of bituminous materials, electric and gas welding, use of hoisting and construction machinery shall be governed by the relevant

IS Safety Codes and the direction of the Engineer.

Chapter 3

Plain Concrete

3.1 MATERIALS

3.1.1 General : Water, cement, lime and fine aggregate shall be as specified in **Chapter 26 'Mortar'**. Fine aggregates are divided into four Zones as described in **Table 26.1 of Chapter 26**. Most of the natural sand found in the country has grading corresponding to one or other of these zones. Typical good sand falls in Zone II Grading. However Finer Sand (Zones III and IV) and Coarse sand (Zone I) may be used with suitable adjustments in the ratio of quantities of Fine to Coarse aggregates as indicated in **Table 3.15** for Nominal Mix Concrete. Fine sand coming under Zone IV grading should not be used except where the concrete is closely controlled by the use of Design Mix. With nominal mix concrete, it is not advisable to use Zone IV Sand under any circumstances and Zone I sand should be avoided if a lean concrete mix is desired.

3.1.2 Coarse Aggregate

3.1.2.1 General : Aggregate, most of which is retained on 4.75mm IS Sieve and contains only as much fine material as is permitted in IS:383 for various sizes and grading is known as Coarse aggregate. Coarse aggregate shall be stone aggregate, gravel or brick aggregate as described below and it shall be obtained from approved / authorized sources.

On Stone aggregate, Gravel and Brick aggregates the following should be kept note of:

(a) **Stone Aggregate :** It shall consist of naturally occurring (uncrushed, crushed or broken) stones. It shall be hard, strong, dense, durable and clean. It shall be free from veins, adherent coatings, injurious amounts of disintegrated pieces, alkali, vegetable matter and other deleterious substances. It shall be roughly cubical in shape; Flaky and elongated pieces shall be avoided. It shall conform to IS:383 unless otherwise specified. Where required by the Engineer, test shall be done in accordance with IS 2386 (Parts I to VIII) with the cost

fully borne by the Contractor except where otherwise stipulated in the Contract.

(b) **Gravel :** It shall consist of naturally occurring (uncrushed, crushed or broken) river bed shingle or pit gravel. It shall be sound, hard and clean. It shall be free from flat particles of shale or similar laminated material, powdered clay, silt, loam, adherent coatings, alkali, vegetable matter and other deleterious substances. Pit gravel shall be washed if it contains soil materials adhering to it. These shall conform to IS:383 unless otherwise specified. Where required by the Engineer, Tests shall be done in accordance with IS 2386 (Parts I to VIII) with the cost fully borne by the Contractor except where otherwise stipulated in the Contract.

(c) **Brick Aggregate :** Brick aggregate which can be used for Plain Cement/ Lime Concrete shall be obtained by breaking well burnt or over burnt dense bricks / brick bats. They shall be homogeneous in texture, roughly cubical in shape and clean. They shall be free from unburnt clay particles, soluble salt, silt, adherent coating of soil, vegetable matter and other deleterious substances. Such aggregate should not contain more than one percent of sulphates and should not absorb more than 20% of their own mass of water.

(d) Light weight aggregates such as bloated clay aggregate and sintered fly ash aggregate may also be used provided the Engineer is satisfied with the data on the properties of concrete made with them.

3.1.2.2 Marine Aggregates (Concrete Bridge Code – C.S. no.1 dated 26.04.2000)

In general, marine aggregate shall not be used for reinforced concrete and prestressed concrete bridges. However, in special cases, use of marine aggregates may be permitted by the Engineer subject to the following :

The marine aggregates shall be thoroughly washed.

Generally, the limits for chloride content and sulphate content in aggregates after washing will be as under :

	Fine Aggregates	Coarse Aggregates
Chloride content (Cl.) max.	0.04% by wt. acid soluble	0.02% by wt. acid soluble
Sulphates (SO ₃) max.	0.4% by wt. acid soluble	0.4% by wt. Acid soluble

After washing and drying, the aggregates should conform to IS:383. The designer should take into account grading of aggregates after washing.

3.1.2.3 Deleterious Material : Coarse aggregate shall not contain any deleterious material, such as pyrites, coal, lignite, mica, shale or similar laminated material, clay, alkali, soft fragments, sea shells and organic impurities in such quantity as to affect the strength or durability of the concrete. Coarse aggregate to be used for reinforced cement concrete shall not contain any material liable to attack the steel reinforcement.

Aggregates which are chemically reactive with alkalies of cement shall not be used. The maximum quantity of deleterious

material shall not be more than five per cent of the weight of coarse aggregate when determined in accordance with IS:2386 (I).

3.1.2.4. Size and Grading

(i) Stone aggregate and gravel

It shall be either graded or single sized as specified. Nominal size and grading shall be as under :

(a) Nominal sizes of graded stone aggregate or gravel shall be 40, 20, 16, or 12.5 mm as specified. For any one of the nominal sizes, the proportion of other sizes as determined by the method prescribed in Annexure 3.1 shall be in accordance with **Table.3.1.**

TABLE 3.1
GRADED STONE AGGREGATE OR GRAVEL

IS Sieve Designation	Percentage passing (by weight) for nominal size of			
	40 mm	20 mm	16 mm	12.5 mm
80 mm	100	-	-	-
40 mm	95 to 100	100	-	-
20 mm	30 to 70	95 to 100	100	100
16 mm	-	-	90 to 100	--
12.5 mm	-	-	-	90 to 100
10 mm	10 to 35	25 to 55	30 to 70	40 to 85
4.75 mm	0 to 5	0 to 10	0 to 10	0 to 10

(b) Nominal sizes of single sized stone aggregate or gravel shall be 63, 40, 20, 16, 12.5 or 10 mm as specified. For any of the nominal size, the proportion of other sizes

as determined by the method prescribed in **Annexure 3.1** shall be in accordance with **Table.3.2.**

TABLE 3.2
SINGLE SIZED (UNGRADED) STONE AGGREGATE OR GRAVEL

IS Sieve Designation	Percentage passing (by weight) for nominal size of					
	63 mm	40 mm	20 mm	16 mm	2.5 mm	10 mm
80 mm	100	--	--	--	--	--
63 mm	85-100	100	-	-	-	-

40 mm	0-30	85-100	100	-	-	-
20 mm	0-5	0-20	85-100	100	-	-
16 mm	--	-	-	85-100	100	--
12.5 mm	--	-	-	-	85-100	100
10 mm	0-5	0-5	0-20	0-30	0-45	85-100
4.75 mm	--	-	0-5	0-5	0-10	0-20
2.36 mm	--	-	-	-	-	0-5

(c) When stone aggregate or gravel brought to site is single sized (ungraded), it shall be mixed with single size aggregates of different sizes in the proportion to be determined by field tests to obtain graded aggregate of specified nominal size. For the required nominal size, the proportions of other sizes in mixed aggregate as

determined by the method prescribed in **Annexure 3.1** shall be in accordance with **Table 3.1** Recommended proportions by volume for mixing of different sizes of single size aggregate to obtain the required nominal size of graded aggregate are given in **Table 3.3**.

TABLE 3.3
MIXING SINGLE SIZED (UNGRADED) STONE AGGREGATE OR GRAVEL TO PRODUCE GRADED AGGREGATE (BY VOLUME)

Cement concrete	Nominal size of graded aggregate required	Parts of single size aggregate of size to be mixed to get graded aggregate (By volume)				
		50 mm	40 mm	20mm	12.5 mm	10mm
1:6:12	63	9	-	3	-	-
1:6:12	40	-	9	3	-	-
1:5:10	63	7 ½	-	2 ½	-	-
1:5:10	40	-	7 ½	2 ½	-	-
1:4:8	63	6	-	2	-	-
1:4:8	40	-	6	2	-	-
1:3:6	63	4 ½	-	1 ½	-	-
1:3:6	40	-	4 ½	1 ½	-	-
1:3:6	20	-	-	4 ½	-	1 ½
1:2:4	40	-	2 ½	1	-	½
1:2:4	20	-	-	3	-	1
1:2:4	12.5	-	-	-	3	1
1:1½:3	20	-	-	2	-	1

Note :

(i) The proportions indicated in **Table 3.3** above are by volume. When considered necessary, these proportions may be varied marginally by the Engineer after making sieve analysis of aggregates brought to site

for obtaining required graded aggregate. No adjustments in rate for item of cement concrete shall be made for any variation in the proportions so ordered by the Engineer. If single size coarse aggregates are not premixed at site, to obtain the graded coarse

aggregate required for the mix, the volume of single size aggregates required to be arranged from the source of supply for making the mix shall be suitably increased to account for reduction in total volume at the site of mixing.

(ii) **Brick Aggregate** : Nominal size of brick aggregate shall be 40 mm and its grading shall be as specified in **Table 3.4** when tested for sieve analysis by the method prescribed in **Annexure 3.1**.

TABLE 3.4
BRICK AGGREGATE

IS Sieve designation	Percentage passing (by weight)
80 mm	100
37.5 mm	95-100
20.0 mm	45-100
4.75 mm	0-5

3.1.2.5 Size of Coarse aggregate

a) The nominal maximum size of coarse aggregate should be as large as possible within limits specified but in no case greater than one fourth of the minimum thickness of the members, provided that the concrete can be placed without difficulty to fill all corners of the form and to surround all reinforcement. For reinforced concrete work and pre-stressed concrete work, aggregates having a nominal size of 20mm are generally considered satisfactory. In special cases larger size may be specifically permitted by the Engineer but in no case the nominal maximum size in such RC/ PSC structures shall be more than 40mm.

Plums above 160mm and upto any reasonable size may be used in plain concrete work upto a maximum limit of 20 percent by volume of concrete when specifically permitted by the Engineer. The plums shall be distributed evenly and shall not be closer than 160mm from the surface. Necessary payment for providing plums and deduction in the rate of CC will however be done accordingly in individual cases.

b) For heavily reinforced concrete members, as in the case of ribs of main beams, the nominal maximum size of aggregate should usually be restricted to 5mm less than the minimum clear distance

between the main bars or 5mm less than the minimum cover to reinforcement whichever is smaller.

Where reinforcement is widely spaced as in solid slabs, limitations on the size of the aggregate may not be so important and the nominal maximum size may sometimes be as great or even greater than the minimum cover.

c) Coarse and fine aggregates shall preferably be batched separately, specially for design mix concrete.

d) The largest possible size, properly graded, should be used in order to reduce the water demand. For high compressive strengths of concrete, this is usually economical.

3.1.2.6 All-in-Aggregate grading

In cases where specifically provided for in the contract, if supply is taken for premixed aggregate consisting of a mix of coarse and fine aggregates, also called All-in-Aggregate they should conform to requirements in **Table 3.5**. If such combined Aggregate supply is taken, there is no need to separate them into Fine and Coarse aggregates, but necessary adjustment may be made in grading by addition of single size aggregate as found necessary.

TABLE 3.5
ALL IN AGGREGATE GRADING

IS Sieve designation	Percentage passing for All-in-Aggregate of	
	40mm nominal size	20mm nominal size
80mm	100	--
40mm	95-100	95-100
20mm	45-75	95-100

4.75mm	25-45	30-50
600 micron	8-30	10-35
150 micron	0-6	0-6

3.1.2.7. Stacking: Aggregates shall be stacked on a hard, dry and level patch of ground. When stockpiling, the aggregate shall not form pyramids resulting in segregation of different sized materials. It shall be stacked separately according to nominal size of coarse aggregates. Stacking shall be done in regular stacks of height not exceeding 100 cm. Coarse aggregates supplied in different sizes and stacked in separate stockpiles shall be mixed only after the quantity required for each size has been separately measured.

3.1.2.8. Testing: Coarse aggregate shall be tested for the following (as per IS: 2386):

- Determination of particle size and shape (**Annexure 3.1**). The aggregate failing in the test should be got removed from the site.
- Estimation of organic impurities (As per IS: 2386 Part II):
- Surface moisture (**Annexure 3.2**)
- Determination of 10% fine value (**Annexure 3.3**)

3.1.3. Chemical Admixtures

3.1.3.1 General:- When required, admixtures of approved quality shall be mixed with concrete, as specified. The admixtures shall conform to IS : 9103.

3.1.3.2. Admixtures may be any one of the following classes for use in concrete:-

- Water reducing Admixtures
- Retarding Admixtures
- Accelerating Admixtures
- Water reducing and retarding Admixtures
- Water reducing and accelerating Admixtures
- Permeability reducing (water proofing) Admixtures

3.1.3.3. Liquid admixtures : Admixtures introduced into the concrete as liquids generally fall into the following categories.

- Air entraining
- Water reducing
- Water reducing retarders
- Retarders
- Water reducing accelerators
- Accelerators

3.1.3.4. Dosage of these admixtures may vary according to manufacturer's specification.

3.1.3.5. Two or more admixtures may not be compatible in the same solution. It is therefore mandatory that when two admixtures manufactured by the same manufacturer are to be used simultaneously, the manufacturer shall certify their compatibility. In case the two or more admixtures are produced by different manufacturers, then, before their use in concrete, test shall be got performed by the manufacturers to establish their compatibility and all such test reports shall be furnished by the Contractor to the Engineer for his approval before their use in concrete.

