

	Sand and sandy soils	Well graded sands and gravelly sands; little or no fines  Well graded sands with excellent clay binder				
<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>
	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 fines, silty sands, clayey sands, poorly graded sand/clay mixtures	Smooth wheeled roller below 500kg per 100mm of roll  Grid roller below 540kg per 100mm of rolling  Pneumatic tired roller below 1500kg per wheel Vibratory roller Vibrating plate compactor Vibro-tamper	3 to 16 depending on type of plant	75 to 300 depending on type of plant	
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	Sheep foot roller Smooth wheeled roller Pneumatic tired roller Vibratory roller over 70 kg per 100 mm of roll Vibratory plate compactor over 1400 kg/sq.m 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. Sheep 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				

**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.**

**APPENDIX- G****QUALITY CHECKS PROFORMA****Proforma No. G-1****Details of Borrow soil/ Formation subgrade/Prepared Subgrade**

S. no	Date of taking sample	Location layer Ch./Km	Soil type				Soil classification	LL	PL	PI
			Gravel %	Sand %	Silt %	Clay %				
1	2	3	4	5	6		7	8	9	10

CBR value	Whether of dispersive nature	Suitable/ Non suitable	Signature and name of Engineer's representative	Signature and name of contractor representative	Remarks
11	12	13	14	15	16

**QUALITY OF BLANKET MATERIAL**

1. Type of material: Manufactured/Naturally available
2. Source location:

S.no	Date of taking sample	Location of laying	Soil type			C <sub>u</sub>	C <sub>c</sub>	Abrasion Value
			Gravel %	Sand %	Fines passing 75 micron sieve %			
1	2	3	4	5	6	8	9	10

CBR value	Signature and name of Rly official	Signature and name of contractor	Remarks
11	12	13	14

**PROFORMA FOR FIELD COMPACTION RECORD**

Chainage / km from .....

to.....

Soil Classification:

Height of embankment:

OMC:

Type of roller being used:

Lab. MDD/ Field Trial MDD:

**CORE CUTTER METHOD**

Date of Laying	Layer no.	location coordinate for check	Placeme nt moisture content (%)	No. of passes	Wt. of core cutter+ wet soil (W <sub>s</sub> ) (g)	Wt. of core cutter (W <sub>c</sub> ) (g)	Wt of wet soil (W <sub>s</sub> - W <sub>c</sub> ) (g)	Vol. of core cutter (V <sub>c</sub> ) (cc)	Bulk density, $\gamma_b = \frac{(W_s - W_c)}{V_c}$ (g/cc)
1	2	3	4	5	6	7	8	9	10

Moisture content of compacted layer (w) (%)	Dry Density( $\gamma_d$ ) = $\gamma_b / 1+w$ *100 (g/cc)	Degree of compaction (%)	Sig. and name of Rly officer	Sig. and name of contractor	Remarks
11	12	13	14	15	16

- Note: 1. In case of compaction of blanket material, percentage of fines should also be mentioned in a column.**
- 2. Determination of Dry Density, ( $\gamma_d$ ) of soil in above table is done as per IS: 2720 Pt 29 – 1975 (latest version) titled as Determination of Dry Density of Soils In-Place By The Core-Cutter Method**

**PROFORMA FOR FIELD COMPACTION RECORD**

Chainage /km from ..... to.....

Soil Classification:

Height of embankment:

**SAND REPLACEMENT METHOD**

Location	Bulk density of sand, $(\gamma_s)$ g/cum	Wt of wet soil from hole, $W_w$ (g)	Wt of Cylinder + Sand, before pouring $W_1$ (g)	Wt of sand + Cylinder after pouring $W_2$ (g)	Mean weight of sand in cone $W_3$ (g)	Wt of sand in hole $W_b = W_1 - W_2 - W_3$	Bulk Density of soil $\gamma_b = (W_w / W_b) * \gamma_s$
1	2	3	4	5	6	7	8

Moisture content of soil $(w)$ , %	Dry Density of soil $\gamma_d = \gamma_b / (1 + w)$	Relative Density $I_D$	Sign. and name of Rly Official	Sign and name of contractor	Remarks
9	10	11	12	13	14

**Ref:** IS: 2720 (Pt 28)1974 (latest version)(Determination of dry density ( $\gamma_d$ ) of soils in-place, by the sand Replacement method)

- Note:** 1. **Density Index (Relative Density) shall be find out as per IS 2720 (Part 14) - 1963 – (latest version).**
2. **The density index,  $I_d$  (relative density) expressed as a percentage should be calculated as follows:**

$$\text{Relative density (ID)} = \gamma_{\max} (\gamma_d - \gamma_{\min}) / \gamma_d (\gamma_{\max} - \gamma_{\min}) \times 100$$

 $\gamma_{\max}$  (from lab as per IS 2720 (Part 14) ..... $\gamma_{\min}$  (from lab as per IS 2720 (Part 14) ..... $\gamma_d$  determined in field as shown in above table by the sand Replacement method.

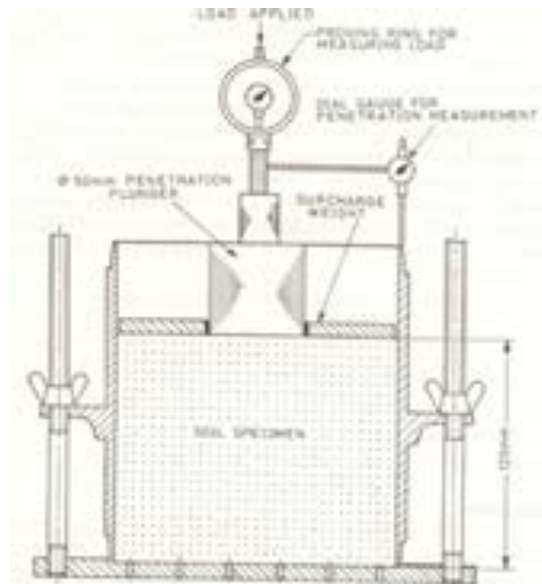
**QUALITY ASSURANCE TESTS (STANDARD TEST PROCEDURES)****1.0 California Bearing Ratio (Laboratory Method)**

**(Ref: IS: 2720 (part 16)–Laboratory Determination of CBR (latest version)**

**1.1 California Bearing Ratio**

California Bearing Ratio (CBR) test is a penetration test developed by the California State Highway Department of USA for the evaluation of subgrade strengths for roads and pavements.

California Bearing Ratio (CBR) is defined as the Ratio of Force per unit Area required to penetrate a soil mass with a circular plunger of 50 mm diameter at the rate of 1.25 mm/minute to that required for corresponding penetration of a standard material. The test results may not be directly related to fundamental properties governing the strength of soils such as cohesion, angle of internal friction etc. Schematic of CBR Test shown below:



**Fig-H 1**

**1.2 Apparatus:**

- i) CBR mould 150 mm diameter and 175 mm high with detachable perforated base plate. (Net capacity is 2250 ml).
- ii) Collar 50 mm high.
- iii) Penetration plunger - 50 mm diameter.
- iv) One annular and a few slotted surcharge masses 2.5 kg each.
- v) Rammer 2.6 kg with 310 mm drop and 4.89 kg with 450 mm drop.
- vi) Steel rod 15-20 mm in dia and 400 mm long.
- vii) Cutting edge.

- viii) Loading machine of approximately 5000 kg capacity, fitted with a calibrated proving ring giving a constant rate of penetration of about 1.25 mm/minute.
- ix) Penetration measuring 2 dial gauges accurate to 0.01 mm.
- x) Soaking tank of pan, drying oven, dishes and calibrated measuring jar.
- xi) Swelling gauge consisting of a perforated plate with an adjustable extension stem.
- xii) I.S. Sieves 4.75 mm and 19 mm.
- xiii) Straight edge, mixing basin.
- xiv) Filter paper
- xv) Weights

### **1.3 Preparation of test specimen:**

The test may be conducted on undisturbed as well as disturbed (remoulded) soil specimen which may be compacted statically or dynamically.

#### **i) Undisturbed soil specimen**

Undisturbed soil specimen shall be obtained from the field in natural condition. For this, use 127.3 mm high mould and attach the steel cutting edge to its one end. Push the mould gently into the ground. When the mould is full of soil, it shall be taken out carefully. The top and bottom surfaces are then trimmed flat so as to achieve the correct length of specimen for testing. The specimen is then sealed with paraffin wax on both sides of the mould so as to preserve it with the natural moisture content.

#### **ii) Remoulded specimen (From disturbed sample) :** (As per para 4.3 of IS 2720- Part-16)

The dry density for a remoulding shall be either the field density or the value of the maximum dry density estimated by the compaction test (IS: 2720 part.7 & part.8) or any other density at which bearing ratio is desired. The water content used for compaction should be at optimum moisture content or the field moisture as the case may be.

Remoulded specimens are prepared in the laboratory by compaction. The material used in the remoulded specimen shall pass 19 mm I.S. sieve. Allowance for large material shall be made by replacing it by an equal amount of material which passes a 19mm I.S.Sieve but is retained on 4.75 mm sieve.

### **1.4 Test Procedure:**

#### **i) Soaking of remoulded specimen:**

Weight the mould with base plate and the specimen. Keep the filter paper on the specimen and place the perforated top plate with adjustable stem over the specimen. Keep the mould in a tank in which water is filled for soaking. Apply weights to produce a surcharge equal to the weight of base material and pavement to the nearest 2.5 kg on the compacted soil specimen. The whole mould and weights shall be immersed in a tank of water allowing free access of water to top and bottom of the specimen. The tripod for the expansion

measuring device shall be mounted on the edge of the mould and the initial dial gauge reading recorded. This set up shall be kept as such undisturbed for 96 hours and noting down the readings every day against the time of reading. A constant water level shall be maintained in the tank throughout the period.

At the end of the soaking period, the final reading of the dial gauge shall be noted, the tripod removed and the mould is taken out of the water tank.

The free water collected in the mould shall be removed and the specimen allowed to draining downward for 15 minutes. After draining out water, the weights, the perforated plate and the top filter paper shall be removed and the mould with the soaked soil sample shall be weighed and the mass recorded.

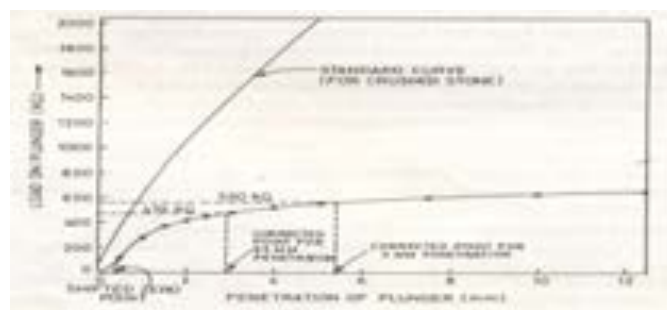
## ii) Penetration Test:

The mould containing the test specimen is placed on the lower plate of the testing machine with the base plate in position and the top surface exposed. Surcharge mass is placed on the specimen. If the specimen has been soaked previously, the surcharge shall be equal to that use during the soaking period. To prevent upheaval of soil into the hole of the surcharge weights, 2.5 kg annular weight shall be placed on the soil surface. The plunger shall be seated under a load of 4 kg so that full contact is established between the surface of the specimen and the plunger. Load shall be applied to the penetration plunger so that the penetration is approximately 1.25 mm per minute. Reading of the load shall be taken at penetrations of 0.0, 0.5, 1.0, 2.0, 2.5, 4.0, 5.0, 7.5, 10.0 and 12.5 mm.

After the completion of the test, the plunger is raised and the mould is detached from the loading equipment. About 20 to 50 g of soil shall be collected from the top 30 mm layer of specimen for water content determination.