3.1.3.6 Some admixtures may be in the form of powder particle or high concentration liquids which may require mixing with water prior to dosing. Under these conditions water in solution shall be considered as part of total water content in the batch in order to maintain the stipulated water – cement ratio.

3.1.3.7 Manufacturer's recommendation shall be carefully followed so as to ensure complete solution of the product or to prepare a standard solution of uniform strength for easier use.

3.1.3.8 Certain admixtures may contain significant amounts of finely divided insoluble materials or active ingredients which may or may not be readily soluble. It is essential for such admixtures that precautions be taken to ensure that these constituents be kept in a state of uniform suspension before actual batching. When relatively small amounts of powdered admixtures are to be used directly, these shall be pre-blended with cement.

3.1.3.9 Admixtures are sold under various trade names and may be in the form of liquids or powders. The proprietary name and the net quantity of content shall be clearly indicated in each package or container of admixtures. The admixtures shall be uniform within each batch and uniform between all batches.

3.1.3.10 No admixtures shall be accepted for use in concrete unless these are tested in accordance with IS: 9103 and the test results are approved by the Engineer.

3.1.3.11 Functions of Admixtures

a) Accelerating admixtures

These are added to hasten the rate of early strength development, which would facilitate early removal of form work; or reduce the required period of curing or concreting in cold weather or in emergency repairs.

Common accelerators are calcium chloride, flourosilicates and triethanolamine; but chloride content in concrete shall be carefully checked before permitting its use.

b) Retarding admixtures

These admixtures tend to slow down the rate of setting of cement. They are useful in hot weather concreting; for avoiding cold joints in mass concrete works and for special treatment of concrete surfaces. Common retarders are starches, cellulose products, sugars and hydroxyl - carboxylic acids and their salts.

c) Water reducing or plasticizing admixtures

These admixtures allow greater workability to be achieved for a given water cement ratio; or for the same workability reduces water content. When used in sufficient quantities, these admixtures function as set-retarders.

The basic ingredients of water reducing admixture are either ligno-sulphonate or poly hydroxy compounds.

d) Air entraining admixtures

These are used to intentionally entrain a controlled quantity of air in the concrete, without altering the setting or hardening of concrete significantly. Their use improves durability, water tightness and workability.

Commonly used air-entraining agents are animal and vegetable oils and fats; natural wood resins and their sodium salts; and alkali salts of sulphated and sulphonated organic compounds.

3.1.3.12 Special Precautions in use of Admixtures

Previous experience with and data on such materials should be considered in relation to the likely standards of supervision and workmanship to the work being specified.

Admixtures should not impair durability of concrete nor combine with the consistment to form harmful compounds nor increase the risk of corrosion of reinforcement.

The workability, compressive strength and the slump loss of concrete with and without the use of admixtures shall be established during the trial mixes before use of admixtures.

The relative density of liquid admixtures shall be checked for each drum containing admixtures and compared with the specified value before acceptance.

The chloride content of admixtures shall be independently tested for each batch before acceptance.

If two or more admixtures are used simultaneously in the same concrete mix, data should be obtained to asses their interaction and to ensure their compatibility.

3.1.3.13 As stipulated in Paras 4.4.2 and 4.4.3 of Indian Railways Concrete Bridge Code (Revised 1997), the following should be strictly adhered to

i) Calcium chloride or admixtures containing calcium chloride shall not be used in structural concrete containing reinforcement, pre-stressing tendon or other embedded metal.

ii) The admixture containing Cl & SO₃ ions shall not be used. Admixtures containing nitrates shall also not be used. Admixtures based on Thicyanate may promote corrosion and therefore shall be prohibited.

3.2 CEMENT CONCRETE**3.2.1 Designation of Concrete :**

3.2.1.1 Designation by Grade : IS 456, Code of Practice for Plain and Reinforced Concrete, designates concrete only by Grade e.g. M15, M20 etc – the number denoting its 28 day characteristic compressive strength in N/mm².

3.2.1.2 Designation by Volume Proportion (Ordinary Concrete) :

Traditionally concrete was being designated by volumetric proportion of its constituents e.g. 1:1½:3, 1:2:4, 1:3:6 etc. Such concrete is generally referred to as ordinary concrete. IS 456, since its 1978 version, has stopped designating concrete by such volumetric proportion as it is not considered correct engineering practice. However in most government departments, including railways, in CPWD, particularly on old standard and type drawings and schedule of rates, concrete by volumetric proportion is still specified and therefore is used. Although use of such concrete is not a recommended practice and should be discouraged, in this Specification it has been included and has been referred to as Ordinary Concrete. It is to be noted that Ordinary Concrete is not Volumetric Mix of Grade Concrete permitted in special circumstances described in Para 3.2.6.4 below.

3.2.2 Classification of Concrete :

3.2.2.1 Grades of Concrete : The concrete shall be in grades designated as given in **Table 3.6**.

TABLE 3.6
GRADES OF CONCRETE

(Based on IS 456-2000; Table-2 of Concrete Bridge Code 1997 CS No.8 dated 15.02.06)

Group	Grade Designation	Specified Characteristic* Compressive Strength of 150 mm Cube at 28 Days in N/mm ²
Ordinary Concrete	M10	10
	M15	15
	M20	20
Standard Concrete	M25	25
	M30	30
	M35	35
	M40	40
	M45	45
	M50	50
	M55	55
High Strength Concrete	M60	60
	M65	65
	M70	70
	M75	75
	M80	80

* The characteristic strength is defined as the strength of material below which not more than 5 per cent of the test results are expected to fall

Notes :

1. In the designation of concrete mix M refers to the mix and the number to the specified compressive strength of 150 mm size cube at 28 days, expressed in N/mm²
2. For concrete of compressive strength greater than M55, mix designs may be obtained from specialized literatures and experimental results.

3. Concrete of grade lower than M-10 may be used for Plain Concrete Constructions, lean concrete, simple foundations, foundations for masonry walls and other simple or temporary reinforced concrete constructions.

3.2.2.2 Mix of Ordinary Concrete :

Ordinary concrete is classified according to the mix proportion by volume of its ingredients viz. cement: fine aggregate: coarse aggregate. The Ordinary Concrete of different mixes to be used for different types of structures are given in **Table 3.7** below for guidance. The list is only indicative.

TABLE 3.7
MIXES OF ORDINARY CONCRETE
DIFFERENT MIXES OF ORDINARY CONCRETE AND THEIR APPLICATION

SL	Type of works	Mix of Ordinary Concrete	Maximum size of coarse aggregate	Water in Litres per Bag of cement	Consistency
1	Concrete deposited under water, RCC water retaining structures, well	1:1 ½ :3	12mm to 20mm	30	Medium

	kerbs, platforms, important RC structures, piles, arches etc.				
2	Beams, slabs, columns, retaining walls, roads, pavements, drive ways, bunkers, foundation of bridges, bed blocks, drain linings etc.	1:2:4	12mm to 40mm	32 to 36	Stiff to medium
3	Mass concrete work for retaining walls, compound walls, part of flooring of water tanks resting on ground, machine bases, foundation of bridges etc.	1:3:6	12mm to 40mm	37 to 40	Stiff to medium
4	Foundations under column footings, wall foundations, mass concrete for heavy wall, Plain Concrete, Hearting of abutments & pipes, retaining walls with stone facing in hilly area etc	1:4:8	20mm to 40mm	45	Medium
5	Foundations of ordinary buildings encasing pipes etc / of light structures	1:5:10	20mm to 40mm	60	Medium

The anticipated compressive strength of different mixes of Ordinary Concrete is as under :

Concrete Mix	Compressive Strength (kg/cm ²)	
	7 days	28 days
1: 1 ½ : 3	175	265
1:2:4	140	210

3.2.3 Durability of Concrete

3.2.3.1 General

A durable concrete is one that performs satisfactorily in the working environment during its anticipated exposure conditions during service. The materials and mix proportions shall be such as to maintain its integrity and, if applicable, to protect reinforcement from corrosion.

The factors influencing durability include :

- the environment;
- the cover to embedded steel;
- the type and quality of constituent materials;
- the cement content and water/cement ratio of the concrete;
- workmanship, to obtain full compaction and efficient curing; and
- the shape and size of the member.

3.2.3.2 Requirements for Durability

3.2.3.2.1 General environment The durability of concrete depends on its resistance to deterioration and the environment in which it is placed. The resistance of concrete to weathering, chemical attack, abrasion, frost and fire depends largely upon its quality and constituents materials. Susceptibility to corrosion of the steel is governed by the cover provided and the permeability of concrete. The cube crushing strength alone is not a reliable guide to the quality and durability of concrete; it must also have an adequate cement content and water-cement ratio. The general environment to which the concrete will be exposed during its working life is classified in five levels of severity that is mild, moderate, severe, very severe and extreme, as described below in **Table 3.8**.

TABLE 3.8
ENVIRONMENTAL EXPOSURE CONDITIONS

(Based on Table 3 of IS 456:2000 and Table in Para 5.4.1 of Concrete Bridge Code, 1997
C.S.No.1 dated 26.04.2000)

SL	Environment	Exposure Conditions
i)	Mild	Concrete surfaces protected against weather or aggressive conditions, except those situated in coastal area.
ii)	Moderate	Concrete surface sheltered from severe rain or freezing whilst wet; Concrete exposed to condensation and rain; Concrete continuously underwater. Concrete in contact or buried under non-aggressive soil/ ground water. Concrete surfaces sheltered from saturated salt air in coastal area.
iii)	Severe	Concrete surfaces exposed to severe rain, alternate wetting and drying or occasional freezing whilst wet or severe condensation; Concrete completely immersed in sea water; Concrete exposed to coastal environment.
iv)	Very severe	Concrete surfaces exposed to sea water spray, corrosive fumes or severe freezing conditions whilst wet. Concrete in contact with or buried under aggressive sub-soil/ ground water.
v)	Extreme	Concrete surface exposed to abrasive action/ Surface of members in tidal zone. Members in direct contact with liquid / solid aggressive chemicals.

Note : For the purpose of determining exposure conditions, all places within a distance of 10 km of coastal line, sea front would be treated as coastal area.

3.2.3.2.2 Freezing and Thawing: Where freezing and thawing actions under wet conditions exist, enhanced durability can be

obtained by the use of suitable air entraining admixtures. When concrete lower than grade M50 is used under these conditions, the mean total air content by volume of the fresh concrete at the time of delivery into the construction site should be as under.

Nominal Maximum Size Aggregate (mm)	Entrained Air Percentage
20	5 ± 1
40	4 ± 1

3.2.3.2.3 Exposure to sulphate attack :
For the very high sulphate concentration in Class 5 conditions given in **Table 3.9** below; some form of lining such as polychloroprene

sheet; or surface coating based on asphalt, chlorinated rubber, epoxy, or polyurethane materials should also be used to prevent access by the sulphate solution.

TABLE 3.9
REQUIREMENTS FOR CONCRETE EXPOSED TO SULPHATE ATTACK
 (Based on IS 456-2000 Table 4)

SL	Class	Concentration of Sulphates Expressed as SO ₃ Concrete in Soil			Type of Cement	Dense, fully compacted made with 20 mm Nominal Maximum Size Aggregates Complying with IS: 383	
		In soil		In Ground Water		Minimum Cement Content kg/m ³	Maximum Free Water Cement Ratio
		Total SO ₃ Percent	SO ₃ in 2:1 Water: Soil Extract gms/ litre				
(i)	1	Traces (<0.2)	Less than 1-0	Less than 0.3	Ordinary Portland cement or Portland slag cement or Portland Pozzolana cement	280	0.55
(ii)	2	0,2 to 0,5	1.0 to 1.9	0.3 to 1.2	Ordinary Portland cement or Portland slag cement or Portland Pozzolana cement	330	0.50
					Super sulphated cement or sulphate resisting Portland cement	310	0.50
(iii)	3	0.5 to 1.0	1.9 to 3.1	1.2 to 2.5	Super sulphated cement or sulphate resisting Portland cement	330	0.50
					Portland Pozzolana cement or Portland slag cement	350	0.45
(iv)	4	1.0 to 2.0	3.1 to 5.0	2.5 to 5.0	Super sulphated cement or sulphate resisting Portland cement	370	0.45
(v)	5	More than 2.0	More than 5.0	More than 5.0	Sulphate resisting cement or Super sulphated cement with protective coatings.	400	0.40

Notes :

1. Cement content given in this table is irrespective of grades of cement.
2. Use of super sulphated cement is generally restricted where the prevailing temperature is above 40°C.
3. Super sulphated cement gives an acceptable life provided that the concrete is dense and prepared with a water-cement ratio of 0.4 or less, in mineral acids, down to pH 3.5.
4. The cement contents as given in col.7 of this table are the minimum recommended. For SO₃ contents near the upper limit of any

class, cement contents above these minimum are advised.

5. For severe conditions, such as thin sections under hydrostatic pressure on one side only and sections partly immersed, considerations should be given to a further reduction of water-cement ratio.

6. Portland slag cement conforming to IS : 455 with slag cement more than 50 percent exhibits better sulphate resisting properties.

7. Where chloride is encountered with sulphate in soil or ground water, ordinary Portland cement with C₃A content from 5 to 8 percent shall be desirable to be used in concrete, instead of sulphate resisting

cement. Alternatively, Portland slag cement conforming to IS:455 having more than 50 percent slag or a blend of ordinary Portland cement and slag may be used provided sufficient information is available on

performance of such blended cements in these conditions.

3.2.3.2.4 Chlorides in Concrete : The total amount of chlorides content (as C1) in the concrete at the time of placing shall be as given in **Table 3.10** below.

TABLE 3.10
MAX. CHLORIDE CONTENT VIS-À-VIS TYPE OF USE
(BASED ON IS 456-2000 TABLE 7)

SL	Type of Use of Concrete	Maximum Total Acid Soluble – Chloride Content Expressed as kg/m ³ of Concrete
(1)	(2)	(3)
(i)	Concrete containing metal and steam cured at elevated temperature and pre-stressed concrete.	0.4
(ii)	Reinforced concrete or plain concrete containing embedded metal.	0.6
(iii)	Concrete not containing embedded metal or any material requiring protection from chloride.	3.0

3.2.3.2.5 Sulphates in Concrete : The total water-soluble sulphate content of the concrete mix, expressed as SO₃, should not exceed 4 percent by mass of the cement in the mix. The sulphate content should be calculated as the total from the various constituents of the mix.

The 4 percent limit does not apply to concrete made with super-sulphated cement complying with IS: 6909.

3.2.3.2.6 Minimum Grade of Concrete

From durability consideration, depending upon the environment to which the structure is likely to be exposed during its service life, minimum grade of concrete shall be as given as per Table 5 of IS-456-2000. However in case of bridges, it shall be as per **Table 4 (b) of IRS Concrete Bridge Code 1997**.

3.2.3.2.7 Maximum Water Cement Ratio for different Environmental Conditions

One of the main characteristics influencing the durability of any concrete is its permeability. With strong, dense aggregates, a suitably low permeability is achieved by having a sufficiently low water-cement ratio, by ensuring as thorough compaction of the concrete as possible and by ensuring sufficient hydration of cement through proper curing methods. Therefore, for given aggregates, the cement content should be sufficient to provide adequate workability with a low water-cement ratio so that concrete can be completely compacted by vibration.

The limits for maximum water cement ratio for design mix shall be based on environmental conditions as defined in **Para 3.2.3.2.1**. The limits for maximum water-cement ratio for different environmental conditions shall be as given in **Table No.3.12** below.

Table 3.12 MAXIMUM WATER CEMENT RATIO
(Based on Table 4(a) C.Slip No.8 dated 15.02.2006 of Concrete Bridge Code 1997)

Environment	Plain Concrete (PCC)	Reinforced Concrete (RCC)	Pre-stressed Concrete (PSC)
Mild	0.55	0.50	0.45
Moderate	0.50	0.50	0.40
Severe	0.50	0.45	0.40

Very Severe	0.50	0.45	0.35
Extreme	0.45	0.40	0.35

3.2.3.2.8 Cementitious Material Content:- (Refer Correction Slip No.8 dated 15.02.2006 to Concrete Bridge Code, 1997) Depending upon the environment to which the structure is likely to be exposed during its service life, minimum cementitious material content in concrete shall be as given in

Table 3.13. Maximum cementitious material content shall be limited to 500 kg/ m³. Cementitious material means cement or cement mixed with mineral admixtures like Pozzolanic Fly Ash (PFA) / Grounded granulated Blast furnace slag (GGBFS), Microsilica, etc.

Table 3.13 MINIMUM CEMENTITIOUS MATERIAL CONTENT
(Based on Table 4(c) C. Slip No.8 dated 15.02.2006 of Concrete Bridge Code 1997)

Environment	Minimum cementitious material content in Kg/m ³		
	Plain Concrete (PCC)	Reinforced Concrete (RCC)	Pre-stressed Concrete (PSC)
Mild	210	300	350
Moderate	250	300	400
Severe	250	350	430
Very Severe	300	400	440
Extreme	300	400	440

Note : For underwater Concrete 10% extra Cement should be added over and above the normal cement content of the Concrete mix specified above.

3.2.4 Workability of Concrete

3.2.4.1 The concrete mix proportion chosen should be such that the concrete is of adequate workability for the placing conditions of the concrete and can properly be compacted with the means available. Suggested ranges of workability of concrete measured in accordance with IS : 1199 are given in **Table 3.14A**. Slump is to be measured by Slump Test (See **Annexure 3.4**). Where required suitable type of plasticiser/ Admixture may be used to achieve the desired workability. Degree of workability and slump are for concreting with vibration. Where concreting is done without vibration, higher degree of workability / greater slump will be required. For concreting with aggregate of smaller size

than 20mm, the workability / slump will be lower whether it is Design Mix Concrete, Nominal Mix Concrete or Ordinary Concrete. The Designer should clearly indicate the Water Cement ratio and slump for the mix based on strength and workability criteria. The field Engineer can then do field check to see if the workability is satisfactory with the water cement ratio stipulated, taking into account the site conditions. Even if there is any difficulty in workability, the water cement ratio should be maintained and the workability improved by use of Plasticiser / admixture with the approval of the Engineer or alternatively by adding more water with corresponding extra quantity of cement. At the time of making the mix at site, the total quantity of free water to be added to the mix based on Water Cement ratio should be reduced to the extent of surface water in the wet aggregates. This aspect has been dealt with in detail in subsequent para 3.2.6.7.

TABLE 3.14A
WORKABILITY VIS-À-VIS PLACING CONDITIONS
 (Based on IS 456-2000; Para 7.1)

Placing Conditions	Degree of Workability	Slump (mm)
Blinding concrete; Shallow sections; Pavements using pavers	Very low	See Note 2
Mass concrete; Lightly reinforced sections in slabs, beams, walls, columns, Floors, Hand placed pavements; Canal lining; Strip footings	Low	25-75
Heavily reinforced sections in slabs, beams, walls, columns	Medium	50-100
Slip form work; Pumped concrete	Medium	75-100
Trench fill; In-Situ piling	High	100-150
Tremie concrete	Very high	See Note 3

Note : 1) For most of the placing conditions, internal vibrators (needle vibrators) are suitable. The diameter of the needle shall be determined based on the density and spacing of reinforcement bars and thickness of sections. For tremie concrete, vibrators are not required to be used (see also Para 3.2.11.5)

2) In the 'very low' category of workability where strict control is necessary, for example, pavement quality concrete, measurement of workability by determination of compacting factor will be more appropriate

than slump (see IS : 1199) and a value of compacting factor of 0.75 to 0.80 is suggested.

3) In the 'very high' category of workability, measurement of workability by determination of flow will be appropriate (see IS : 9103).

3.2.4.2 Para 5.3.1 of Concrete Bridge Code 1997 has laid down the following on workability as given in **Table 3.14B**.

TABLE 3.14B
WORKABILITY VIS-À-VIS PLACING CONDITIONS
 (Based on Para 5.3.1 of Concrete Bridge Code 1997)

Placing conditions	Degree of workability	Values of workability
(1)	(2)	(3)
Concreting of shallow sections with vibration	Very low	20-10 seconds vee-bee time or 0.75-0.80 compacting factor
Concreting of lightly reinforced sections with vibration	Low	10-5 seconds vee-bee time or 0.80-0.85 Compacting factor
Placing conditions	Degree of workability	Values of workability
Concreting of lightly reinforced sections without vibration or heavily reinforced section with vibration	Medium	5-2 seconds vee-bee time or 0.85-0.92 compacting factor or 25-75 mm slump for 20mm aggregate (see Note 1)
Concreting of heavily reinforced sections without vibration	High	Above 0.92 compacting factor or 75-125mm slump for 20mm aggregate. (See Note 1)

Note : 1) For smaller aggregates the slump values will be lower.

2) Suitable plasticizer/ admixture may be used to achieve workability of the order of 160/200mm. Plasticizer/admixture should

conform to Clause 4.4 of Concrete Bridge Code, extracts given in Para 3.1.3.13 above.

3.2.5 Concrete Mix Proportioning :

3.2.5.1 Mix Proportion

The mix proportion shall be selected to ensure the workability of the fresh concrete and when concrete is hardened, it shall have the required strength, durability and surface finish.

Information required:- In specifying a particular grade of concrete, the following information shall be included:-

- i) Type of mix i.e. design mix concrete or nominal mix concrete;
- ii) Grade designation;
- iii) Type of cement;
- iv) Maximum nominal size of aggregate;
- v) Minimum cement content (for design mix concrete);
- vi) Maximum water cement ratio;
- vii) Workability;
- viii) Mix proportion (for nominal mix concrete);
- ix) Exposure conditions;
- x) Maximum Temperature of concrete at the time of placing;
- xi) Method of placing;
- xii) Degree of supervision;
- xiii) Type of aggregate;
- xiv) Maximum cement content; and
- xv) Whether an admixture shall or shall not be used and the type of admixture and the conditions of use; and

3.2.5.2. Proportioning for Grade Concrete:

The determination of the proportion of cement, aggregate and water to attain the required strengths shall be made as follows:-

- (a) Design Mix: By designing the concrete mix; such concrete shall be called "Design mix concrete".
- (b) Nominal Mix: By adopting nominal concrete mix such concrete shall be called 'Nominal mix concrete'.

Design mix concrete is preferred to nominal mix. If design mix concrete cannot be used on a work for any reason such as non availability of a competent Engineer who can do the design, small quantity of Concrete involved in the work etc., for grades of M20 or lower, nominal mixes, as indicated in **Para 3.2.5.5** below, may be used with the permission of the Engineer.

It should be noted that in Nominal Mix Concrete the proportion of ingredients is by weight and not by volume.

3.2.5.3 Proportioning for Ordinary Concrete:

Since 1978 IS 456 does not include volumetric mix method of mix proportioning and therefore its use is to be discouraged. In exceptional circumstances, when even nominal mix Grade concrete can not be used, volumetric mix may be used for concrete of grade M20 and below with the permission of the Engineer. The volumetric mixes equivalent to various grades is indicated in **Para 3.2.5.6** below.

Similarly in some of the existing Type drawings etc, ordinary Concrete with the volumetric proportions like 1:2:4, 1:3:6 etc are specified and the same shall be used for mix proportioning.

3.2.5.4 Design Mix Concrete: (Grade Concrete)

(a) **General** :-This is the recommended method for all concrete designated by Grade. Design Mix is mandatory for grades higher than M20. For concrete of compressive strength greater than M55 specialised literature should be consulted.

(b) Mix design and proportioning:

Recommended Guidelines for Concrete Mix Design are given in IS 10262 which may be referred to for details. As mentioned therein in order that not more than the specified proportion of test results are likely to fall below the characteristic strength, the concrete mix has to be designed for a somewhat higher target average compressive strength. In terms of Clause 9.2.2 of IS 456 the Target Mean Strength of Concrete mix should be equal to the characteristic strength plus 1.65 times the Standard Deviation. Mix proportions shall be designed to ensure that the workability of fresh concrete is suitable for conditions of handling and placing, so that after compaction it surrounds all reinforcements and completely fills the form work. When concrete is hardened, it shall have the stipulated strength, durability and impermeability.

Determination of the proportions by weight of cement, aggregate and water shall be based on design of the mix.

As a trial the manufacturer of concrete may prepare a preliminary mix according to provisions of SP:23-1982. (Special Publication 23-1982 of Bureau of Indian Standards).

Mix design shall be tried and the mix proportions checked on the basis of tests conducted at a recognized laboratory approved by the Engineer.

All concrete proportions for various grades of concrete shall be designed separately and the mix proportions established keeping in view the workability for various structural elements, methods of placing and compacting.

(c) Standard Deviation

Standard deviation calculations of test results based on tests conducted on the same mix design for a particular grade destination shall be done in accordance with Clause 9.2.4 of IS 456. Table 8 of IS 456 gives the standard deviation that can be assumed for design of mix in the first instance. The final standard deviation figures may be determined based on test results for the particular grade of concrete when available.

(d) Approval of Design Mix

The producer/manufacturer/contractor of concrete shall submit details of each trial mix

of each grade of concrete designed for various workability conditions to the Engineer for his comments and approval. Concrete or any particular design mix and grade shall be produced/manufactured for works only on obtaining written approval of the Engineer.

For any change in quality/quantity in the ingredients of a particular concrete, for which mix has been designed earlier and approved by the Engineer the mix has to be redesigned and approval obtained again.