## iii) Load Penetration Curve

The load penetration curve is drawn as shown in Fig-H 2. The curve is generally convex upwards, although the initial portion of the curve may be concave upwards due to surface irregularities. A correction shall then be applied by drawing a tangent to the upper curve at the point of contra flexure. The corrected curve shall then be taken to be this tangent plus the convex portion of the original curve with the origin of strains shifted to the point where the tangent cuts the horizontal strain axis as illustrated in Fig-H 2 below:



**Fig-H 2: Load Penetration Curve for a CBR Test**

#### iv) Determination of CBR

Corrected load value shall then be taken from the load penetration curve corresponding to the penetration value at which CBR is desired. The CBR is then determined as follows: -

$$\text{CBR} = P_T / P_s \times 100$$

Where,  $P_T$  = Corrected load corresponding to the chosen penetration from the load penetration curve,

$P_s$  = Standard load for the same depth of penetration as for  $P_s$

The CBR values are usually calculated for penetration of 2.5mm and 5mm. Generally, the CBR value at 2.5 mm penetration will be greater than that at 5mm penetration and in such a case; the former shall be taken as the CBR value for design purpose. If the CBR value corresponding to a penetration of 5mm exceeds that for 2.5mm, the test shall be repeated. If identical results follow, the bearing ratio corresponding to 5mm penetration shall be taken for design.

**Table-H-1 Standard Loads for CBR test**

<b>Penetration Depth (mm)</b>	<b>Unit Standard Load (kg/cm<sup>2</sup>)</b>	<b>Total Standard Load (kg)</b>
2.5	70	1370
5.0	105	2055
7.5	134	2630
10.0	162	3180
12.5	183	3600

Test Observations are recorded in the table as given in the code.

#### 5.0 Report:

The CBR value shall then be reported correct to the first decimal place. The details shall be reported in prescribed proforma: -

CBR of specimen at 2.5 mm penetration -

CBR of specimen at 5 mm penetration -

CBR of specimen at .....Penetration -

Results of repeat test, if conducted:

## 2.0 Field determination of $E_{v2}$

(Ref.: DIN 18134 – April 2012)

### 2.1 Introduction:

Deformation Modulus ( $E_{v2}$ ) is a parameter which gives the deformation characteristics of a finished layer of soil and it is determined from the second cycle of loading in the Plate Load Test. It is to be determined on top of compacted Blanket layer, prepared sub-grade layer and Subgrade layer.

### 2.2 Test Procedure

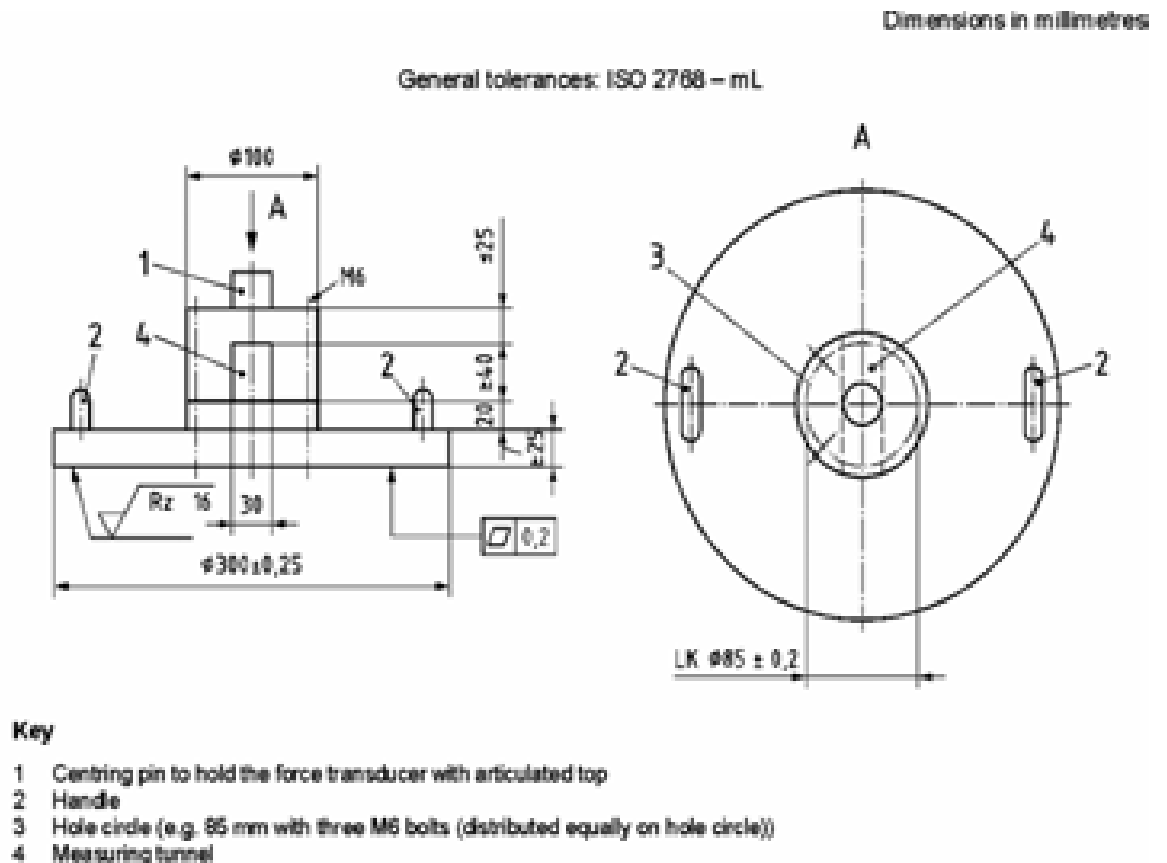
#### a) Apparatus

##### i) Reaction Loading System

The reaction loading system shall produce a reaction load which is at least 10 kN greater than the maximum test load required. It may be a loaded truck or roller or any other object of sufficient mass.

##### Loading plate

The 300mm dia loading plate shall have two handles (Fig-H 3) and minimum thickness of 25 mm.



**Fig-H 3: 300mm Dia Loading Plate**

## ii) Loading system

The loading system consists of a hydraulic jack, capable of applying and releasing the load in stages. The hydraulic jack shall be hinged on both sides and secured against tilting. The pressure piston shall act through at least 150mm.

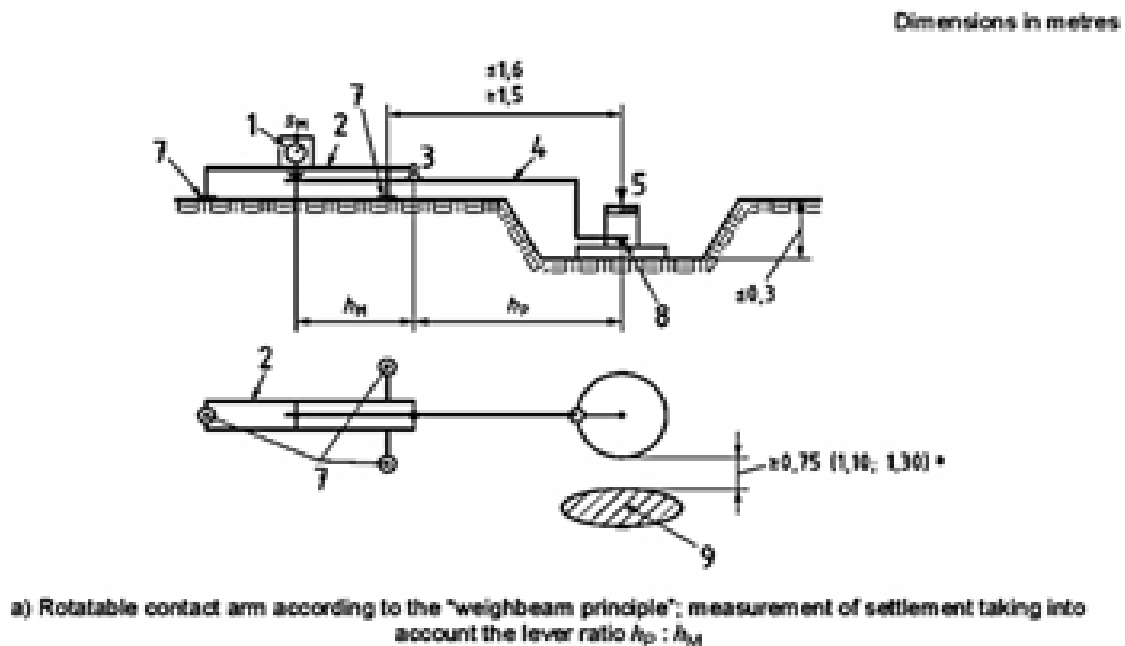
The height of the plate loading apparatus during operation should not exceed 600 mm. In order to compensate for differences in the heights of the vehicles used as reaction loads, elements shall be provided that allow the initial length of the hydraulic jack to be increased to at least 1000 mm. Suitable means shall be provided to prevent buckling of these elements.

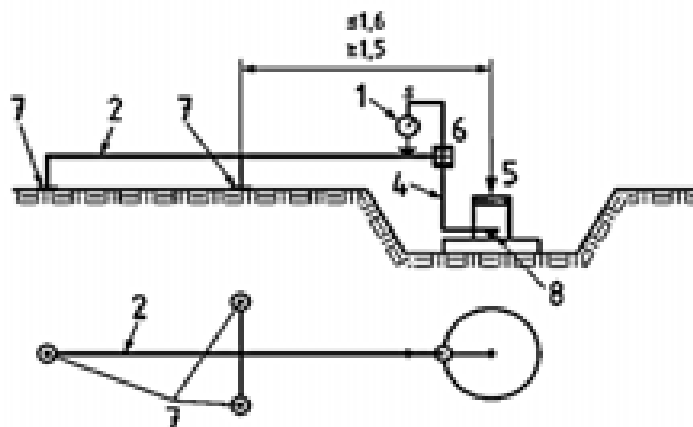
## iii) Force-measuring apparatus

A mechanical or electrical force transducer shall be fitted between the loading plate and the hydraulic jack. It shall measure the load on the plate with a maximum permissible error of 1 % of the maximum test load. The stress shall be indicated at a resolution of at least  $0.001 \text{ MN/m}^2$ .

## iv) Settlement-measuring device

The settlement-measuring device can be with a rotatable contact arm (Fig-H 4) or with a contact arm capable of being moved horizontally in axial direction (i.e. with a slide bearing, see Fig-H 4).





b) Contact arm with slide bearing; measurement of settlement in the lever ratio 1:1

#### Key

1	Dial gauge or displacement transducer	6	Slide bearing
2	Supporting frame	7	Support
3	Fulcrum	8	Stylus
4	Contact arm	9	Area taken up by reaction load system
5	Load		
$s_M, x$ Settlement reading on dial gauge or displacement transducer			

**Fig-H 4: Settlement Measuring Device**

#### The settlement-measuring device consists of:

- (i) A frame supported at three points (see "2" in Fig-H4),
- (ii) A vertically adjustable, torsion-proof, rigid contact arm (see "4" in Fig-H4),
- (iii) A displacement transducer or dial gauge (see "1" in Fig-H 4).

The distance from the center of the loading plate to the Centre line of the support shall be at least 1.5 m and shall not be greater than 1.6 m (see Fig-H 4).

The  $h_p:h_M$  ratio (Fig-H 4 a) shall not exceed 2.0. The setting of the assembly shall be capable of being locked so that the  $h_p/h_M$  ratio does not change during measurement.

The settlement-measuring device shall be capable of measuring the settlement of the loading plate with a maximum permissible error of 0.04 mm in the measuring range up to 10mm. The indication shall have a resolution of at least 0.01 mm.

Measurement of settlement with alternative measuring devices is permitted if these have at least the same resolution and measure to the same accuracy and are recognized as remaining unaffected by soil deformation occurring as a result of testing.

## **2.3 Test conditions**

In the case of soil which has formed a surface crust, has been softened or has been otherwise disturbed in its upper zone, this disturbed soil shall be removed before the plate load test is carried out. The density of the soil under test shall remain as unchanged as possible.

For fine-grained soil (e.g. silt, clay), the plate load test can only be carried out and evaluated satisfactorily if the soil is stiff to firm in consistency. In case of doubt, the consistency of the soil under test shall be determined at various depths up to a depth "d" below ground level (d= diameter of loading plate).

## **2.4 Procedure for Plate Load Test**

### **2.4.1 Test area preparation**

An area sufficiently large to receive the loading plate shall be leveled using suitable tools (e.g. steel straightedge or trowel) or by turning or working the loading plate back and forth. Any loose material shall be removed.