3.2.5.5 Nominal Mix Concrete : (Grade Concrete)

(a) With the approval of the Engineer, Nominal Mix Concrete (proportions by mass/weight) may be used for concrete of Grade M15 or lower. The proportions of materials for nominal mix concrete shall be in accordance with **Table.3.15** below.

TABLE 3.15
(a) PROPORTIONS FOR NOMINAL MIX CONCRETE M5 TO M 15
(On other than Bridge works Based on IS 456-2000: Table 9)

Grade of Concrete	Total Quantity of Dry Aggregates by Mass per 50 Kg of Cement, to be taken as the Sum of the Individual Masses of Fine and Coarse Aggregates, Kg. Max.	Proportion of Fine Aggregate to Coarse Aggregate (by Mass)	Quantity of Water per 50 kg. Of Cement, Max.
M5	800	Generally 1:2 but subject to an upper limit of 1:1 ½ and a lower limit of 1:2 ½.	60
M 7.5	625		45
M 10	480		34
M 15	330		32

Note :

1) The proportion of the fine to coarse aggregates should be adjusted from upper limit to lower limit progressively as the grading of fine aggregates becomes finer and the maximum size of coarse aggregate becomes larger. Graded coarse aggregate shall be used. Example : For an average grading of fine aggregate falling under Zone II of Table 4 of IS : 383-The proportions shall be 1:1 ½ , 1 : 2 and 1 : 2 ½ for maximum size of aggregates in the ascending order 10 mm, 20 mm and 40 mm respectively.

2) The proportion of Fine to Coarse Aggregate should be fixed keeping in mind the above guidelines and Cubes of mix cast and tested at 28 days to confirm that the minimum characteristic strength stipulated has been attained with Cement, fine aggregate, Coarse aggregate and water (all

by weight) on the proportions given in **Table 3.15**

3) The cement content of the mix specified above shall be proportionately increased if the quantity of water in a mix has to be increased to overcome the difficulties of placement and compaction, so that the water-cement ratio as specified is not exceeded.

4) In case of vibrated concrete the limit specified for water may be suitably reduced to avoid segregation.

5) The quantity of water used in the concrete mix for reinforced concrete work should be sufficient, but not more than sufficient to produce a dense concrete of adequate workability for its purpose, which will surround and properly grip all the reinforcement. Workability of the concrete should be controlled by maintaining a water content that is found to give a concrete,

which is just sufficiently wet to be placed and compacted without difficulty by means available.

6) If nominal mix concrete made in accordance with the proportions given for a particular grade does not yield the specified strength, such concrete shall be specified as belonging to the appropriate lower grade. Nominal mix concrete proportioned for a given grade in accordance with Table 3.15 above shall not however be classified in higher grade on the ground that the test strengths are higher than the minimum specified.

7) It is recommended that fine aggregate conforming to grading Zone IV should not be used in reinforced concrete unless tests have been made to ascertain the suitability of proposed mixed proportions.

3.2.5.6 Ordinary Mix Concrete:

a) (i) For concrete of Grades M 20 and lower when volumetric mix is used the following volumetric mixes can be assumed to correspond to the Grade of concrete shown against them. These figures were included in IS 456-1964 for general guidance on approximate correspondence between Grade concrete and Ordinary Concrete. In subsequent revisions of IS 456 these equalising mix proportions have not been included.

M-10	--	1:3:6
With 40mm Coarse Aggregate		
M-15	--	1:2:4
M-20	--	1:1 ½:3

Though not mentioned in any earlier IS, based on field experience M-5 can be taken as equivalent to 1:5:10/ 1:6:12 and M-7.5 equivalent to 1:4:8. Volumetric mix will also become applicable in cases of works to be carried out as per older type plans of buildings etc wherein concrete mix has been shown as 1:3:6, 1:2:4, 1: 1 ½ :3 etc.

These volumetric proportions are to be taken with the aggregates in a surface dry condition. Accordingly allowance should be made for the bulking in volume of fine aggregate to be used in the mix. Also the quantity of free water to be added to the mix should take into account the surface moisture already present in the wet aggregates. Similarly the water required for bone dry aggregates to become surface dry should also be kept in mind. Detailed explanation on this issue has been given in subsequent **Para 3.2.6.7**.

b) **Proportioning** : All ingredients shall be measured separately and accurately in

properly constructed gauge boxes on a clean platform. If the sand is moist necessary allowance shall be made for bulking. The contents of the gauge boxes shall not be consolidated by ramming but it will be desirable to shake them lightly in order to remove the excessive looseness.

Notes :

- 1) All aggregates to be used should be graded aggregates.
- 2) Sand should be coarse sand only. Stone dust should not be used for any RCC work or important mass concrete.
- 3) Fine sand can be used only for 1:3:6 concrete with 40mm coarse aggregate and other leaner mixes.
- 4) Cement shall be measured by weight only. A standard bag of Cement can be partaken as weighing 50 kg. or 0.50 quintal equivalent volume of 0.035 cum.

3.2.6 Batching

3.2.6.1 (a) To avoid confusion and error in batching, consideration should be given to using the smallest practical number of different concrete mixes on any site or in any one plant. In batching concrete, the quantity of both cement and aggregate shall be determined by mass except where volumetric batching is permitted by the Engineer; admixture, if solid, by mass; liquid admixture may however be measured in volume or mass as recommended by manufacturer; water shall be weighed or measured by volume in a calibrated tank (see also IS : 4925). Batching plant, if used, should conform to IS:4925.

(b) Ready-mixed concrete supplied by ready-mixed concrete plant shall be preferred. For large and medium project sites the concrete shall be sourced from ready-mixed concrete plants or from on site or off site batching and mixing plants. (see IS : 4926). **Annexure 3.5** may be seen for details.

3.2.6.2 Except where it can be shown to the satisfaction of the Engineer that supply of properly graded aggregate of uniform quality can be maintained over a period of work, the grading of aggregate should be controlled by obtaining the coarse aggregates in different sizes (single size upgraded) and blending them in the right proportions when required, the different sizes being stocked in separate stock – piles. The materials should be stock-piled for several hours preferably a day before use. The grading of coarse and fine aggregate should be checked as frequently as possible, the frequency for a given job

being determined by the Engineer to ensure that the specified grading is maintained. The grading of coarse aggregates shall be as per IS 383 (see **Table 3.1**). The combined aggregate shall also conform to "All in aggregate" of the grading under IS 383 (See **Table 3.5**).

3.2.6.3 The accuracy of the measuring equipment shall be within ± 2 percent of the quantity of cement being measured and ± 3 percent of the quantity of aggregate, admixtures and water being measured.

3.2.6.4 In terms of Para 5.6.2.2 of Concrete Bridge Code, in case uniformity in the materials used for concrete making has been established over a period of time, the proportioning may be done by volume batching for M 20 grade and below Grade concrete with the approval of the engineer, provided the materials and aggregates conform to the grading as per IS:383. Where weigh batching is not practicable, the quantities of fine and coarse aggregate (not cement) may be determined by volume batching for concrete of grade upto M 20. If the fine aggregate is moist and volume

batching is adopted, allowance shall be made for bulking in accordance with IS:2386 (Part III).

3.2.6.5 It is important to maintain the water-cement ratio constant at its correct value. To this end, determination of moisture contents in both fine and coarse aggregates shall be made as frequently as possible, the frequency for a given job being determined by the Engineer according to weather conditions. The amount of the added water shall be adjusted to compensate for any observed variations in the moisture contents. For determination of moisture content in the aggregates. IS : 2386 (Part 3) may be referred to. To allow for the variation in mass of aggregate due to variation in their moisture content, suitable adjustments in the masses of aggregates shall also be made. In the absence of exact data, only in the case of nominal mixes, the amount of surface water may be estimated from the values given in **Table 3.17** below. Field Test for determination of Surface Moisture is at **Annexure 3.2**.

TABLE 3.17
SURFACE WATER CARRIED BY AGGREGATE

(Based on IS:456-2000, Table 10/ Concrete Bridge Code 1997 Table 6)

SL	Aggregate	Approximate Quantity of Surface Water	
		Percent by Mass	Litre /m ³ of aggregate
(i)	Very wet sand	7.5	120
(ii)	Moderately wet sand	5.0	80
(iii)	Moist sand	2.5	40
(iv)	Moist gravel or crushed rock	1.25-2.5	20-40

Note : Coarser the aggregate, less the surface water it will carry for the same Volume of aggregate.

3.2.6.6 No substitutions in materials used on the work or alteration in the established proportions, except as permitted in 3.2.6.4. and 3.2.6.5. shall be made without additional tests to show that the quality and strength of concrete are satisfactory.

3.2.6.7 Implication of existence of Surface Water or absence of it in coarse and fine aggregates

a) Bulking of aggregates : This phenomenon is prominent in fine aggregate and is not taken into account for the coarse aggregate. Surface Dry and fully saturated

sand have almost the same volume. But damp sand increases in volume depending upon moisture content. The allowance for bulking for any sample of sand shall be determined as per IS 2386 (Part III). Reference may be made Table 26.4 of Chapter 26 on "Mortar" giving relation between the moisture content and percentage of bulking of average sand.

b) **Absorption of water by Bone dry aggregate** : In hot summer the sand and coarse aggregate will be bone dry and will actually absorb some water from the concrete mix to become "surface dry". This absorption will reduce the effective quantity of water in the mix. In the absence of a regular test to determine the absorption

capacity of the aggregates, absorption may be assumed as 1.00% by weight for average sand and 0.50% by weight for coarse aggregates such as Trap rock and granite.

c) Surface water in aggregates : For the determination of actual moisture content in the aggregates, **Annexure 3.2** and IS 2386 (Part III) may be referred to. In the absence of exact data, only in the case of mixes other than design mix, the amount of surface water may be estimated from the values given on Table 10 of IS 456 given as **Table 3.17**.

d) Mix Proportion on volumetric Basis – Fine aggregate to be used : In this case the volume of sand is stipulated on the assumption that the sand is surface dry. If it is wet or has surface water, there will be bulking. The actual bulking % should be determined as per IS 2386 (Pt. III). In absence of test result, the figures given in sub para (c) above may be assumed. Thus, if the volume of surface dry sand (average grade) in the mix is specified as 100 litres, the actual wet sand volume to be used will be 122 litres, if the moisture content % by weight is 3%.

e) Mix Proportion on weight basis – Coarse and Fine aggregates to be added : In this case also, the weights of coarse and fine aggregates are stipulated on the assumption that they are surface dry. If they are wet, their unit weight will be more due to weight of surface water. This should be correctly assessed by tests as per IS 2386 (part III). In absence of exact data, the % by mass for fine and coarse aggregates may be taken as shown in (e) above. Thus if 100 gm of surface dry sand is to be used and at site it is very wet sand, the weight of wet sand to be used will be 107.50 gm; Similarly if 100 gm of coarse aggregate is to be used and it is moist; the weight of moist coarse aggregate to be used will be 101.25 gm to 102.50 gms depending on the coarseness.

f) Mix proportions whether on Volumetric basis or weight basis – quantity of free water to be added : The water cement ratio is specified for the mix and the weight and corresponding volume of water to be used for the mix per bag of cement can be determined based on the same

If the aggregates are wet with surface water, they will contribute to this requirement of water as indicated in (e) above. While the actual volume of surface water has to be determined by IS 2386 (Part III), the approximate figures may be seen in (e)

above. Thus from the quantity of water stipulated as per water cement ratio, the surface water available in Fine and coarse aggregates should be deducted before adding free water to the mix.

If the aggregates are bone dry, they will absorb some water to become surface dry as explained in (d) above. Thus, for the quantity of water stipulated as per water cement ratio, extra quantity of free water should be added to maintain the water cement ratio as stipulated.

In all cases, if there is any difficulty in placement and compaction due to non workability with the water cement ratio as stipulated for the mix, extra water as required may be added but simultaneously adding extra cement so that the stipulated water cement ratio is not exceeded. Alternatively with the approval of the Engineer, suitable plasticizer / admixtures may be used to improve workability.

3.2.7 Mixing

3.2.7.1 General : To avoid confusion and error in batching, consideration should be given to using the smallest practical number of different concrete mixes on any site or in any one plant. A competent person shall supervise all stages of production of concrete. Competent person is one who has been authorized by the Engineer for executing and supervising relevant aspect of concreting. Preparation of test specimens and site tests shall be properly supervised. The Engineer shall be afforded all reasonable opportunity and facility to inspect the materials and the manufacture of concrete and to take any samples or to make any tests.

Concrete shall be mixed in mechanical batch type concrete mixers conforming to IS : 1791 having two blades and fitted with power loader (lifting hopper type). Half bag mixers and mixers without lifting hoppers shall not be used for mixing concrete.