### **2.4.2 Setting up the plate loading apparatus**

The loading plate shall lie on, and be in full contact with, the test surface. If necessary, a thin bed (i.e. only a few millimeters in thickness) of dry medium-grained sand or gypsum plaster paste shall be prepared to obtain a level surface. The plate shall be bedded on this surface by turning and slightly tapping on its upper face. When using gypsum plaster as bedding material, the plate shall be greased on its underside. Any excess plaster shall be removed with the spatula before it sets. Testing shall not begin until the plaster has set.

The hydraulic jack shall be placed onto the middle of, and at right angles to, the loading plate beneath the reaction loading system and secured against tilting. The minimum clearance between loading plate and contact area of the reaction load shall be 0.75 m. The reaction load shall be secured against displacement at right angles to the direction of loading.

### **2.4.3 Arrangement of settlement-measuring device**

In order to measure settlement, the stylus shall be placed in the center of the loading plate. The distance between the support for the supporting frame and the area taken up by the reaction load shall be at least 1.25 m. The dial gauge or transducer shall be set up so as to be vertical.

When placing the loading plate, care shall be taken to ensure that the stylus of the contact arm can be passed without hindrance into the measuring tunnel in the plinth of the loading plate and positioned centrally on the plate.

The settlement-measuring device shall be protected from sunlight and wind. Care shall be taken to ensure that the device and the reaction loading system are not subjected to vibration during the test.

### **2.4.4 Preloading**

Prior to starting the test, the force transducer and dial gauge or displacement transducer shall be set to zero, after which a load shall be applied corresponding to a stress of  $0.01 \text{ MN/m}^2$ . The reading of the gauge or

transducer shall not be reset to zero until at least 30 s after the preload has been applied.

#### 2.4.5 Loading and unloading

To determine the strain modulus,  $E_v$ , the load shall be applied in not less than six stages, in approximately equal increments, until the required maximum stress is reached. Each change in load (from stage to stage) shall be completed within one minute. The load shall be released in 3 stages, to 50%, 25% and approximately 2 % of the maximum load. Following unloading, a further (2<sup>nd</sup>) loading cycle shall be carried out, in which; however, the load is to be increased only to the penultimate stage of the first cycle (so that the full load is not reached).

When increasing and decreasing the load, 60 s after the previous loading stage has been reached shall elapse before beginning the next stage. The load shall be held constant during this period. The reading shall be recorded at the termination of each loading stage (see Table H-2 & H-3).

To determine the strain modulus, a 300 mm loading plate shall be used and load is increased until a settlement of 5 mm or a normal average stress below the plate of  $0.5 \text{ MN/m}^2$  is reached. If the required settlement is reached first, the normal average stress measured at this stage shall be taken as maximum stress.

**Table H-2: Measured values for first loading and unloading cycle**

<b>Loading stage no.</b>	<b>Load <math>F</math> (kN)</b>	<b>Normal Stress <math>\sigma_0</math> (MN/m<sup>2</sup>)</b>	<b>Dial gauge reading <math>S_m</math> (mm)</b>	<b>Settlement of loading plate <math>S</math> (mm)</b>
0	0.71	0.01	0	0
1	5.65	0.080	0.86	1.15
2	11.31	0.160	1.57	2.09
3	17.67	0.250	2.15	2.87
4	23.33	0.330	2.44	3.25
5	29.69	0.420	2.85	3.80
6	35.34	0.500	3.16	4.21
7	17.67	0.250	2.97	3.96
8	8.84	0.125	2.78	3.71
9	0.71	0.01	1.94	2.59

**Table H-3: Measured values for second loading test**

Loading stage no.	Load $F$ (kN)	Normal Stress $\sigma_0$ (MN/m <sup>2</sup> )	Dial gauge reading $S_m$ (mm)	Settlement of loading plate $S$ (mm)
9	0.71	0.01	1.94	2.59
10	5.65	0.080	2.42	3.23
11	11.31	0.160	2.65	3.53
12	17.67	0.250	2.84	3.79
13	23.33	0.330	2.99	3.99
14	29.69	0.420	3.10	4.13

If any local inhomogeneity is encountered (e.g. stones, or soil of varying consistency), this shall be recorded.

If, during the loading cycle, a higher load than intended is inadvertently applied, this load shall be maintained and a note made in the test report.

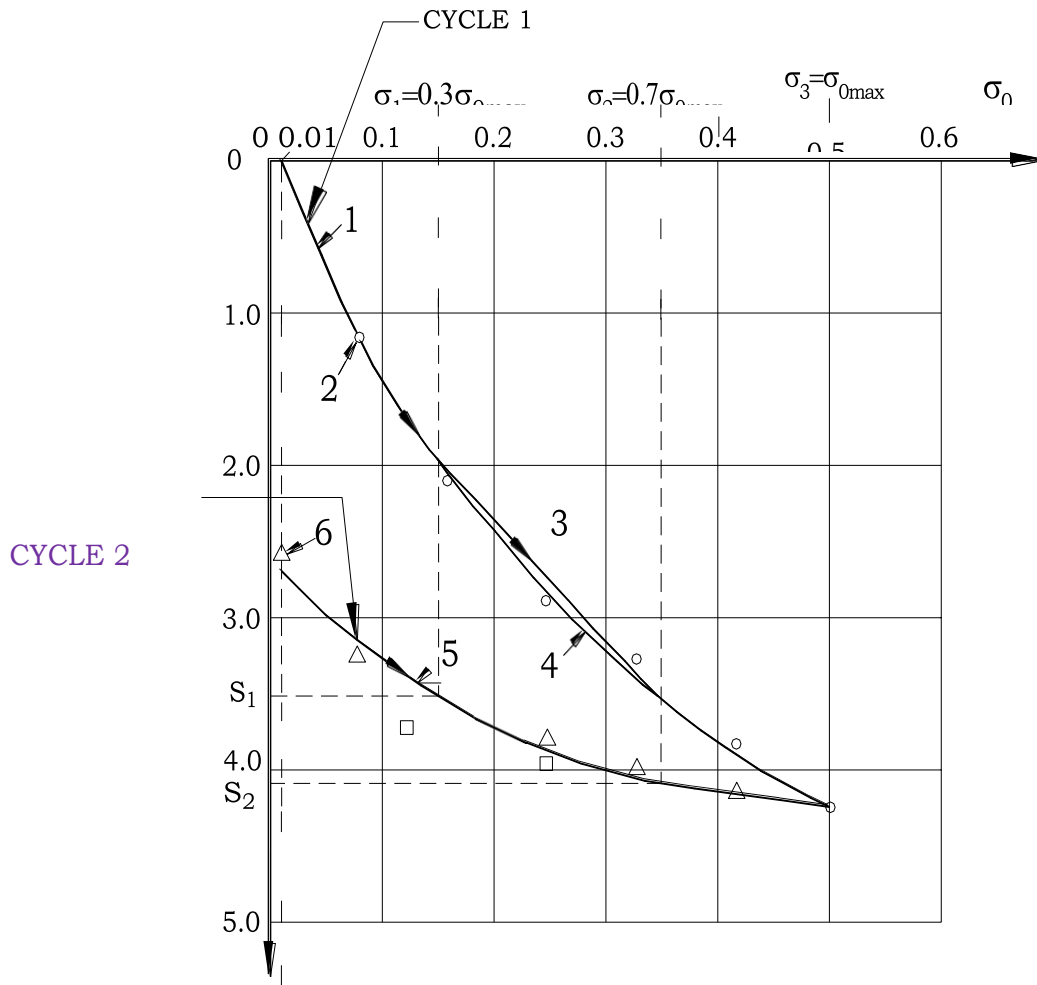
## 2.5 Evaluation and representation of results

### 2.5.1 Load-settlement curve

For each load increment, the average normal stress ( $\sigma_0$ ) and the associated settlement reading (M) shall be recorded on the dial gauge or displacement transducer. For the assembly shown in Fig. 2b, M shall be taken as the settlement (s) of the plate. For the assembly shown in Fig-H 4, s is to be obtained by multiplying the settlement reading ( $S_M$ ) by the lever ratio  $h_P$ :  $h_M$ , in accordance with Equation (1):

$$s = S_M \cdot \frac{h_P}{h_M} \quad (1)$$

A load (mean stress below the plate)-settlement fitting curve shall be drawn for the first loading cycle and second loading cycle as shown in Fig-H 5.



S

#### Key

- Measurement points from the first loading cycle
- Measurement points from the unloading cycle
- △ Measurement points from the second loading cycle
- 1. Line connecting point (0.01  $\text{MN/m}^2$ ; 0 mm) and the first point from the first loading cycle
- 2. First point from the first loading cycle.
- 3. Secant between 0.3  $\sigma_{0\max}$  and 0.7  $\sigma_{0\max}$ .
- 4. Quadratic parabola between the first and the last point from the first loading cycle.
- 5. Quadratic parabola between the first and the last point from the second loading cycle
- 6. First point from the second loading cycle.
- s Settlement in mm
- $\sigma_0$  Normal stress in  $\text{MN/m}^2$

**Fig-H 5: Load (Stress)-Settlement curve**

### 2.5.2 Calculation of strain modulus, $E_v$

Calculation of the strain modulus ( $E_v$ ) from the first and of the second loading cycle shall be based on load-settlement curves, by using following equation:

$$E_v = 1.5 * r * \frac{(\Delta\sigma)}{(\Delta s)}$$

Where:  $E_v$  is the strain modulus, in  $\text{MN/m}^2$ ;

$r$  is the radius of loading plate, in mm;

$\Delta\sigma$  is the change in stress between  $0.7\sigma_{\text{max}}$  and  $0.3\sigma_{\text{max}}$ ; and

$\Delta s$  is the change in settlement corresponding to stress values of  $0.7\sigma_{\text{max}}$  and  $0.3\sigma_{\text{max}}$ , from the load settlement curve, in mm.

The subscript 1 shall be used after  $E_v$  to denote the first loading cycle, and the subscript 2 to denote the second loading cycle.  $\sigma_{0\text{max}}$  from the first loading cycle shall also be used to determine the parameters of the second loading cycle also.

## 2.6 Examples for determination of $E_v$

A typical load (stress) – settlement curve is plotted in Fig-H 5 and using this curve, values of  $E_v$  are calculated as under:

(i) For First loading cycle:

$$\begin{aligned} E_{v1} &= 1.5 * 150 * (0.7\sigma_{0\text{max}} - 0.3\sigma_{0\text{max}}) / (S \text{ at } 0.7\sigma_{0\text{max}} - S \text{ at } 0.3\sigma_{0\text{max}}) \\ &= 1.5 * 150 * (0.4 * 0.500) / (3.5 - 1.95) \\ &= 29.03 \text{ MN/m}^2 \end{aligned}$$

(ii) For Second loading cycle:

$$\begin{aligned} E_{v2} &= 1.5 * 150 * (0.7\sigma_{0\text{max}} - 0.3\sigma_{0\text{max}}) / (S \text{ at } 0.7\sigma_{0\text{max}} - S \text{ at } 0.3\sigma_{0\text{max}}) \\ &= 1.5 * 150 * (0.4 * 0.500) / (4.08 - 3.50) \\ &= 77.58 \text{ MN/m}^2 \end{aligned}$$



**Fig-H 6:  $E_{v2}$  Measuring Equipment**

### 3.0 Measuring in-situ Density and Water Content by Nuclear Moisture Density Gauge

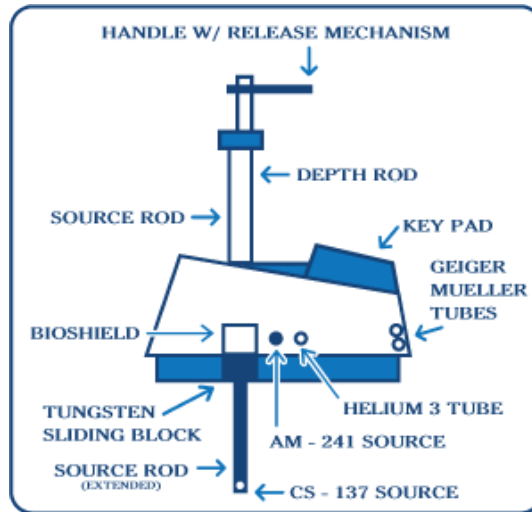
#### 1.0 Apparatus:

##### 1.1 Nuclear Density/Moisture Gauge:

While exact details of construction of the apparatus may vary, the system shall consist of:



**Fig.H-7 : Nuclear Gauge**



**Fig.H-8 : Parts of a Nuclear Gauge**

- (a) Gamma Source: A sealed source of high-energy gamma radiation, such as cesium or radium.
- (b) Gamma Detector: Any type of gamma detector such as a Geiger-Mueller tube(s).
- (c) Fast Neutron Source: A sealed mixture of a radioactive material such as americium, radium and a target material such as beryllium, or a neutron emitter such as californium-252.
- (d) Slow Neutron Detector: Any type of slow neutron detector such as boron trifluoride or helium-3 proportional counters.