In exceptional circumstances, such as mechanical break down of mixer, work in remote areas or power breakdown and when the quantity of concrete work is very small, hand mixing may be done with the specific prior permission of the Engineer in writing subject to adding 10% extra cement. When hand mixing is permitted, it shall be carried out on a water tight platform and care shall be taken to ensure that mixing is continued until the concrete is uniform in colour and consistency. In case Brick aggregate is used, before mixing, the brick aggregate shall be well soaked with water for a minimum period

of two hours and stone aggregate or gravel shall be washed with water to remove, dirt, dust and other foreign materials. For guidance, the mixing time may be 1 ½ to 2 minutes for normal mixer and 45 to 60 seconds for high rated Batching Plant. For hydrophobic cement it may be taken as 2 ½ to 3 minutes.

3.2.7.2 Power Loader: Mixer will be fitted with a power loader complying with the following requirements:-

(a) The hopper shall be of adequate capacity to receive and discharge the maximum nominal batch of unmixed materials without spillage under normal operating conditions on a level site.

Note : In such a case the volume of the maximum nominal batch of mixed material will be 50% greater than the nominal mixed batch capacity.

(b) The minimum inside width of the feeding edge of the hopper shall be as specified below.

Nominal size of mixer (T, NT or R) litre	Minimum inside width of hopper feeding edge (metre)
140	1.0
200	1.1
280	1.2
375	1.4
500	1.5
1000	2.0

T – tilting NT – non-tilting R – Reverse

c) The design of the loader shall be such that it allows the loading hopper to be elevated to such a height that the centre line of the chute plate of the hopper when in discharge position, is at an angle of not less than 50° to the horizontal. A mechanical device to aid discharge of the contents as quickly as possible from the hopper to the drum may also be provided. Even when a mechanical device is provided, it is recommended that the angle of centre line of the chute plate of the hopper when in discharge position, should be as large as practicable, preferably not less than 40° to horizontal.

(d) When the means of raising and lowering the loading hopper includes flexible wire ropes winding on to a drum or drums, the method of fastening the wire to rope to the drums shall be such as to avoid, as far as possible any tendency to cut the strands of the ropes and the fastening should preferably be positioned clear of the barrel of the drum as for example, outside the drums flange. When the loading hopper is lowered to its normal loading position, there should be at least one and a half drums of rope on the drum.

(e) Clutch brake and hydraulic control lever shall be designed so as to prevent displacement due to liberation by accidental contact with any person.

(f) The clutch and brake control arrangements also be so designed that the operator can control the falling speed of the loader.

(g) Safety device shall be provided to secure the hopper in raised position when not in use.

3.2.7.3 Mixing Efficiency : (a) The mixer shall be tested under normal working conditions in accordance with the method specified in IS: 4643 with a view to check its ability to mix the ingredients to obtain concrete having uniformity within the prescribed limits.

3.2.7.4. Procedure for Machine Mixing: The mixer shall be flushed clean with water. Measured quantity of coarse aggregate shall be placed first in the hopper. This shall be followed with measured quantity of fine aggregate and then cement. In case fine aggregate is damp, half the required quantity of coarse aggregate shall be placed in the hopper, followed by fine aggregate and cement. Finally the balance quantity of coarse aggregate shall be fed in the hopper. Then the dry materials are slipped into the drum by raising the hopper and the dry materials mixed for at least four turns of the drum. While the drum is rotating, water shall be added gradually to achieve the water cement ratio as specified or as directed by

the Engineer. After adding water, the mixing shall be continued until concrete of uniform colour, uniformly distributed material and consistency is obtained. Mixing shall be done for at least two minutes after adding water. If there is segregation after unloading from the mixer, the concrete should be remixed. The drum shall be emptied before recharging. When the mixer is closed down for any time exceeding 20 minutes, the drum shall be flushed clean with water.

3.2.7.5 Procedure for Hand Mixing : When hand mixing has been specifically permitted in exceptional circumstances by the Engineer subject to adding **10% extra cement**, it shall be carried out on a smooth, clean and water tight platform of suitable size. Measured quantity of sand shall be spread evenly on the platform and the cement shall be dumped on the sand and distributed evenly. Sand and cement shall be mixed intimately with spade until mixture is of even colour throughout. Measured quantity of coarse aggregate shall be spread on top of cement sand mixture. Three quarters of the total quantity of water required shall be added in a hollow made in the middle of the mixed pile and the material is turned towards the middle of pile with spade. The whole mixture is turned slowly over again and again and the remaining quantity of water is added gradually. The mixing shall be continued until concrete of uniform colour and consistency is obtained. The mixing platform shall be washed and cleaned at the end of the day.

3.2.7.6. Transportation and Handling: Concrete shall be transported from the mixer to the place of laying as rapidly as possible by methods which will prevent the segregation or loss of any of the ingredients duly maintaining the required workability.

During hot or cold weather, concrete shall be transported in deep containers. Other suitable methods to reduce the loss of water by evaporation in hot weather and heat loss in cold weather may also be adopted.

3.2.8 Placing

3.2.8.1 The concrete shall be deposited as nearly as practicable in its final position to avoid re-handling. It shall be laid gently (not thrown) and shall be thoroughly vibrated and compacted before setting commences and should not be subsequently disturbed. Method of placing shall be such as to preclude segregation. Care shall be taken to avoid displacement of reinforcement or movement of form work and damage due to rains. As a general guidance, the maximum

free fall of concrete that can be permitted may be taken as 1.5 metre.

3.2.8.2 To place concrete on heights, the most economical and convenient method is concrete lift. For large works cranes are used. Concrete is also conveyed by means of pumps in very large work. The concrete should be placed in horizontal layers of uniform thickness. Unless the previous layer is properly compacted the second layer should not be started. The concrete should be laid fast as otherwise before the second layer is started the first layer may get set thus forming a cold joint. The thickness of layer in an RCC work can be 150mm to 200mm and for plain concrete the same can be 375mm to 500mm. While concreting members like walls, beams, and girders, the first batch should be placed at the ends and the subsequent pouring continued towards the centre. When the concrete has to be placed at a lower level, chutes are generally used. However, an open chute should not be permitted under any circumstance. A totally covered chute should be used. The slope of chute should be between 1:2 to 1:3 and must be adequately supported on all sides. To prevent any segregation, the height of drop of concrete from chute to the point of placing should be properly adjusted. Sometimes it is noticed that while speedily concreting the tall forms, water gathers on the top surface of concrete. This should not be allowed. In such a case the concreting should be stopped for about half an hour when the top 300mm high concrete is to be laid. The concreting can be restarted immediately thereafter. At the same time, one should carefully note that no initial set takes place as it will result in forming a cold joint. In arch work, the arch must be subdivided in the direction of the axis of the barrel into such widths that a complete ring can be laid continuously without stopping. These rings should be laid alternately and the gaps between laid afterwards. The Engineer or his authorized representative must always supervise all concrete laid in arches. If, from any unforeseen occurrence, it is found not possible to complete by continuous laying any ring of an arch, the cement concrete must be stopped with a slope that is radial to the soffits of the arch. Before the arch ring is completed oiled paper must be placed over the surface of the already deposited concrete so as to form a joint.

3.2.9 Compaction

3.2.9.1 General : Concrete shall be thoroughly compacted and fully worked around embedded fixtures and into corners of the form work. Compaction shall be done by mechanical vibrator of appropriate type till a dense concrete is obtained. The mechanical vibrators shall conform to IS: 2505, IS:2506, IS.2514 and IS.4856. To prevent segregation, over vibration shall be avoided.

Compaction shall be completed before the initial setting starts. For the items where mechanical vibrators are not to be used, the contractor shall take permission of the Engineer in writing before the start of the work. After compaction the top surface if exposed but not subject to wear shall be finished even and smooth with wooden trowel before the concrete begins to set. Any excess water or cream on the surface shall be removed. Dry cement or a dry mixture of cement and sand shall not be sprinkled on the surface to absorb such excess moisture.

3.2.9.2 Hand Compaction : This, where permitted by the Engineer, is the most suitable method for small jobs and in very thin sections where a mechanical vibrator of any type cannot be used.

The hand tapping is done by a tamping rod of suitable length and thapis. The rod should be long enough to reach the bottom and thin enough to pass through the reinforcements to reach the bottom.

Another method of hand tapping is spading. In this case the trowel (Thapi) or spade like tool is inserted between side of form work and concrete, thus forcing the larger aggregate of concrete deeper into the mass of concrete. This way, the air entrapped during transporting and placing is able to escape.

In case of paving work or a heavy flooring work, a heavy timber beam with proper camber is placed on the top of concrete and the same is rammed. This gives proper compaction.

3.2.9.3 Compaction by Machines

(a) The following **advantages** accrue by compacting the concrete by machines and is to be adopted in circumstances other than in **Para 3.2.9.2** above.

- i) Mix with low water cement ratio can be used.
- ii) A section with heavy and congested reinforcements can be successfully compacted.

- iii) With perfect vibration higher density concrete with good homogeneity and higher strength can be obtained.
- iv) Concrete with greater durability can be achieved.

Different types of vibrators in use are as follows :

- 1) Internal pin vibrators
- 2) External form vibrators
- 3) Table vibrators
- 4) Plate vibrators
- 5) Screed vibrators

(b) Vibration Functions

External or internal vibration is commonly used on construction works, for compacting concrete. When concrete is vibrated, the vibration produces a series of rapid compressive impulses which greatly reduces the friction, or internal cohesion between various size particles of the mix. Thus, the concrete just behaves like liquid and easily settles under the action of gravity in the forms, and during the process the unwanted entrapped air rises to the top surface. As soon as the vibration is stopped the internal friction gets re-established and the concrete starts setting.

(c) Internal Pin Vibrators

These vibrators are called immersion vibrators or needle vibrators or poker vibrators. They are operated on petrol, diesel or even on electricity. The vibrating heads called needles range from 20mm to 175mm diameter connected to the flexible shaft. The vibrating head is immersed in concrete imparting vibratory motion in the concrete.

(d) External Form Vibrators

These vibrators are attached to the form work. The forms must be strong enough to withstand the effect of vibration. Form vibrators are either electrically or pneumatically operated. They should be so placed that the intensity of vibration is uniformly spread over the form. The time required for proper vibration by a form vibrator is considerably longer than by internal vibration.

When the form vibrators are being used, the top 750mm portion should not be covered by the action of the form vibrators. The above gap can be vibrated by internal vibrator.

The form vibrators are most suitable when the reinforced section is very heavy and the internal vibrator cannot be used at all. Form vibrator can be attached to the exposed face of the reinforcement bars to vibrate them.

This will help remove the air trapped under the bars. This type of vibration will increase the bond between the concrete and reinforcement bars.

(e) Table Vibrators

These vibrators are mainly used for pre-cast items. These are attached to the tables where the precasting moulds are kept and the unit vibrates along with the table top.

(f) Plate/ Surface Vibrators

These are best suited for pavement and similar type works. They apply vibration through a flat plate at bottom direct to the concrete surface. These vibrators save a great deal of labour in levelling and finishing of concrete. These vibrators should not be used for concrete with a slump greater than 75mm.

Also the surface vibrators should not be used on a surface which is already adequately compacted since the additional vibration will result in accumulation of mortar and fine material in excess quantity on the surface which in turn will reduce wear resistance.

(g) Screed Vibrators

These are mostly used for road works. The vibrator is attached to the timber section having handles on both ends. The unit is thus called screed vibrator. All the conditions mentioned for surface vibrators apply to screed vibrators as well.

3.2.10. Construction Joints

3.2.10.1 : Concreting shall be carried out continuously up to construction joints. The position and arrangement of construction joints shall be as shown in the structural drawings or as directed by the Engineer. Number of such joints shall be kept minimum. Joints shall be kept as straight as possible. Construction joints should comply with IS:11817.

3.2.10.2 When the work has to be resumed on a surface which has hardened, such surface shall be roughened. It shall then be swept clean and thoroughly wetted. For vertical joints, neat cement slurry of workable consistency by using 2 Kg of cement per sqm shall be applied on the surface before it is dry. For horizontal joints, the surface shall be covered with a layer of mortar about 10-15 mm thick composed of cement and sand in the same ratio as the cement and sand in concrete mix. This layer of cement slurry or mortar shall be freshly mixed and applied immediately before placing of the concrete.

3.2.10.3 Where the concrete has not fully hardened, all laitance shall be removed by

scrubbing the wet surface with wire or bristle brushes, care being taken to avoid dislodgement of particles of coarse aggregate. The surface shall be thoroughly wetted and all free water removed. The surface shall then be coated with neat cement slurry @ 2 kg. of cement per sqm. On this surface, a layer of concrete not exceeding 150 mm in thickness shall first be placed and shall be well rammed against corners and close spots of work. Thereafter, work shall proceed in the normal way.

3.2.10.4 On construction joints in plain and reinforced concrete in General Bridge Constructions reference may be made to Para 8.5 and Appendix "A" of Concrete Bridge Code, 1997.