**1.2 Reference Standard:** A block of material used for checking instrument operation, correction of source decay, and to establish conditions for a reproducible reference count rate.

**1.3 Site Preparation Device:** A plate or straight edge or other suitable leveling tool used for levelling the test site to the required smoothness, and in the Direct Transmission Method, guiding the drive pin to prepare a perpendicular hole.

- 1.4 Drive Pin:** A pin of slightly larger diameter than the probe, used to prepare a hole in the test site for inserting the probe:



- (a) Drive Pin Guide: A fixture that keeps the drive pin perpendicular to the test site. Generally part of the site preparation device.
- (b) Drive Pin Extractor: A tool that is used to remove the drive pin in a vertical direction so that the pin will not distort the hole in the extraction process.
- 1.5 Hammer:** Heavy enough to drive the pin to the required depth without undue distortion of the hole.

## **2.0 General**

- 2.1** This procedure covers determination of in-situ density and water content of soil by means of a Nuclear Gauge designed to operate on the ground surface. Most of the gauges normally have combined facilities for determination of density and moisture content both.
- 2.2** The quality of the result produced is dependent on the competence of the personnel using the gauge and the suitability of the equipment and facilities used.
- 2.3** Two alternative modes are provided in the gauges:
- a) Direct Transmission Mode in which the gamma source rod extends through the base of the gauge in to a pre-formed hole to a desired depth. This is preferred mode for Density Measurement and should be used where possible because of its deeper zone of influence.
  - b) Backscatter Mode in which the gamma and neutron source and the detectors are kept at the surface. Moisture Density can be determined only by using the backscatter mode.
- 2.4** The presence of moisture inside the gauge cavity will cause malfunctioning of the gauge. Hence, they should be stored in a warm and dry place and not used in the rain.
- 2.5** Gravel particles or large voids in the source-detector path may cause higher or lower density measurements. Where lack of uniformity in the soil due to layering, aggregate or voids is suspected, the test site should be excavated and visually

examined to determine whether the test material is representative of the in-situ material in general and whether an oversize correction is required, in accordance with practice ASTM D4718.

### **3.0 Calibration of the Gauge**

**3.1** Calibration of the gauge should be done by an Accredited Agency or by the Manufacturer of the gauge, in accordance with procedure given in Annex A1 and Annex A2 of ASTM: D-6938.

**3.2** Gauges shall be calibrated initially and after any repairs that can affect the gauge geometry or the existing calibration. To be within specified tolerances, calibration curves, tables, or equivalent coefficients shall be verified, at periods not to exceed 12 months. If the tolerances cannot be met at any time, the gauge shall be calibrated to establish new calibration curves, tables, or equivalent coefficients. If the owner does not establish a verification procedure, the gauge shall be calibrated at a period not to exceed 12 months.

**3.3** Record of calibration shall be maintained, in conformity with procedure given in Annexure- A1 and Annexure- A2 of ASTM: D-6938 and before use of any gauge it should be ensured that the gauge is having valid calibration certificate issued in conformity with stipulated standard.

### **4.0 Standardization of the Gauge**

**4.1** Nuclear moisture density gauges are subject to long-term aging of the radioactive sources, which may change the relationship between count rates and the material density and water content. To correct for this aging effect, Standardization of the **gauge shall be performed at the start of each day's work and a record of this data** should be retained. This procedure shall also be repeated after 8 Hours of continuous use.

**4.2** Standardization should be done with the gauge located at least 9 m away from other nuclear moisture density gauges and clear of large masses of water or other items which can affect the reference count rates.

#### **4.3 Standardization Process**

- (a) Turn on the gauge and **allow for stabilization according to the manufacturer's** recommendations.
- (b) Using the reference standard block, whose serial number matches with the serial number on the gauge, take a reading that is at least four times the duration of a normal measurement period (typically one minute). Use the procedure recommended by the gauge manufacturer to establish the compliance of the standard measurement to the accepted range. Without specific recommendations from the gauge manufacturer, use the procedure given in Para (c) below.

- (c) If the values of the current standardization counts are outside the limits set by Eq.1 and Eq.2, repeat the standardization check. If the second standardization check satisfies Eq. 1 and Eq.2, the gauge is considered satisfactory operating condition.

$$0.99(N_{dc})e^{\frac{-(\ln(2)t}{T_d(1/2)}} \leq N_{d0} \leq 1.01(N_{dc})e^{\frac{-(\ln(2)t}{T_d(1/2)}} \quad (1)$$

and

$$0.98(N_{mc})e^{\frac{-(\ln(2)t}{T_m(1/2)}} \leq N_{m0} \leq 1.02(N_{mc})e^{\frac{-(\ln(2)t}{T_m(1/2)}} \quad (2)$$

Where:

$T_d (1/2)$  = the half-life of the isotope that is used for the density determination in the gauge.

$T_m (1/2)$  = the half-life of the isotope that is used for the water content determination in the gauge.

$N_{dc}$  = the density system standardization count acquired at the time of the last calibration or verification.

$N_{mc}$  = the moisture system standardization count acquired at the time of the last calibration or verification,

$N_{d0}$  = the current density system standardization count,

$N_{m0}$  = the current moisture system standardization count,

$t$  = the time that has elapsed between the current standardization test and the date of the last calibration or verification.

$\ln (2)$  = the natural logarithm of 2, which has a value of approximately 0.69315,

$e$  = the inverse of the natural logarithm function, which has a value of approximately 2.71828.

- 4.4** If for any reason, the measured density or moisture becomes suspect during the day's use, another standardization check should be performed.

## **5.0 Procedure for measurement**

- 5.1** Select a test location where the gauge will be placed at least 600 mm away from any object sitting on or projecting above the surface of the test location. If measurement is to be made at a specific location and the aforementioned clearance cannot be achieved, such as in a trench, follow the gauge manufacturer's correction procedure(s). Keep all other radioactive sources at least 9 m away from the gauge to avoid any effect on the measurement.

- 5.2** Prepare the test site in the following manner:

- (a) Remove all loose and disturbed material and additional material as necessary to expose the true surface of the material to be tested.
- (b) Prepare an area to accommodate the gauge by grading or scraping the area to a smooth condition so as to obtain maximum contact between the gauge and material being tested.
- (c) The depth of the maximum void beneath the gauge shall not exceed 3 mm. Use native fines or fine sand to fill the voids and smooth the surface with a rigid straight edge or other suitable tool. The depth of the filler should not exceed approximately 3 mm.
- (d) The placement of the gauge on the surface of the material to be tested is critical to accurate density measurements. The optimum condition is total contact between the bottom surface of the gauge and the surface of the material being tested. The total area filled should not exceed approximately 10% of the bottom area of the gauge.

**5.3** Turn on and allow the gauge to stabilize (warmup) according to the manufacturer's recommendations.

#### **5.4** Direct Transmission Mode

- a) Make a hole perpendicular to the prepared surface using the rod guide and drive pin. The hole should be a minimum of 50mm deeper than the desired measurement depth and of an alignment that insertion of the probe will not cause the gauge to tilt from the plane of the prepared area. Care must be taken in the preparation of the access hole in uniform cohesionless granular soils. Measurements can be affected by damage to the density of surrounding materials when forming the hole.
- b) Remove the hole-forming device carefully to prevent the distortion of the hole, damage to the surface or loose material to fall in to the hole.
- c) Place the gauge on the material to be tested. Lower the probe in to the hole to desired test depth. As safety measure, it is recommended that the probe not be extended out of its shielded position prior to placing it in to the test site.
- d) Secure and record one or more sets(s) of one-minute bulk density and water content readings. Read the in-situ bulk density and water content directly.
- e) Retract the probe into the housing and check that the radioactive source is safely housed.

#### **5.5** Backscatter Mode:

- a) Seat the gauge firmly. Set the gauge in to the Backscatter position.
- b) Secure and record one or more set(s) of one-minute density and water content readings.
- c) Read the in-situ bulk density and water content.

## 5.6 Water Content Correction and Oversize Particle Correction:

- a) For getting accurate values of water content and bulk density, both of these corrections need to be made when applicable.
- b) Prior to using the gauge-derived water content on any new material, the value should be verified. As part of a user developed procedure, occasional samples should be taken from beneath the gauge and comparison testing done to confirm gauge-derived water content values. All gauge manufacturers have a procedure for correcting the gauge-derived water content values.
- c) When oversize particles are present, the gauge can be rotated about the axis of the probe to obtain additional readings as a check. When there is any uncertainty as to the presence of these particles it is advisable to sample the material beneath the gauge to verify the presence and the relative proportion of the oversize particles.
- d) When sampling for water content correction or oversize particle correction, the sample should be taken from a zone directly under the gauge. The size of the zone is approximately 200 mm in diameter and a depth equal to the depth setting of the probe when using the direct transmission mode; or approximately 75 mm in depth when using the backscatter mode.

## 6.0 Calculation and expression of Results

In most of the gauges, the Bulk Density, Water Content and Dry Density are calculated and displayed directly. Otherwise, calculate the Dry Density ( $\rho_d$ ) as under:

$$\rho_d = (100 \times \rho) / (100 + w)$$

where:

$\rho$  = Bulk Density of the soil determined by Nuclear Gauge

$w$  = Moisture Content of the soil (in %)

If the Nuclear Gauge determines the Water Content of the soil per unit volume of the soil, then the Dry Density is calculated as under:

$$\rho_d = \rho - W$$

Where,

$\rho$  = wet density

$W$  = Moisture Density i.e. water mass per unit volume of soil

The Moisture Content (in %) “ $W$ ” can be calculated as:  $w = (W \times 100) / (\rho - W)$

## 7.0 Reporting of Results

The Field Data Records shall include, as a minimum, the following:

- (i) Make, model and serial number of the Nuclear Gauge.
- (ii) Validity date of Gauge calibration.
- (iii) Data for Standardization of the gauge.
- (iv) Data/details about daily Verification of gauge Results (see Para 8.0)
- (v) Location of test (e.g. Chainage and Lift/Layer No.).
- (vi) Visual description of material tested.
- (vii) Name of the operator(s).

- (viii) Test mode (i.e. Direct transmission or Backscatter) and depth of test.
- (ix) Any corrections made in the reported values and reasons for these corrections (i.e. over-sized particles, water content).
- (x) Maximum Laboratory Density value.
- (xi) Bulk Density measured.
- (xii) Water Content in percent.
- (xiii) Dry Density Calculated/measured.
- (xiv) Degree of Compaction/Percent Compaction.

## **8.0 Daily Verification of Gauge Results**

- 8.1** At the start of each day's work, the Degree of Compaction (% compaction) should be measured at minimum 3 locations by the Nuclear Gauge and compared with the results given by the conventional methods like Sand Replacement Method or Core Cutter Method at the same locations.
- 8.2** If the difference in Degree of Compaction (%) at any of the location is more than 6%, the reason for the difference should be examined in detail.
- 8.3** If the difference in average Degree of compaction (%) of all the locations, ignoring its' sign, is more than 4%, the standardization of the gauge shall be repeated.
- 8.4** After standardization, the procedure given in Para 8.1 to 8.3 shall be repeated again. If the difference in average Degree of compaction (%) of all the locations, ignoring its' sign, is still more than 4%, the nuclear gauge shall be re-calibrated, to bring the difference in average Degree of compaction (%) of all the locations within 4%.

## **9.0 Safety Precautions**

- 9.1 These gauges utilize radioactive materials that may be hazardous to the health of the users unless proper precautions are taken. Users of these gauges must become familiar with applicable safety procedures and government regulations.
- 9.2 Effective user instructions, together with routine safety procedures and knowledge of and compliance with Regulatory Requirements, are a mandatory part of the operation and storage of these gauges.
- 9.3 This procedure does not purport to address all of the safety concerns, if any, associated with its use. The user of this standard should establish appropriate safety and health practices and ensure compliance to all regulatory limitations.

#### **4.0 COMPACTION TEST (Laboratory Method)** **[As per IS: 2720 (Part 8)-1983]**

Compaction is the process of densification of soil by reducing air voids. The degree of compaction of a given soil is measured in terms of its dry density. The dry density is maximum at the optimum water content. A curve is drawn between the water content and dry density to obtain the maximum dry density and optimum water content. Dry density =  $M / V (1+w)$

Where,

M = total mass of soil

V = volume of soil

w = water content

#### **APPARATUS**

1. Cylindrical metal compaction mould  
Capacity: 1000 cc with dia 100 mm + 0.1,  
2250 cc with dia 150 mm + 0.1  
Internal diameter: 100 mm + 0.1, 150 mm + 0.1  
Internal effective height of mould: 127.3 + 0.1 mm  
Collar: 60 mm high  
Detachable base plate
2. Rammer Mass: For Heavy compaction = 4.9 kg, Dia: 50 mm
3. IS sieve: 19 mm & 4.75 mm
4. Oven: Thermostatically controlled to maintain a temperature of 105 ° to 110 ° C
5. Weighing Balance: sensitivity - 1 g for capacity 10 kg,  
0.01g for capacity 200 g
6. Steel straight edge of about 300 mm in length with one edge levelled.
7. Gradation jar
8. Large mixing pan
9. Spatula

#### **Preparation of Sample**

1. Break the clods of soil sample as received from the field and remove the organic matter like tree roots, pieces of bark etc. from the sample.
2. Dry the sample in the air. In wet weather, use drying oven but the temperature of the sample should not exceed 60 ° C.
3. Take a representative portion of air-dried soil material and large enough to provide about 6 kg of material passing a 19-mm IS sieve (for soils not susceptible to crushing during compaction, or about 15 kg of material passing a 19-mm IS sieve (for soils susceptible to crushing during compaction))
4. Sieve above material through 19 mm & 4.75 mm IS sieve.
5. Sieve above material through 19-mm IS sieve and if soil retained on this sieve is more than 5%, use mould of 2250 cm<sup>3</sup> and reject soil retained on 19-mm sieve after its proportion of the total sample has been recorded.
6. If percentage retained on 4.75 mm IS sieve is greater than 20, then use mould of 2250 cm<sup>3</sup> otherwise use small mould of 1000 cm<sup>3</sup>.
7. Determine the ratio of fraction retained and that passing 4.75 mm IS sieve to to access the density of the soil.

8. Mix the soil sample retained on 4.75 mm sieve and that passing 4.75 mm sieve for further testing.
9. The amount of water to be mixed with air-dried soil at the commencement of the test will vary with the type of soil under test.
  - (a) Sandy and gravely soil: a moisture content of 3 to 5 % would be suitable.
  - (b) Cohesive soil: Moisture content about 12 to 16% below the plastic limit of the soil should be suitable.
10. With clay of high plasticity or where hand mixing is employed, it may be difficult to distribute the water uniformly through the air dried soil by mixing alone, and it may be necessary to store the mixed sample in a sealed container for a minimum period of about 16 hours before continuing with the test.

## **PROCEDURE**

1. Clean and dry the mould and base plate and apply a thin layer of grease on the inside the mould.
2. Weigh the mould to the nearest 1 gram. Attach the collar to the mould and place on a solid base.
3. Compact the moist soil in to the mould in five layers of approximately equal mass, each layer being given 25 blows from 4.9 kg rammer dropped from a height of 450 mm above the soil. The blows should be distributed uniformly over the surface of each layer.
4. Remove the collar and trim off the excess soil projecting above the mould by using straight edge. Take the weight of mould with compacted soil in it.
5. Remove 100 g of compacted soil specimen for the water content determination.
6. Add water in increment of 1 to 2 % for sandy and gravely soils and 2 to 4 % for cohesive soils
7. Above procedure will be repeated for each increment of water added. The total number of determinations shall be at least four and moisture content should be such that the OMC at which MDD occurs, is within that range.

## **PRECAUTIONS**

1. Ramming should be done continuously taking care of height of 450 mm free fall accurately.
2. The amount of soil taken for compaction should be in such a way that after compacting the last layer, the soil surface is not more than 5 mm above the top rim of the mould.
3. Weighing should be done accurately.

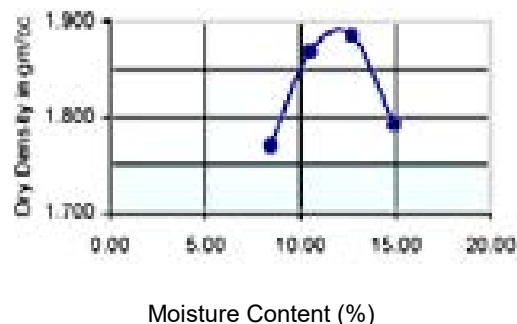


Fig-H 10: Curve for Dry Density v/s Moisture Content

## 5.0 LOS ANGELES ABRASION TEST FOR BLANKET MATERIAL (Based on IS: 2386-Part-4)

**Purpose:** - To determine the Los Angeles abrasion value of Blanket Material.

**Apparatus:** - Los-Angeles Machine, Drying Oven, IS sieves of size 10 mm, 6.3 mm, 4.75 mm, 2.36 mm and 1.70 mm.

**Preparation of Test sample:** -

- The sample shall be dried in oven at 105-110°C to a constant weight.
- The sample shall be sieved through 4.75 mm IS sieve and grading of test sample shall be decided based on percentage passing through it.

Sample passing 4.75 mm IS sieve	Grading to be adopted for preparation of test sample
Less than 50%	C
Equal to or more than 50%	D

- The sample shall be prepared for the grading 'C' or 'D' [as decided in (ii) above]

Grading	IS Sieve Size		Weight of Sample taken for testing (g)	
	Passing	Retained on		
C	10 mm	6.3 mm	2500	Weight 'A'
	6.3 mm	4.75 mm	2500	
D	4.75 mm	2.36 mm	5000	Weight 'A'

- The abrasive charge shall consist of cast iron or steel spheres approx. 48mm diameter and each weighing between 390 and 445g.  
The abrasive charge, depending upon the grading of the test sample as follows:

Grading	Number of Spheres	Weight of Abrasive Charges (g)
C	8	3330±20
D	6	2500±15

**Testing Procedure:** -

- The test sample and the abrasive charge shall be placed in the Los Angeles Abrasion Machine and the machine rotated at a speed of 20 to 33 revolution / minute. For grading C & D, the machine shall be rotated for 500 revolutions.
- At the completion of test, the material shall be discharged and sieved through 1.70 mm IS Sieve.
- The material coarser than 1.70 mm IS Sieve shall be washed, dried in oven at 105-110°C to a constant weight and weighed (Weight 'B').

**Calculation:** -

- The proportion of loss between Weight 'A' and 'B' of the test sample shall be expressed as a percentage of the original weight of the test sample.
- This value shall be reported as:  
Aggregate Abrasion Value (%) =  $(A-B) \times 100/A$   
A= Original weight of the Sample  
B= Final weight of the Sample

**Precautions:** -

- Avoid loss of any part of sample.
- Ensure revolutions according to grading.
- Separate material on completion of test, on appropriate sieve coarser than 1.70mm.

## **Fitment of Existing Railway Formation**

### **1.0 Introduction**

The methodology to assess the fitment of existing formation & requirement for 22.9T/25T axle load operation at 100 kmph & passenger train operations at 160 kmph, is covered in this Appendix.

### **2.0 Methodology:**

The adopted methodology involves determination of induced stress at top of subgrade due to design axle load including dynamic augment for different speeds and makes an arrangement by providing a suitable thickness of blanket layer so that the induced stress at top of subgrade should not exceed the threshold stress of the subgrade soil.

#### **2.1 Assumptions:**

- i) The induced stress on top of subgrade is calculated by Empirical formula on the basis of various assumptions. References have been taken from IIT/Kanpur Research report no. 1/93, April-1993, **"Modern Railway Track"** book by C. Esveld. However, the actual stresses may vary, which are measured by instrumentation in the field.
- ii) Dynamic Augment (for live load) to be considered for different speed has been **calculated assuming an average condition of Track i.e. 'Good' condition.**
- iii) The permissible stress on the formation has also been calculated using empirical **formula. References have been taken from "Modern Railway Track" book by C. Esveld, ORE Report No. D-117, RP-28 and ORE Report No. D-71, RP-12.**
- iv)  $E_{v2}$  value wherever used for calculations, corresponds to the lower limits of different soil quality class and approximate correlation to the different CBR values from ORE report D 117 RP 28 has been used.
- v) The CBR of the subgrade soil which is considered in calculation is assumed as minimum CBR value for soil available in top 1.5 - 2.0 m depth of the formation, below the bottom of the ballast.
- vi) The thickness of ballast (ballast cushion) used in calculations is total clean ballast cushion of 350 mm.
- vii) As per IPWE technical diary 2019-20, passenger locomotive WAP5 has maximum speed of 160 kmph and its axle load is 19.5 T. This is considered for calculation for assessment of requirement for Passenger train operations at 160Kmph.
- viii) It is assumed that 30% reduction in blanket thickness requirement can be achieved with application of two layers of geo-grid.
- ix) In fitment calculations, it is presumed that there are no persisting problems in sub-soil/subgrade like ground settlement, slope failure etc. in existing formation.

- x) In case of stretches where weak/unstable formation exists - Formation rehabilitation measures should be adopted first in pursuance to Para 291 to 295 of IRPWM, before implementation of the recommendations mentioned in Para 4.0.
- xi) Other considerations like cess width, slope of embankment etc. for railway formation as per extant policies shall also have to be ensured.

## 2.2 Calculation of blanket layer thickness:

On the basis of methodology described above & various assumptions, requirement of blanket layer thickness for 22.9T/25 T (Heavy Axle Load) operation upto 100 Kmph and Passenger Train operations upto 160 Kmph has been calculated for different speed and CBR values of soil & are presented below:

### 2.2.1 22.9 T Axle load:

**Table-I 1**

Speed → (kmph) CBR ↓	Thickness of Blanket Layer (mm) Assuming Ballast cushion - 350 mm			
	40	60	75	100
<b>2</b>	550	550	550	600
<b>3</b>	450	450	450	500
<b>4</b>	300	300	300	350
<b>5</b>	150	150	150	200
<b>6</b>	50	50	100	100
<b>7</b>	0	0	0	50

### 2.2.2 25 T Axle Load:

**Table-I 2**

Speed → (kmph) CBR ↓	Thickness of Blanket Layer (mm) Assuming Ballast cushion - 350 mm			
	40	60	75	100
<b>2</b>	600	600	650	650
<b>3</b>	500	500	550	550
<b>4</b>	350	350	400	400
<b>5</b>	200	200	250	250
<b>6</b>	150	150	150	200
<b>7</b>	50	50	100	100

### 2.2.3 Passenger Trains (for 17T Axle Load/Train 18):

**Table-I 3**

Speed → (kmph) CBR ↓	Thickness of Blanket Layer (mm) Assuming Ballast cushion - 350 mm			
	100	130	140	160
2	300	300	300	350
3	200	250	250	250
4	50	100	100	100

### 2.2.4 Passenger Trains (for 19.5 T Axle Load/WAP-5 loco.):

**Table-I 4**

Speed → (kmph) CBR ↓	Thickness of Blanket Layer (mm) Assuming Ballast cushion - 350 mm					
	60	75	100	130	140	160
2	400	400	450	450	450	500
3	300	300	350	350	350	400
4	150	150	200	200	200	250
5	0	0	50	50	100	100

## 3.0 Determination of CBR of Subgrade Soil (Sampling & Testing):

- i) The soil samples should be collected @ of 4 to 5 locations in a block section. The testing shall be done on a few samples based on the visual examination.
- ii) Take out the three soil samples from a location at the depth of 50-100 cm (50 cm depth where embankment height is 1-2 m, assuming ballast penetration if any is less than 30cm) according to sketch-I. (i).
  - a) One sample below ballast in the line of rail seat between two sleepers.
  - b) One sample on each side of the Cess near the toe of ballast.
  - c) Soil samples should not contain pulverised ballast, grass roots etc.
- iii) Determine CBR value of soil samples in the Geo-tech lab/soil testing laboratory.
- iv) Take the average value of all three CBR values of a location.
- v) Based on the determined average value of the CBR of subgrade soil, provision of blanket layer (if required) shall be made, as per the recommendations given in Para 4.0.