3.2.11 Concreting under Special Conditions

3.2.11.1 Mass Concrete

(a) Mass Concrete is to be deposited in layers not exceeding 40 cm thickness and complete layers of concrete should be laid in a day.

(b) Care shall be exercised to avoid disturbing the setting action of the concrete, and unless sufficient time has elapsed for the setting to take place, no imposed load, such as that caused by walking over it, laying planks or other timber upon it or other loads, however light, shall be allowed. Earth must never be rammed in the vicinity of reinforced concrete less than one month old.

(c) Use of Stone plums : Stone plums upto a maximum limit of 20 percent of the volume of concrete may be used in mass concrete, where so specified or permitted by the Engineer, with a view to economy. The plums shall be of granite or other approved hard stone, and of maximum dimension from 150 to 220mm but not greater than one-third the least dimension of the concrete mass. The plums shall be located only in zones not subject to tensile stresses, which may generally be taken as the middle half of the cross section on the case of piers and the front three-fourth in the case of abutments. The plums shall be free from sharp corners and shall be staggered laterally and spaced suitably apart to permit proper filling and consolidation of the inter-space with concrete.

3.2.11.2 Concreting in Cold weather

During cold weather, precautions shall be taken, to the satisfaction of the Engineer to ensure that the concrete shall have a temperature of atleast 4.5 deg. C and that the temperature of the concrete shall be

maintained above 2°C until it has thoroughly hardened. If necessary, aggregates and / or water used on mix shall be heated before mixing. No frozen materials or material containing ice shall be used. The concrete placed shall be protected against frost by suitable covering. Dependence should not be placed on salt or other chemicals for the prevention of freezing.

3.2.11.3 Concreting in hot weather

During hot weather, precautions shall be taken to see that the temperature of wet concrete does not exceed 38 deg. C. For this, concreting may be avoided during the hottest part of the day and may be done during the morning and evening hours.

3.2.11.4 Concreting in Rainy Weather

During rainy weather, sufficient supply of tarpaulins or other water proof cloth shall be provided by the contractor at the site of work. Any time when it rains, all freshly laid concrete which has not been covered for curing purposes, shall be adequately protected by means of such tarpaulins or other waterproof cloth. Any concrete injured by rain shall be removed and replaced at the expense of the contractor.

3.2.11.5 Concreting under water

(a) When it is necessary to deposit concrete under water, the methods, equipment, materials and proportions of the mix to be used shall be submitted to, and approved by the Engineer before the work is started.

(b) Concrete shall not be placed in water having a temperature below 4.5°C. The temperature of the concrete, when deposited, shall be not less than 16 deg. C nor more than 38 deg. C.

(c) The concrete shall contain at least 10 percent more cement than that required for the same mix placed in the dry, the quantity of extra cement varying with conditions of placing. The volume or weight of the coarse aggregate shall be not less than one and a half times, nor more than twice, that of the fine aggregate. The concrete shall be so proportioned as to produce a concrete having a slump of not less than 10 cm and not more than 18 cm.

(d) The water under which the concrete is laid shall be quite still and any movement in the water shall be stopped by sheeting so as to divide into compartments the place where the concrete is being deposited.

(e) In case cofferdams or forms are being provided, the same shall be sufficiently tight to ensure still water if practicable, and in any

case to reduce the flow of water to less than 3m per minute through the space into which concrete is to be deposited. Cofferdams or forms in still water shall be sufficiently tight to prevent loss of mortar through the walls. Dewatering by Pumping shall not be done while concrete is being placed, or until 24 hours thereafter.

(f) Concrete shall be deposited continuously until it is brought to the required height. While depositing, the top surface shall be kept as nearly level as possible and the formation of seams avoided. The methods to be used for depositing concrete under water shall be one of the following:-

Tremie : The concrete should be coherent and slump shall be more than 150mm but should not exceed 180mm. When concreting is carried out under water, a temporary casing should be installed to the full depth of bore hole or 2 m into non-collapsible stratum, so that fragments of ground cannot drop from the sides of the hole into the concrete as it is placed. The temporary casing may not be required except near the top when concreting under drilling mud. The top section of the tremie shall be a hopper large enough to hold one entire batch of mix or the entire contents of the transporting bucket when one is used. The tremie pipe shall be not less than 200mm in diameter and shall be large enough to allow free flow of concrete and strong enough to withstand the external pressure of the water in which it is suspended, even if a partial vacuum develops inside the pipe. Preferably flanged steel pipe of adequate strength to sustain the greatest length and weight required for the job should be used. A separate lifting device shall be provided for each tremie pipe with its hopper at the upper end. Unless the lower end of the pipe is equipped with an approved automatic check valve, the upper end of the pipe shall be plugged with a wadding of gunny sacking or other approved material before delivering the concrete to the tremie pipe through the hopper, which plug will be forced out of the bottom end of the pipe by filling the pipe with concrete. It will be necessary to raise slowly the tremie by 25 cm to 30 cm in order to cause a uniform flow of the concrete, but the tremie shall not be emptied so that water enters above the concrete in the pipe. At all times after the placing of concrete is started and until all the concrete is placed, the lower end of the tremie pipe shall be at least 600mm below the top surface of the plastic concrete as ascertained by sounding.. This will cause the concrete to build up from below instead

of flowing out over the surface, to avoid formation of laitance layers. If the charge in the tremie is lost while depositing, the tremie shall be raised above the concrete surface, and unless sealed by a check valve, it shall be re-plugged at the top end, as at the beginning, before refilling for depositing concrete.

Drop Bottom Bucket : The concrete shall be gently laid in position by means of approved skips or buckets with flaps or doors automatically opening at the bottom. The top of the bucket shall be open. The bottom doors shall open freely downward and outward when tripped. The bucket shall be filled completely and lowered slowly to avoid backwash. It shall not be dumped until it rests on the surface upon which the concrete is to be deposited and when discharged shall be withdrawn slowly until well above the concrete.

(g) To minimise the formation of laitance, great care shall be exercised to disturb the concrete as little as possible while it is being deposited. No tamping or ramming shall be done until the concrete surface rises above water level, and even then, the surface shall be tamped gently so as not to squeeze the water. Care must be taken that tamping is not done in a manner as to permit any disturbance of mortar or leakage or suction of the same from the concrete.

3.2.11.6 Concrete in Sea Water: Concrete in sea-water or exposed directly along the sea-coast shall be at least M20 Grade in the case of plain concrete and M30 in case of reinforced concrete. The use of slag or Pozzolana cement is advantageous under such conditions.

(i) Special attention shall be given to the design of the mix to obtain the densest possible concrete. Slag, broken brick, soft lime stone, soft sandstone, or other porous or weak aggregates shall not be used.

(ii) As far as possible, preference shall be given to use of pre cast members unreinforced, well-cured and hardened, without sharp corners, and having trowel-smooth finished surfaces free from crazing, cracks or other defects. Plastering should be avoided.

(iii) No construction joint shall be allowed within 60 mm below low water-level or within 60 mm of the upper and lower planes of wave action. Where unusually severe conditions or abrasion are anticipated, such parts of the work shall be protected by bituminous or silico-fluoride coatings or stone facing bedded with bitumen.

(iv) In reinforced concrete structures, care shall be taken to protect the reinforcement from exposure to saline atmosphere during storage, fabrication and use. It may be achieved by treating the surface of reinforcement with cement wash or by other suitable methods as provided for in the Contract.

3.2.11.7 Concrete in Aggressive Soils and Water

The destructive action of aggressive waters on concrete is progressive. The rate of deterioration which varies with the alkali resisting property of the cement used decreases as the concrete is made stronger and more impermeable, and increases as the salt content of the water increases. Where structures are only partially immersed or are in contact with aggressive soils or water on one side only, evaporation may cause serious concentrations of salts with subsequent deterioration even where the original salt content of the soil or water is not high. The selection of type of cement, therefore, should be made after thorough investigation. For particular problems the Engineer should decide upon the method. No concrete shall be allowed to come in contact with sea water within 72 hours of casting.

3.2.12 Curing

3.2.12.1 General : Curing is the process of preventing loss of moisture from the concrete. The importance of curing can be appreciated from the details given at **Annexure 3.6**. The following methods shall be employed for effecting curing.

3.2.12.2. Moist curing : Exposed surfaces of concrete shall be kept continuously in a damp or wet condition by ponding or by covering with a layer of sacking, canvas, Hessian or similar materials and kept constantly wet for at least 7 days from the date of placing concrete in case of ordinary Portland cement and at least 10 days where mineral admixtures or blended cements are used. The period of curing shall not be less than 10 days for concrete exposed to dry and hot weather conditions. In the case of concrete where mineral admixtures or blended cements are used, it is recommended that above minimum period may be extended to 14 days.

3.2.12.3 Membrane Curing: Approved curing compounds may be used in lieu of moist curing with the permission of the Engineer. Such compound shall be applied to all exposed surfaces of the concrete as soon as possible after the concrete has set.

Impermeable membrane such as polythene sheet covering the concrete surface may also be used to provide effective barrier against the evaporation.

3.2.12.4 Freshly laid concrete shall be protected from rain by suitable covering.

3.2.12.5 Over the foundation concrete, the masonry work may be started after 48 hours of its completion, but the curing of exposed surfaces of cement concrete shall be continued along with the masonry work for at least 7 days. And where the cement concrete is used as base concrete for flooring, the flooring may be commenced before the curing period of base concrete is over but the curing of base concrete shall be continued along with top layer of flooring for a minimum period of 7 days.

3.2.13 Testing of concrete :

This will be done as described in Chapter 4 on R.C.C.

3.2.14 Form work

Form work shall be as described in Chapter 4 on R.C.C. and shall be paid for separately unless otherwise specified.

3.2.15 Finishes

Plastering and special finishes other than those obtained through form work shall be specified and paid for separately unless otherwise provided for in the Contract.

3.2.16 Application of Load

The following minimum periods shall be allowed to elapse after the concreting is completed before the load is imposed on it.

	50 percent of designed load	75 percent of designed load	Full designed load
Ordinary Cement concrete	7 days	14 days	28 days
Rapid - hardening Cement Concrete	5 days	10 days	14 days

Note : 1. The expression "Load" means the total calculated load with the appropriate impact allowance specified for the speed at which the load is permitted.

2. The above periods shall be suitably increased where the mean air temperature is less than 5°C.

3.2.17. Measurements

3.2.17.1. Dimensions of length, breadth and thickness shall be measured correct to nearest cm. except for the thickness of slab and partition which shall be measured to nearest 5 mm. Areas shall be worked out to nearest 0.01 sqm and the cubic contents of consolidated concrete shall be worked out to nearest 0.001 cum. Any work done in excess over the specified dimensions or sections shown in the drawing shall be ignored.

3.2.17.2. Concrete work executed in the following conditions shall be measured separately, unless otherwise specified in the contract.

- Work in or under water
- Work in liquid mud
- Work in or under foul positions

3.2.17.3. Cast-in-situ concrete and /or pre-cast concrete work shall be measured in stages described in the Schedule of item of work:

3.2.17.4 No deduction shall be made for the following:-

- Ends of dissimilar materials for example beams, posts, girders, rafters, purlins, trusses, corbels and steps up to 500 sq.cm in cross sections.
- Opening upto 0.1 sq.metre (1000 sq.cm.)
- Volume occupied by pipes, conduits, sheathing etc., not exceeding 100 sq.cm. each in cross sectional areas.
- Small voids when these do not exceed 40 sq.cm. each in cross section.

Note : In calculating area of opening, the thickness of any separate lintel or sill shall be included in the height. Nothing extra shall be payable for forming such openings or voids.

3.2.17.5 Cast-in-situ and precast concrete work shall be measured separately.

3.2.17.6 Cast-in-situ concrete shall be classified and measured as follows, unless otherwise stipulated in the Schedule of Rates.

- Foundation, footings, bases for columns.
- Walls (any thickness) including attached pilasters, buttresses, plinth and string courses, fillets etc.,
- Shelves
- Slabs

5. Chajjas including portions bearing on the wall
6. Lintels, beams and bressummers
7. Columns, piers, abutments, pillars, post and struts
8. Staircase including stringer beams but excluding landings
9. Balustrades, Newels and sailing
10. Spiral staircase (including landings)
11. Arches
12. Domes, vaults
13. Shell roof, arch ribs and folded plates
14. Chimneys and shaft
15. Breast walls, retaining, walls return walls
16. Concrete filling to precast components

17. Kerbs, steps and the like

18. String or lacing courses, parapets, copings, bed block, anchor blocks, plain window sills and the like

19. Cornices and moulded windows sills.

20. Louvres, fins, fascia

3.2.17.7 Precast cement concrete solid articles shall be measured separately and shall include use of moulds, finishing the top surfaces even and smooth with wooden trowel, before setting in position in cement mortar 1:2 (1 cement:2 coarse sand) Plain and moulded work shall be measured separately and the work shall be classified and measured as under :

Classifications	Method of measurement
(a) Wall panels	In square meters stating the thickness.
(b) String or lacing courses, copings bed plats, plain windows sills, shelves, louvers, steps etc.	In cubic meters.
(c) Kerbs, edgings etc.,	In cubic meters.
(d) Solid block work	In square meters stating the thickness or in cubic meters.
(e) Hollow block work	In square meters stating the thickness or in cubic meters.
(f) Light weight Partitions	In square meters stating the partition's thickness.