#### 4.0 Recommendations for Fitment of Existing Formation:

For operations of 22.9T / 25T axle load at 100 Km/h and Passenger Train (for 19.5T axle load) at 160 Km/h, in existing Railway Formation, the recommendations are as given below (assuming 350 mm ballast cushion and 60 kg Rail Section): -

##### 4.1 Recommendations for 22.9T/25T axle load operation at 100 Km/h:

CBR of Subgrade soil	Recommendation	Remarks
<b>&lt;2</b>	A minimum <b>1000 mm</b> thick blanket layer should be provided.  Alternatively, thickness of blanket layer can be reduced to 700 mm by provisions of two layers of geogrid one at bottom and another in middle of blanket layer (sketch-I.(ii)).	However, as CBR is low, detailed geotechnical investigation shall also be conducted & if necessary suitable additional measures required as per site conditions/soil investigation should be taken for fitment of existing formation.
<b>≥2 and &lt;4</b>	A <b>650 mm</b> thick blanket layer should be provided along with a 350 mm thick layer of better quality soil i.e. soil having CBR ≥ 4.  Alternatively, thickness of blanket layer can be reduced to 450 mm by provisions of two layers of geogrid one at bottom and another in middle of blanket layer (sketch-I.(ii)).	
<b>≥4 and &lt;5</b>	A <b>400 mm</b> thick blanket layer should be provided.	
<b>≥5 and &lt;8</b>	A <b>300 mm</b> thick blanket layer should be provided.	
<b>≥8</b>	No blanket layer is required.	

##### 4.2 Recommendations for Passenger train operations (assuming 19.5 T Axle Load for passenger train/ WAP-5 loco) at 160 Km/h :

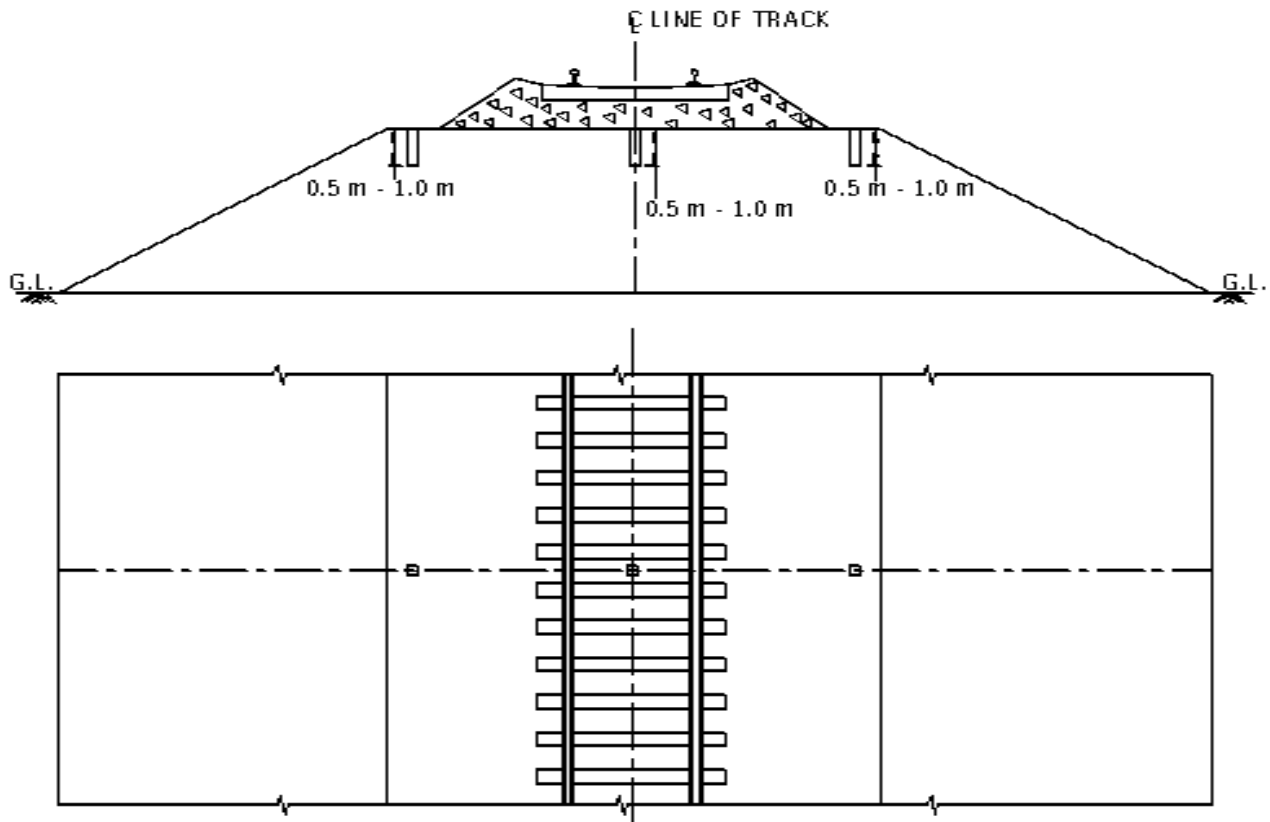
CBR of Subgrade soil	Recommendation	Remarks
<b>&lt;2</b>	A minimum <b>1000 mm</b> thick blanket layer should be provided.  Alternatively, thickness of blanket layer can be reduced to 700 mm by provisions of two layers of geogrid	However, as CBR is low, detailed geotechnical investigation shall also be conducted & if necessary suitable additional measures required as per

	one at bottom and another in middle of blanket layer (sketch-I.(ii)).	site conditions/soil investigation should be taken for fitment of existing formation.
<b><math>\geq 2</math> and <math>&lt;4</math></b>	A <b>600 mm</b> thick blanket layer should be provided along with a 350 mm thick layer of better quality soil i.e. <b>soil having CBR <math>\geq 4</math></b> .  Alternatively, thickness of blanket layer can be reduced to 400 mm by provisions of two layers of geogrid one at bottom and another in middle of blanket layer (sketch-I.(ii)).	
<b><math>\geq 4</math> to <math>&lt;6</math></b>	A <b>300 mm</b> thick blanket layer should be provided.	
<b><math>\geq 6</math></b>	No blanket layer is required.	

- 4.3** Wherever the blanket layer is to be provided; a suitable non-woven geo-textile layer should be provided below the blanket layer as a separator layer to prevent upward migration of fines from subgrade to blanket layer and penetration of coarse particles of blanket into subgrade.
- 4.4** The above recommendations are on the basis of 350 mm clean ballast cushion. Wherever it is less, full clean ballast cushion of 350 mm shall be ensured in the section, even where no blanket layer requirement is recommended based on CBR of subgrade.
- 4.5** Geo-grid and Geo-textile to be used as per RDSO specification no. RDSO/2018/GE: IRS-0004 Pt.-III (Feb 2020) and RDSO/2018/GE: IRS-0004 Pt-I (March 2019) respectively mentioned in **Appendix - C**.
- 4.6** The above recommendations cover formation related aspects only.
- 4.7** The formation stretches where the above recommendations are implemented, should be monitored for a period of two year and feedback/suggestions are to be given to RDSO. Based on the feedback of Railways, the above guidelines will be reviewed and improvement suggested (if any) will be incorporated for finalisation accordingly.
- 4.8** After implementation of above-mentioned recommendations, if any problem arises in the formation the same shall be referred to RDSO. Even otherwise also, subgrade soils with higher CBR values where no blanket requirement has been stated as per para 4.1 & 4.2 above, if any problem is reported in the formation after heavy axle load operation and passenger train at 160 kmph same shall also be reported.

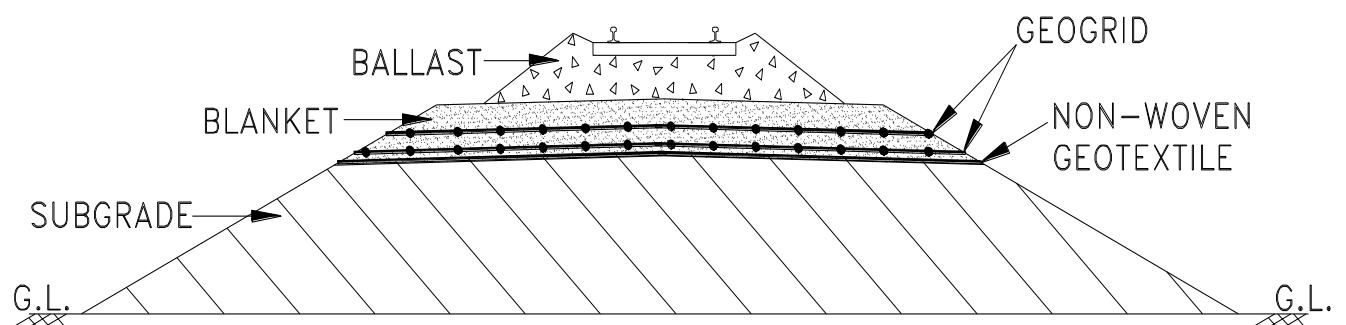
**Sketch- I - (i)**

**LOCATION OF SOIL SAMPLE TO BE COLLECTED**



**Sketch- I-(ii)**

**Illustrative diagram for Geo-grid and Geo-textile Application**



**PROFORMA FOR REPORTING UNSTABLE FORMATION**

**1. General Details:**

Affected Km.      From:..... To:.....  
 Station between .....  
 Section.....  
 Division.....  
 Railway.....

Officer		Name	HQ	Telephone Nos.
1.	CE Construction or concerned CE (Open line)			
2.	CTE			
3.	Sr.DEN (CO)			
4.	Dy. CE or concerned Sr.DEN/DEN			
5.	ADEN/AXEN			
6.	PWI/IOW In-charge			

**Reference:** By:.....Letter No..... Dated:.....

**2. Sectional Details:**

Gauge	No. of lines	Max. Permissible Speed	Axle Load	GMT per year	Construction Year	Open to traffic/Year

**3. Track Particulars:**

Km.	Strength/Curved	Degree	Cant (in mm)	Gradient

**4. Track Structure :**

Km	Rail			Sleeper			Ballast Cushion mm	
	Section	Year laid	Single/SWR/LWR	Type	Density	Year laid	Clean	Caked

**5. Condition of rails**

Type			Percentage
Roaring	Scabbed	Wheel Burnt	

**6. Condition of sleepers/fastenings (Tick ✓ any one)**

Good	Fair	Bad
------	------	-----

**7. Specific deficiencies of track structure:****8. Last deep screening done on:**

Month	Year

**9. Track Quality Index Values of Previous Three Years:**

Date of TRC Run	Track Quality Index (TOI)/Composite Track Quality index	Date of OMS Run	Oscillation monitoring System(OMS) data

**10. Formation/Cutting Details:**

Km	Bank/Cutting	Max. height/depth (in m)	Condition of		Condition of Cess and adequacy of width
			Catch Water drain	Side drain	

**11. Details of ballast penetration** (Attach Cross section of problematic location with ballast penetration profile)

Depth of Ballast Penetration (cm)		
Under left rail	Under right rail	At Centre

**12. Details of Erosion control measure, if any**

**13. Hydrological Characteristics**

Average annual rainfall	Erosion of slope during rain (Yes/No)	Position of water table below RL	
		Highest	Lowest

**14. Important incidents/problems faced with brief details:**

Year of occurrence	Km	Kind of incident	Remarks

**Slips/Breach/Raising/Conversion etc.**

(Enclose Sketch &amp; brief description)