3.2.18 Rate

The rate is inclusive of the cost of labour and materials involved in all the operations described above, unless otherwise provided for in the Contract.

3.3. CEMENT FLY ASH CONCRETE

3.3.1. General:-

3.3.1.1 Fly Ash Concrete shall be prepared by mixing graded coarse aggregate of nominal size as specified with fine aggregate, ordinary Portland cement and fly ash in specified proportions with required quantity of water. The recommended composition of cement-fly ash concrete is given in **Table 3.18** below for Ordinary Mix Concrete.

TABLE 3.18
FLY ASH CONCRETE MIXES

Composition	(Dry volume)	Compressive strength at 7 days
Lean Concrete (1:5:10)		2.8 kg. /cm ²
Cement (Ordinary Port land)	1.0	
Fly Ash	2.5	
Sand	4.0	
Stone Aggregate	11.0	
Lean Concrete (1:4:8)		3.7 kg/cm ²
Cement (Ordinary Port land)	1.0	

Fly ash	2.0	
Sand	3.5	
Stone aggregate	9.0	

Note : No fly ash is to be added to Pozzolana cement.

3.3.1.2 In terms of Correction Slip No. 9 dated 27.03.2006 to Concrete Bridge Code, when Portland Pozzolana Cement is used in Plain and Reinforced Concrete, it is to be ensured that proper damp curing of concrete is done atleast for 14 days and supporting form work is not removed till concrete attains atleast 75% of Design strength.

3.3.2. Proportioning : This shall be as specified in 3.2.5.

3.3.3. Mixing : This shall be as specified in 3.2.7 except that the fly ash shall be placed in the hopper before cement in case of machine mixing.

3.3.4 Placing and compaction : This shall be as specified in 3.2.8 and 3.2.9.3

3.3.5 Curing:- This shall be as specified in 3.2.12

3.3.6 Form work : This shall be as specified in 3.2.14.

3.3.7 Measurements : This shall be as specified in 3.2.17.

3.3.8 Rate : This shall be as specified in 3.2.18.

3.4 DAMP PROOF COURSE WITH CEMENT CONCRETE

3.4.1 Cement Concrete layer

This shall consist of cement concrete of specified proportions and thickness. The surface of brick or stone masonry work shall be levelled and prepared before laying the cement concrete. Edge of damp proof course shall be straight, even and vertical. Side shuttering shall consist of steel forms and shall be strong and properly fixed so that it does not get disturbed during compaction and the mortar does not leak through. The concrete mix shall be of workable consistency and shall be tamped thoroughly to make a dense mass. When the sides are removed, the surface should come out smooth without honey-combing. Continuity shall be maintained while laying the cement concrete layer and laying shall be terminated only at the predetermined location where damp proof course is to be discontinued. There shall be no construction joint in the Damp Proof Course.

3.4.2 Curing

Damp proof course shall be cured for at least seven days, after which it shall be allowed to dry.

3.4.3 Application of Hot Bitumen

Where so directed, hot bitumen in specified quantity shall be applied over the dried up surface of cement concrete properly cleaned with brushes and finally with a piece of cloth soaked in kerosene oil. Bitumen of penetration A 90 or equivalent where used shall be heated to a temperature of $160^{\circ} \pm 5^{\circ}\text{C}$. The hot bitumen shall be applied uniformly all over, so that no blank spaces are left anywhere. It will be paid for separately.

3.4.4 Water proofing Materials

Where so specified, water proofing material of approved quality shall be added to the concrete mixture in accordance with the manufacturer's specifications stating the quantity of water proofing material in litres or kg per 50 kg of cement and this will be paid for separately. A layer of 400 micron thick polyethylene sheet may be laid over the bitumen layer which will be paid extra.

3.4.5 Measurements

The length and breadth shall be measured correct to a cm and its area shall be calculated in square metres correct to two places of decimal. The depth shall not be less than the specified thickness at any section.

3.4.6 Rate

The rate is inclusive of the cost of materials and labour involved in all the operations described above except for the applications of a coat of hot bitumen and addition of water proofing materials which shall be paid for separately, unless otherwise specified.

3.5 Specifications for Bisphenol and Butyl Based Products :

3.5.1 Bisphenol and Butyl Based Epoxy Coating

The coating should adhere to following **Standards :**

1. ISO Standards as per ISO / TS / 16949-2002 / 069734 TS2

2. EN Standards – EN ISO 14001 – 2004 / 069734 UM
3. OHSAS 18001 : 1999 / 069734 OH
4. CFIA standards.

Product **Characteristics** :

1. Curing – 24 hours.
2. Working life @ 25 °C : 40 to 60 minutes (Easy application)
3. Compressive Strength as per ASTM D695 : 15000 psi
4. High Temperature Resistant : -29°C to +107°C
5. Non Shrinking after 100% curing
6. Resistant to Chemicals and Ultra Violet light.

3.5.2 Magnesium Poly Phosphate Based Concrete Fast Repair Epoxy :

The coating should adhere to following **Standards** :

1. ISO Standards as per ISO / TS / 16949-2002 / 069734 TS2
2. EN Standards – EN ISO 14001 – 2004 / 069734 UM
3. OHSAS 18001 : 1999 / 069734 OH
4. CFIA standards.

Concrete Fast Repair (*Beam Repair – Before*)



Concrete Fast Repair (*Beam Repair – After*)



Product **Characteristics** :

1. Fast Curing – 1 hours.
2. Compressive Strength as per ASTM C109 13000 psi
3. High Temperature Resistant : -29°C to +1090°C
4. Coefficient of Thermal Expansion as per ASTM C 531:10 power -6 in/in/F

Pre Tg	- 5.95
Post Tg	- 6.11
5. Resistant to Chemicals and Ultra Violet light.

3.5.3 Gun Grade, Poly Urethane Based Crack Sealer :

The coating should adhere to the following **Standards** :

1. ISO Standards as per ISO / TS / 16949-2002 / 069734 TS2
2. EN Standards – EN ISO 14001 – 2004 / 069734 UM
3. OHSAS 18001 : 1999 / 069734 OH
4. CFIA standards.
5. USDA Approved.

Product **Characteristic** :

1. Tensile Strength as per ASTM D 412 - 200 psi
2. Shear Strength as per ASTM D 1002 - 170 psi
3. Elongation at Break as per ASTM D 412 - 1000 %
4. Hardness in Shore A – 33.
5. Can be used for indoor and outdoor applications.
6. Paintable.
7. Resistant to chemicals and ultra Violet light.

3.5.4 Bisphenol Polyurethane Coating of 100% Solid Epoxy :

The coating should adhere to the following **Standards** :

1. ISO Standards as per ISO / TS / 16949-2002 / 069734 TS2
2. EN Standards – EN ISO 14001 – 2004 / 069734 UM
3. OHSAS 18001 : 1999 / 069734 OH
4. CFIA standards.
5. Salt water spray resistant with min. 1000 hrs. spray.
6. Compatible to potable water.

Product Characteristic :

1. Viscosity – 40000 – 60000 cps.
2. Coefficient of Thermal Expansion as per ASTM C 531 K-1
Pre Tg - 5.95
Post Tg – 6.11
3. Compressive Strength as per ASTM D695 – 9840 psi
4. Shear Strength as per ISO 4587 – 2190 psi.
5. Abrasion Resistant as per ASTM D 4060 – 49 mg.
6. Water Vapour Transmission rate as per ASTM E 96 – 4×10^{-11}
7. Thermal Conductivity as per ASTM F – 433 watt / mk – 0.42.

3.5.5 Special Anti-Slip Coating :

Supplying and applying of two components anti-slip coating, which should withstand heavy vehicular and pedestrian traffic. It should also adhere to metal, wood and concrete surfaces. Coating must be chemical and corrosion resistant. Job includes cleaning and priming of the surface with suitable metal or concrete primer, abrasive cleaning of surface followed by cleaning with suitable solvents.

The coating should adhere to following **Standards** :

1. ISO Standards as per ISO /TS / 16949-2002 / 069734 TS2
2. EN Standards - EN ISO 14001 -2004 / 069734 UM
3. OHSAS 18001 : 1999 / 069734 OH
4. CFIA standards.

**Product Characteristic :**

1. Curing – Light pedestrian traffic: 12 hours. Heavy pedestrian traffic: 72 Hours
2. Working life @ 25 ° Cel – 04 Hours (Easy application)
3. Coefficient of friction, ASTM F609, 1.05
4. High Temperature Resistant: - 29° C to 60° C.
5. Resistant to acids, alkalis, solvents, grease, oil, salt water, detergents, alcohol, gasoline, jet fuels & hydraulic oils.

Scope of Work :

1. The surface to be repaired has to be cleaned thoroughly using water based cleaner to remove all visible and invisible contaminants.
2. Area has to be roughened using sander, chipping or other tools as will be required.
3. Re-cleaning of area with brush or dry compressed air.
4. Application of the product on the prepared surface using primer as per substrate concrete / metal.
5. Finish it off with roller or brush.

ANNEXURE 3.1**DETERMINATION OF PARTICLE SIZE**

The apparatus, sample size and test procedure shall be same as specified in Annexure 26.4 in Chapter 26 on "Mortar".

In order that the sieves shall not be overloaded, care must be taken to ensure that the maximum sieve loads shown in table below are not exceeded at the completion of sieving.

I.S. Sieve	Maximum weight for	
	45 cm dia sieve (kg)	30 cm dia sieve (kg)
45 mm	10	4.5
40 mm	8	3.5
31.5 mm or 22.1 mm	6	2.5
20 mm	4	2
16 mm or 12.5 mm	3	1.5
10 mm	2	1.0
5.6 mm	1.5	0.75
4.75 mm	1.0	0.50
3.35 mm	--	0.30

The sample weights taken will thus normally require several operations on each sieve. Each sieve should be shaken separately over a clean tray or receiver until no more than a trace passes, but in any case for not less than two minutes. Material should not be forced through the apertures but hand

placing is permitted. A light brush should be used with fine sieves. The cumulative weight passing each sieve should be calculated as a percentage of the total sample weight to the nearest whole number.

ANNEXURE 3.2**TEST FOR SURFACE MOISTURE**

Take a sample of wet aggregate and weigh it (A). Then place it in a frying pan and gently apply heat, meanwhile stirring with a glass rod until the surface moisture disappears. This is apparent when the aggregate loses its shining wet appearance and becomes dull, or when it just attains a free running condition. The saturated surface-dry material is then weighed (B). Continue the

heating thereafter until the moisture is evaporated and weigh the dry sample (C). The surface moisture is then calculated as follows:-

$$\text{Surface moisture} = 100 \frac{A - B}{C}$$

It is expressed as a percentage of dry aggregate.

ANNEXURE 3.3**DETERMINATION OF TEN PERCENT FINE VALUE**

Apparatus : The apparatus for the standard test shall consist of the following:

- (a) A 15 cm diameter open-ended steel cylinder, with plunger and base plate. The surfaces in contact with the aggregate shall be machined and case hardened or otherwise treated so as to have a diamond (VH) pyramid hardness number of not less than 650 VH.
- (b) A straight metal tamping rod of circular cross-section 16 mm in diameter and 45 to 60 cm long. Rounded at one end.
- (c) A balance of capacity 3 kg. readable and accurate to one gram.
- (d) I.S. Sieve of 12.5, 10 and 2.36 mm.
- (e) A compression testing machine capable of applying a load of 50 tonnes and which can be operated to give a uniform rate of loading so that the maximum load in any test is reached in 10 minutes. This load may vary from 0.5 to 50 tonnes.
- (f) For measuring the sample, a cylindrical metal measure of sufficient rigidity to retain its form under rough usage and of the following internal dimensions:-

Diameter	11.5 cm
Height	18.0 cm

- (g) Means of measuring the reduction in the distance between the plates of the testing machine to the nearest one millimetre during the test (for example, dial gauge).

Test Sample : Material for the test shall consist of aggregate passing a 12.5 mm I.S. Sieve and retained on a 10 mm I.S. Sieve. The aggregate shall be tested in a surface dry condition. If dried by heating, the period of drying shall not exceed four hours, the temperature shall be 100°C to 110°C and the aggregate shall be cooled to room temperature before testing.

The quantity of aggregate shall be such that the depth of material in the cylinder, after tamping as described below, shall be 10 cm.

The weight of material comprising the test sample shall be determined (weight A) and the same weight of sample shall be taken for the repeat test.