**15. Details of past rehabilitation measures (km-wise)**

Km		Type of treatment	Year of execution	Approx. cost	Comments on performance
From	To				

(Enclose separate annexure, if necessary)

**16. Details of track attentions in past years, Km-wise (With details)**

Year/Km	No. of attentions/year								Remarks
	Km	Km	Km	Km	Km	Km	Km	Km	

**17. Speed Restrictions imposed due to unstable formations:**

Year/Km	Restriction Imposed			
	1	2	3	4

**18. Any proposals for renewals/LWR/CWR: Give brief details****19. Blanket provided: Yes/No**

If blanket provided (test results of blanket material to be provided)

**20. Type of ground/Formation soil** (if not available, relevant tests shall be got done and test reports generated for further analysis as required):

Bank soil/ Cutting	Type of soil	CBR	Remarks
Ground soil			
Formation Soil			

**21. Bore log details/report of problematic stretch for sub soil** (if not available, bore log should be conducted and report generated for problem analysis, as required):

**(Type of Soil & other parameters etc.)**

**22. Slope stability analysis carried out: Yes/No**

If yes, attach the report

**23. Maintenance efforts during summers & monsoons, along with brief description of the problem being faced:**

**24. Any settlement problem of track being faced: Yes/No**

If yes, give details

**25. Geological details of site** (should be made available especially for cuttings related problem & in hilly areas):

**26. Details of minor/ major bridge near the problematic location**

**27. Any rehabilitation carried out using Geosynthetics such as Non-woven Geotextile/Geogrid in past: Yes/No**

If yes, give details

**28. Any other relevant data/information: Such as consultancy reports rendered by other parties etc.**

**Signature of Railway Officer**  
**Name:**  
**Designation:**

**LIST OF EQUIPMENTS FOR FIELD LAB**  
**Table-K.1**

S N.	Description of Equipment	Reference Of I.S. Code (latest version to be used)	UNIT
1	IS set of sieves with base & top lid 20mm,19mm,10mm, 4.75mm, 2mm 600mic, 425mic, 212mic, 75mic,.	IS-460	sets
2	Hand operated sieve shaker for above sieves.		1 no.
3	BALANCE i) Pan balance/ <b>Electronic weighing machine</b> - 10 kg capacity (with 1.0 gm Least Count)		1 no. 1 no.
4	ii) Electronic balance - 500 gm capacity (with 0.1 gm Least Count ) iii) <b>Electronic weighing machine</b> <b>200gm(LC-0.01g)</b>		2 sets 5 sets
5	Field density apparatus complete. sand replacement core cutter with dolly	2720-1974 part-XXVIII 2720-1975 part-XXIX 2720 part-8-1983	2 sets 1 set 2 sets
6	Heavy Compaction Test apparatus full unit.	2720 part-16-1987	1 no.
7	Laboratory California Bearing Ratio(CBR) <b>Test Apparatus &amp; it's required accessories</b>	2386 part-4 IS 2720 Part-5-1985	1 no. 3 no.
8	Abrasion Test Apparatus	IS 2720 Part-6-1972	4 no.
9	Liquid Limit apparatus hand operated with counter & grooving tools.		6 no.
10	Shrinkage limit apparatus		2 no.
11	Stainless steel spatula - 25cm long		2 no.
12	Porcelain bowl for LL - 15cm dia.		3 no.
13	Aluminium dish with lid – 5cm dia.		3 no.
14	Wash bottle - 1 lit. capacity 500ml capacity		3 no.
15	Glass plate 10mm thick 50x50 cm		3 no.
16	Ground glass 5mm thick 50x50 cm		10 no.
	ENAMELED trays 45x30cm		10 no.
	20x20cm		10 no.
	& ENAMELED plates 6inch dia		3 no.
	8 inch dia.		2 no.
17	10 inch dia.		3 no.
18	Frying pans		3 no.
19	Stove janta		1 no.
20	Straight edge 300mm long		2 no.
21	Sample Tube (Size Dia-150mm, Length-450mm)		5 no.

**LIST OF EQUIPMENT FOR FIELD LAB**  
**Table-K.2**

S. NO.	DESCRIPTION OF EQUIPMENT	REFERENCE OF I.S. CODE (latest version to be used)	UNIT
22	Grain size analyser of fines a) Hydrometer b) Thermometer 0 to 50 c c) Glass cylinder 1000cc capacity with 60mm dia. d) Nomogram chart e) Stop Watch	IS-2720 part-4-1985	2 no. 2 no. 5 no. 1no. 1no.
22	Desiccators as IS -6128		2 no.
23	Gallon of 10 litter capacity for distilled water		3 no.
24	Wooden mortar and pestle.		1 no.
25	Specific gravity test apparatus.		2 no.
26	Density bottle-50ml capacity		2 no.
27	Glass cylinder 100 cc capacity (for Free Swell index test)		1 no.
28	Oven- thermostatically controlled to maintain a temperature 105-110c		
29	Relative Density test Apparatus	IS-2720 Part-14-1983	1 no.
30	Standard Penetration Test (SPT) Appratus	IS- 2131- 1981 (Reffeed- 1997)	1 no.
31	Nuclear Moisture Density Gauge (NMDG) Apparatus		
32	<b>Note</b> -Preparation of dry soil samples for various test	Follow IS-2720 Part-1- 1983	
33	<b><u>Consumable Item</u></b>		
34	Sieve brush		
35	Wire brush		
36	Sodium carbonate		
37	Sodium hexa meta phosphate.		
38	Kerosene		
39	Mercury		
40	<b>Additional Equipment</b> Hand auger 150mm dia with extension rod Sampling tube 100mm dia. And 450mm length		
41	All machines and equipments should have Calibration Certificate.		

## **1.0 Soil Classification**

**(Ref: IS: 1498 – 1970, Reaffirmed 2016)**

### **1.1 Background and Basis of Classification:**

The Geotechnical Engineers/Agencies had evolved many soil classification systems, over the world. The soil classification system developed by Casagrande was subsequently modified and named as 'Unified Classification' system. In 1959, Bureau of Indian Standards adopted the Unified classification system as a standard, which was revised in 1970. According to BIS classification system, soils are primarily classified based on dominant particle sizes and its plasticity characteristics. A soil particle mainly consists of following four size fractions:

- Gravel : 80 – 4.75 mm
- Sand : 4.75mm – 0.075mm (75 micron)
- Silt : 75 – 2 micron
- Clay : less than 2 micron

Particle size distribution of a soil is determined by a combination of sieving and sedimentation analysis as per procedure detailed in IS: 2720 (Part 4) – 1985 (Reaffirmed 2015) and its plasticity characteristics are determined by Liquid Limit and Plastic Limit as per procedure detailed in IS:2720 (Part 5) –1985 (Reaffirmed 2015).

### **1.2 Symbols used in Soil Classification:**

Symbols and other soil properties used for soil classification are given below:

#### **Primary Letter**

G: Gravel  
S: Sand  
M: Silt  
C: Clay  
O: Organic soil  
P: Peat

#### **Secondary Letter**

W: well-graded  
P: poorly graded  
M: with non-plastic fines  
C: with plastic fines  
L: of low plasticity  
I : of medium plasticity  
H: of high plasticity

#### **Other soil parameters required for soil classification:**

- $C_u$  : Coefficient of Uniformity =  $D_{60} / D_{10}$
- $C_c$  : Coefficient of Curvature =  $(D_{30})^2 / (D_{60} * D_{10})$
- $D_{60}$ ,  $D_{30}$  &  $D_{10}$  are particle sizes, below which 60,30 and 10 percent soil particles by weight are finer than these sizes.
- Plasticity Index (PI) = Liquid Limit (LL) - Plastic Limit ( PL)
- Coarse-grained soils: Soils having fines ( particles of size less than 75 micron) upto 50%
- Fine grained soils: Soils having fines( particles of size less than 75 micron) more than 50%

### **1.3 Based on above, soils encountered in India are classified as under (as per IS Code):**

#### **1.3.1 Coarse grained soils:**

GW-Well graded gravels, gravel-sand mixtures; little or no fines  
GP-Poorly graded gravels or gravel-sand mixtures; little or no fines  
GM-Silty gravels, poorly graded gravel-sand-silt mixtures

GC-Clayey gravels, poorly graded gravel-sand-clay mixtures  
 SW-Well graded sands, gravelly sands; little or no fines  
 SP – Poorly Graded Sands or gravelly sands; little or no fines  
 SM-Silty sands, poorly graded sand-silt mixtures  
 SC-Clayey sands, poorly graded sand-clay mixtures

### 1.3.2 Fine grained soils:

ML-Inorganic silts and very fine sands rock flour, silty or clayey fine sands or clayey silts with none to low plasticity  
 CL-inorganic clays, gravelly clays, sandy clays, silty clays, lean clays of low plasticity  
 OL-Organic silts and organic silty clays of low plasticity  
 MI-Inorganic silts, silty or clayey fine sands or clayey silts of medium plasticity  
 CI-Inorganic clays, gravelly clays, sandy clays, silty clays, lean clays of medium plasticity  
 OI-organic silts and organic silty clays of medium plasticity  
 MH-Inorganic silts of high compressibility, micaceous or diatomaceous fine sandy or silty soils, elastic silts  
 CH-Inorganic clays of high plasticity, fat clays  
 OH- Organic clay of medium to high plasticity  
 Pt-Peat and other highly organic soils with very high compressibility.

**Table-L.1 Coarse grained soils**

Soil Particle	Gradation		Mixed Soils(s)
	Well Graded	Poorly Graded	Silt & Clay
Sand	SW	SP	SM, SC
Gravel	GW	GP	GM, GC

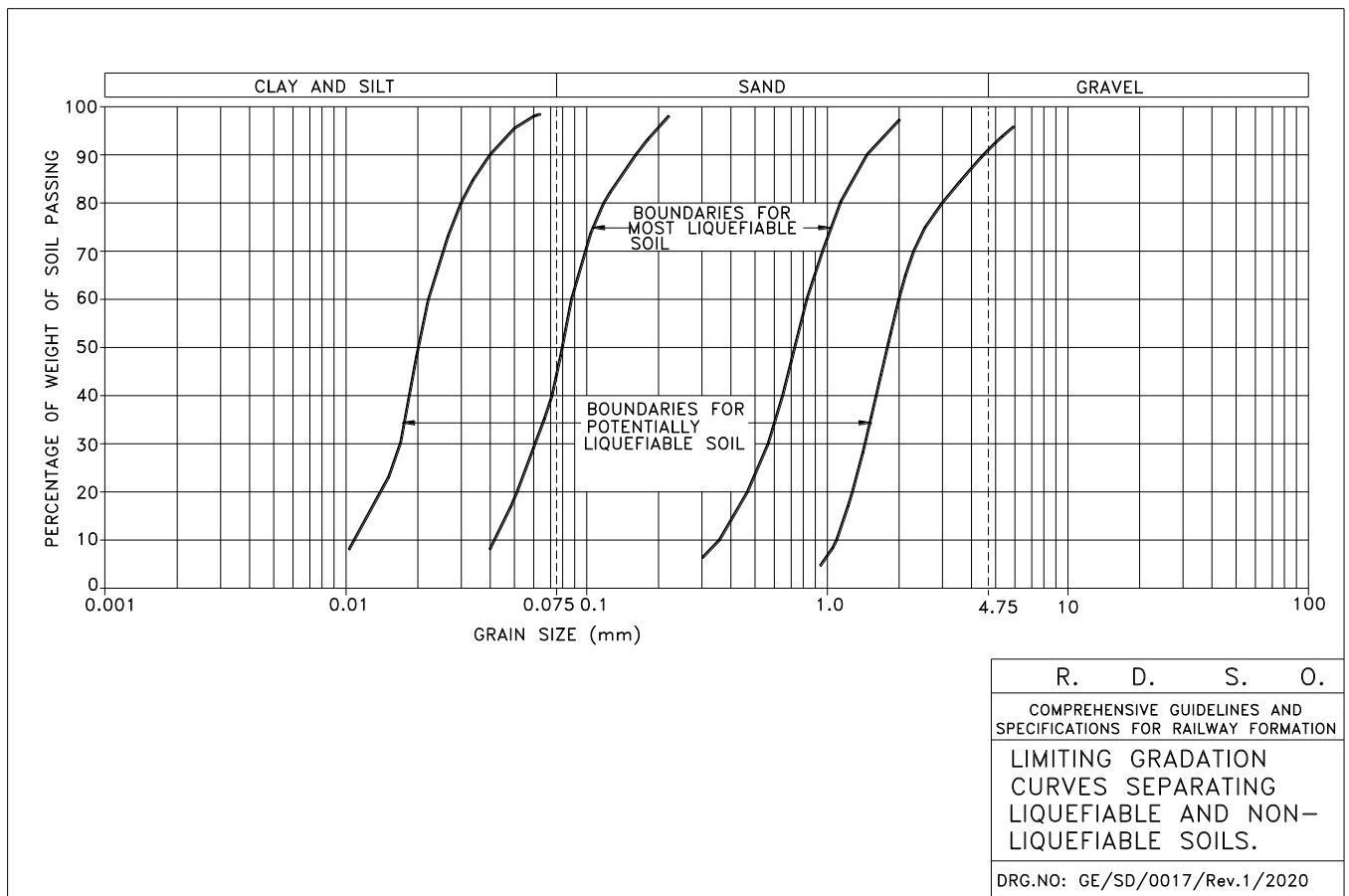
**Table – L.2 Fine grained soils**

Soil Particle	Plasticity/compressibility		
	Low	Medium	High
Clay	CL	CI	CH
Silt	ML	MI	MH
Organic	OL	OI	OH & Peat