Note : About 6.5 kg. of natural aggregate is required to provide the two test samples. The measuring cylinder is filled in three layers of approximately equal depth with aggregate passing a 12.5 mm I.S. Sieve and

retained on 10 mm I.S. Sieve. Each layer is subjected to 25 strokes from the tamping rod (16 mm dia and 45 to 60 cm long) rounded at one end, care being taken in case of weak materials not to break the particles. The surface of the aggregate shall be carefully levelled and the plunger inserted so that it rests horizontally on this surface.

Test procedure : The apparatus, with the test sample and plunger in position, shall then be placed in the compression testing machine. The load shall be applied at a uniform rate so as to cause a total penetration of a plunger in 10 minutes of about 15.0 mm for rounded or partially rounded aggregates (for example, expanded shales and slags). These figures may be varied according to the extent of the rounding or honey combing.

After reaching the required maximum penetration, the load shall be released and the whole of the material removed from the cylinder and sieved on a 2.36 mm I.S. Sieve. The fines passing the sieve shall be weighed, and this weight expressed as a percentage of the weight of the test sample. Normally, this percentage will fall within the range 7.5 to 12.5 but if it does not, a further test shall be made at a load adjusted appropriately, to bring the percentage fines within the range of 7.5 to 12.5.

A repeat test shall be made at the load that gives as percentage fines within the range 7.5 to 12.5.

Calculations : The mean percentage fines from the two tests at this load shall be used in the following formula to calculate the load required to give 10 percentage fines.

$$\text{Load required for 10 percent fines} = \frac{14 \times Y}{Y + 4}$$

Where X = Load in Tonnes and

Y = Mean percentage of fines from two tests at X Tonnes load.

Reporting of results : The load required to produce 10 percent fines shall be reported to the nearest whole number for loads of 10 tonnes or more and the nearest 0.5 tonne for loads of less than 10 tonnes. The value expressed to the nearest 0.5 tonne should be as follows:-

- (a) For normal concrete, not less than 5 tonnes.
- (b) For wearing surfaces, not less than 10 tonnes.
- (c) For granolithic concrete not less than 15 tonnes.

ANNEXURE 3.4**SLUMP TEST**

Apparatus : Mould shall consist of a metal frustum of cone having the following internal dimensions:

Bottom diameter	20 cm
Top diameter	10 cm
Height	30 cm

The mould shall be of a metal other than brass and aluminium of at least 1.6 mm (or 16 BG) thickness. The top and bottom shall be open and at right angles to the axis of the cone. The mould shall have a smooth internal surface. It shall be provided with suitable foot pieces and handles to facilitate lifting it from the moulded concrete test specimen in a vertical direction as required by the test. A mould provided with a suitable guide attachment may be used.

Tamping rod shall be of steel or other suitable material 16 mm in diameter 60 mm long and rounded at one end.

Procedure : The internal surface of the mould shall be thoroughly cleaned and free from superfluous moisture and any set concrete before commencing the test. The mould shall be placed on a smooth horizontal, rigid and non absorbent surface viz. levelled metal plate. The operator shall hold the mould firmly in place while it is being filled with test specimen of concrete. The mould shall be filled in four layers, each approximately one quarter of height of mould. Each layer shall be tamped with twenty five strokes of the rounded end of the tamping rod. The strokes shall be distributed in a uniform manner over the cross-section of the mould and for the

second and subsequent layers shall penetrate into the underlying layer. The bottom Layer shall be tamped through out its depth. After the top layer has been rodded, the concrete shall be struck off level with trowel or the tamping rod, so that the mould is exactly filled. Any mortar which shall leak out between the mould and the base plate shall be cleaned away. The mould shall be removed from the concrete immediately after filling by raising it slowly and carefully in a vertical direction. The moulded concrete shall then be allowed to subside and the slump shall be measured immediately by determining the difference between the height of the mould and that of the highest point of specimen.

The above operations shall be carried out at a place free from vibration or shock, and within a period of two minutes after sampling.

Result : The sump shall be recorded in terms of millimetres of subsidence of the specimen during the test. Any slump specimen which collapses or shears off laterally gives incorrect result. If this occurs, the test shall be repeated with another sample.

The slump test shall not be used for dry mixes as the results obtained are not accurate.

ANNEXURE 3.5**READY MIX CONCRETE**

Indian Railway Standard Code of Practice for Plain, Reinforced and Pre-stressed concrete for General Bridge Construction (Concrete Bridge Code)

Note : Based on Correction Slip No. 3 dated 01.08.2000 to Concrete Bridge Code 1997.

1. "Ready Mixed Concrete (RMC) : RMC means concrete produced by completely mixing cement, aggregates, admixtures, if any, and water at a Central Batching and Mixing Plant and delivered in fresh condition at site of construction.

2. Use of Ready Mixed Concrete : Ready Mixed Concrete may be used, wherever required. It shall conform to the specifications of concrete, as laid down in Concrete Bridge Code. For other aspects, which are not covered in Concrete Bridge Code IS: 4926 (Specification for Ready Mixed Concrete) may be referred.

3. Effect of transit (transportation) time on Ready Mixed Concrete : As Ready Mixed Concrete is available for placement

after lapse of transit time, reduction in workability occurs, which may lead to difficulty in placement of concrete. In addition, in case of longer transit time, initial setting of concrete may also take place, which may render it unusable. Thus, while planning for using of Ready Mixed Concrete, these aspects should be kept in view.

4. Checking suitability of Admixtures :

Generally admixtures, like water reducing agent, retarder etc., are used in Ready Mixed Concrete for retention of desired workability and to avoid setting of concrete. In such cases, admixtures should be tested for their suitability as per IS: 9103 at the time of finalizing mix design. Regarding specification of admixtures, clause 4.4 of Concrete Bridge Code may be referred.

5. Re-tempering with Concrete : Under any circumstances, re-tempering i.e. addition of water after initial mixing, shall not be allowed, as it may affect the strength and other properties of concrete.

6. Time period for delivery of concrete :

The concrete shall be delivered completely to the site of work within 1½ hours (when the atmospheric temperature is above 20°C) and within 2 hours (when the atmospheric temperature is at or below 20°C) of adding the mixing water to the dry mix of cement

and aggregate or adding the cement to the aggregate, whichever is earlier. In case, location of site of construction is such that this time period is considered inadequate, increased time period may be specified provided that properties of concrete have been tested after lapse of the proposed delivery period at the time of finalizing mix design.

7. Transportation of Ready Mixed Concrete :

The Ready Mixed Concrete shall be transported in concrete transit agitators conforming to IS: 5892 (Specification for concrete transit mixers and agitators). Agitating speed of the agitators during transit shall not be less than 2 revolutions per minute nor more than 6 revolutions per minute.

ANNEXURE 3.6

IMPORTANCE OF CURING

Curing :

The most important aspect in concrete is curing. A concrete which is cured properly will be stronger, durable, impermeable and will be in a position to take up stress.

Chemical Action During Curing

When water is mixed in concrete a chemical reaction called hydration takes place. This hydration continues rapidly for first few days, after the concrete is placed, but, for this hydration to take place without interruption, favourable temperature and moisture conditions are to be maintained. The act of protection of hydration in concrete is in broad terms called curing.

Thus, it can be concluded that to facilitate the hydration in cement, the water that is added in concrete during construction should be prevented from evaporation. In other words, it is prevention or replenishment of the loss of moisture from freshly placed concrete, which is termed as curing.

The loss of water due to evaporation from the freshly laid concrete depends mainly upon the temperature and relative humidity of the surrounding air. The velocity of wind over the surface of newly laid concrete also adds to quick evaporation. Thus, if the temperature is hot with low relative humidity and hot winds blowing one must be very careful about curing.

It has to be understood that if hydration is halted as a result of the loss of water due to evaporation, the concrete in question shrinks, thus creating tensile stresses within the concrete, and if these stresses develop before the concrete reaches its tensile strength the surface starts cracking endangering the stability of the structure itself. Therefore to protect the quality of concrete adequate curing arrangement should be made and this is applicable whether the work is big or small.

The strength of concrete directly depends upon the period of curing a concrete member is subjected to as may be seen from the Table below.

EFFECT OF CURING IN ACHIEVING THE STRENGTH IN CONCRETE

SL	Curing Days	Compressive Strength percent of 28 day moist cured concrete
1	No curing after laying	50% to 55%
2	Just 3 days curing	75% to 80%
3	7 days curing	95% to 100%
4	Full 28 days curing	120% to 125%

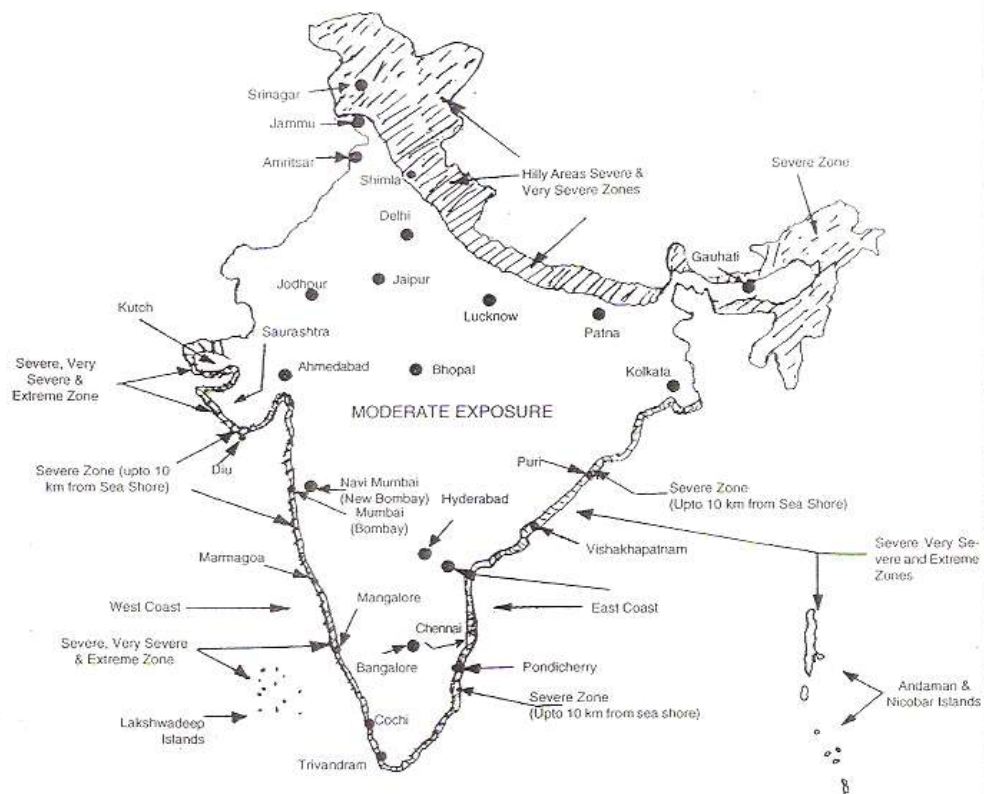
RECOMMENDED LIST OF TESTS ON MATERIALS AND WORKS

Material	Para	Test	Field / Laboratory	Test Procedure	Minimum quantity of Material for carrying out test	Frequency of testing
Stone aggregate	3.1.2.1	Percentage of soft or deleterious material	General visual Inspection / Laboratory Test where required by the Engineer	IS 2386 Part I	One test for each source	One test for each source
	3.1.2.4	Particle size distribution	Field / Lab	Annexure 3.1	10 cum	Every 40 cum or part thereof
	3.1.2.8	(a) Estimation of organic impurities	Field / Lab	IS 2386 Part II	10 cum	-do-
		(b) Surface moisture	Field / Lab	IS 2386	10 cum	-do-
		(c) Determination of 10% fine value	Field / Lab	IS 2386	10 cum	-do-
		(d) Specific gravity	Field / Lab	IS 2386	10 cum	-do-
		(e) Bulk density	Field/ Lab	IS 2386	10 cum	-do-
		(f) Aggregate crushing strength	Field /Lab	IS 2386	10 cum	-do-
		(g) Aggregate impact value	Field/Lab	IS 2386	10 cum	-do-
Concrete	3.2.4.1	Slump test	Field	ANNEXURE 3.4	10 cum	15 cum or part thereof

Figure 3.1
(Para 3.2.1.6 (b))

ENVIRONMENTAL EXPOSURE CONDITIONS (GEOGRAPHICAL)

A. Moderate, Severe and Very Severe Exposure Conditions



B. Very Severe Exposure Condition (Coastal Area)



C. Extreme Exposure Condition (Just on Seashore)

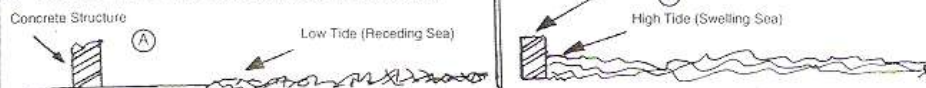


Exhibit 4.2 : Geographical Environmental Exposure Conditions