**Soils having dual symbol:** GW-GM, GW-GC, GP-GM, GP-GC, SW-SM, SP-SM, SP-SC & CL-ML

### 1.4 Limiting gradation curve for separating liquefiable and non-liquefiable soil is as given below for reference:

Poorly graded sand and gravel with  $C_u < 2.0$ , should not be used in earthwork for the banks to safeguard against liquefaction. Generally, most liquefiable soils as falling in gradation zone as indicated in the Fig-L1 & having coefficient of uniformity,  $C_u < 2$  shall not be used. Potentially liquefiable soils as falling in gradation zone as shown in Fig-L1 should be specifically examined and designed to prevent possibility of any liquefaction.



**Fig-L1: Limiting Gradation Curves Separating Liquefiable and Non-Liquefiable Soils**

**CHECKLIST FOR CERTIFICATION OF QUALITY OF EARTHWORK IN RAILWAY PROJECTS**

(NEW LINES/ DOUBLING/ GAUGE CONVERSION PROJECTS)

(As per Guideline & Specification for Railway Formation No. RDSO/2020/GE: IRS-0004, June 2020)

**1.0 GENERAL INFORMATION:**

- i) Name of the Project :
- ii) Length of the Project :
- iii) New Line/Doubling/Gauge Conversion :
- iv) Section & Length being certified :

**2.0 SOIL EXPLORATION:**

(As per Chapter 1 of RDSO/2020/GE: IRS-0004)

- (i) Is soil survey carried out as per para 1.2 of Chapter 1 of RDSO/2020/GE: IRS-0004. :
- (ii) Reference of record/report of soil exploration :
- (iii) Any problematic soils encountered in soil exploration such as soft soil, Organic clays & silts etc. :
- (iv) Whether results of soil exploration taken into account in project formulation and alternatives explored. :
- (v) Whether geological investigations carried out in case of hilly terrain. :
- (vi) Reference of record/report of geological investigation :
- (vii) Reference if any, to RDSO for proof checking & consultancy report submitted by private agencies. :

**3. FIELD COMPACTION TRIALS**

(As per para 6.2.3 (c), Chapter 6 of RDSO/2020/GE: IRS-0004)

- (i) Whether field trials conducted :
- (ii) Details of field trial (indicate) :
  - (a) Classification of soil :
  - (b) Type of roller used and its weight :
  - (c) Optimum thickness of layer achieved :

- (d) Optimum number of passes of the roller used :
- (e) Field moisture content :
- (f) Maximum attainable field dry density :
- (iii) Whether field compaction trial taken into account in execution. :
- (iv) Reference of record of field trials :
- (v) Reference of record of field compaction trails (maintained as given in Annexure III, IV, V & VI) :

#### **4. QUALITY CHECK OF EARTH WORK**

(As per Para 6.2.8, Chapter 6 of RDSO/2020/GE: IRS-0004)

- (i) Whether GE Field Laboratory has been set up at site for quality check. :
- (ii) Whether equipment available in the GE Lab is as per Annexure –VIII (attached). :
- (iii) Dates of inspection of GE Lab by CE/Con based on which item Nos (i) & (ii) above is certified. :

##### **4.1 BORROW MATERIAL**

(As per para 7.3.1, Chapter 7 of RDSO/2020/GE: IRS-0004)

- (i) Type of fill material (indicate classification as per IS-1498): used in the earth work. :
- (ii) Is soil suitable for embankment (As per Para 3.7 of Chapter 3 of RDSO/2020/GE: IRS-0004) :
- (iii) Frequency of testing at site to assess the suitability of fill materials (As per Table 7.2 Chapter 7 of RDSO/2020/GE: IRS-0004) :
  - (a) Total quantum of earthwork involved :
  - (b) Minimum number of test required (at least one test at every change of subgrade/ Prepared subgrade material subjected to minimum of one test per 5000 cum) :
  - (c) Number of tests actually done :
- (iv) Maximum size of materials used in the bank in case of cobbles/boulders/rock etc. :

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- (v) Is it certified that record of quality of fill material has been maintained as given in format in Annexure VII (A), attached record of testing is preserved in the reference :

## 4.2 BLANKET MATERIALS

(As per para 7.3.2, Chapter 7 of RDSO/2020/GE: IRS-0004)

- (i) Source of blanket material :
- (ii) Type of blanket material used (Natural/Mechanically Crushed/ Blended) :
- (iii) Whether quality of blanket material selected in conforming to specification as given in para (As per table 3.3, 3.4, 3.5 & 3.6, Chapter 3 of RDSO/2020/GE: IRS-0004) :
- (iv) Thickness of blanket layer
- (a) Type of sub-grade (in top 1m) :
- (b) Thickness required (As per table 3.3, 3.4, 3.5 & 3.6, Chapter 3 of RDSO/2020/GE: IRS-0004) :
- (c) Thickness actually provided :
- (d) Deviation from prescribed thickness, if any :
- (v) Frequency of testing to assess the suitability of blanket material (As per Table 7.2, Chapter 7 of RDSO/2020/GE: IRS-0004) :
- (a) Total quantum of blanket material involved in cum :
- (b) Minimum number of test required (at least one test per 5000 cum) :
- (c) Number of tests actually done :
- (vi) Reference of record of testing where quality of blanket material has been maintained as given in format in Annexure VII (B) attached.

## 4.3 QUALITY CONTROL CHECKS ON FINISHED EARTHWORK

(As per Para 7.4, Chapter 7 of RDSO/2020/GE: IRS-0004)

### 4.3.1. For Soil

- (i) Frequency of tests for degree of compaction (As per Table 7.2, Chapter 7 of RDSO/2020/GE: IRS-0004) :
- (a) Total area of earth work involved (Cumulative for every layer in Sqm.) :

- (b) Minimum number of density test required :  
(at least one per 200 sqm for top one metre of  
subgrade and one per 500 sqm for balance)
- (c) Number of density test check actually done :
- (d) Number of test where degree of compaction :  
is less than 98% of MDD
- (e) Action taken in case of (d) :
- (ii) Reference of record where report of checking of :  
degree of compaction has been preserved as given  
in format in Annexure VII (C) (enclosed)
- (iii) Soil used as subgrade (SQ1/SQ2/SQ3) :
- (iv)  $E_{v2}$  Value on top of subgrade (As per Table 7.2, :  
Chapter 7 of RDSO/2020/GE: IRS-0004)
- (v) Compaction at top layer of subgrade(As per :  
Table 7.2, Chapter 7 of RDSO/2020/GE: IRS-0004)

#### 4.3.2 For Ballast

Ballast Cushion Thickness :

#### 4.3.3 For Blanket

- (i) Frequency of tests for degree of compaction / :  
Relative Density done (As per Table 7.2, Chapter 7 of  
RDSO/2020/GE: IRS-0004)
- a) Total area of blanket involved :
- b) Minimum number of density test required :  
(at least one per 200 sqm for every blanket layers)
- c) Number of density check actually done :
- d) Number of test where degree of compaction is less :  
than 98% of MDD or 70% of Relative Density (Relative  
Density should be calculated if fines in the soil are less  
than 5%)
- e) Action taken in case of (d) :
- (ii) Reference of record where report of checking of degree :  
of compaction has been maintained as given in format in  
Annexure VII (D) attached.
- (iii) Compaction of blanket layer (100% of MDD(As per :  
Table 7.2, Chapter 7 of RDSO/2020/GE: IRS-0004)
- (iv) Blanket material specification test Report : Y/N
- (v) Blanket thickness (Single layer/ Two layer) :
- (vi)  $E_{v2}$  Value on top of blanket layer (As per Table 7.2, :  
Chapter 7 of RDSO/2020/GE: IRS-0004)

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**4.3.4. Prepared Subgrade** (As per table 3.4 & 3.6 of RDSO/2020/GE: IRS-0004)

**(For Two Layer Formation system only)**

- (i) Prepared sub grade specification and test report : Y/N
- (ii) Soil used as prepared sub grade (SQ2/SQ3) :
- (iii) Prepared sub grade thickness :
- (iv) Compaction of Prepared Sub-grade :
- (v) EV2 Value on top of Prepared Sub-grade :

**4.3.5. Formation level** (As per para 7.6, Chapter 7 of RDSO/2020/GE: IRS-0004)

- (i) Has it been ensured that finished top sub grade level is :  
within  $\pm 25$  mm of designed level and finished top of  
blanket layer is within +25 mm from designed level  
and top of formation is level without ruts or low pocket.
- (ii) Reference of level book maintained to ensure item (i) :  
above

**4.3.6 Cross Slope** (As per para 7.7 of RDSO/2020/GE: IRS-0004) :

**4.3.7. Side Slope** (As per para 7.8 of RDSO/2020/GE: IRS-0004) :

**4.3.8. Formation System** (As per para 3.1 of RDSO/2020/GE: IRS-0004)

Single layer/ Two layer :

**4.3.9. Formation width** (As per IRSOD latest version) :

**4.3.10 Cess Width** (90cm Min.) :

(As per Para 3.3 (a) of RDSO/2020/GE: IRS-0004)

**4.3.11 a) Provision of Berm** (for more than 6m High embankment): Y/N

**b) Berm Width** (2.0m Min.)

(As per Para 5.1.2 of RDSO/2020/GE: IRS-0004) :

**5.0 SLOPE STABILITY FOR EMBANKMENT/ CUTTING**

(As per chapter 5 of RDSO/2020/GE: IRS-0004)

- (i) Maximum height of bank (at chainage) :
- (ii) Maximum depth of cutting (at chainage) :
- (iii) Designed side slope in bank/cutting as per slope stability :  
analysis (attach profile duly approved)
- (iv) Agency which carried out slope stability analysis :
- (v) Actual side slope provided in bank/cutting at site :  
(attach profile duly approved)

**6.0 EROSION CONTROL MEASURES**

(As per para 8.3, Chapter 8 of RDSO/2020/GE: IRS-0004)

- (i) Type of soil used in earth work :
- (ii) Chainage where erosion control measures required : Y/N

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- (iii) Chainage where erosion control measures planned :
- (iv) Type of erosion control measures provided chainage wise:

## 7.0 Slope Protection Measures

(Ref: RDSO Guidelines for Cuttings in Railway Formations, GE: G-2)

- (i) Slope protection measures required : Y/N
- (ii) Slope protection planned :
- (iii) Slope protection provided :

## 8.0 Drainage system (As per para 6.2.6, Chapter 6 of RDSO/2020/GE: IRS-0004)

- (i) Drainage system required : Y/N
- (ii) Catch water Drain System Planned :
- (iii) Catch water Drain System Provided :
- (iv) Side drain planned :
- (v) Side drain Provided :

## 9.0 CUTTINGS (Ref: Para 8.4, Chapter 8 of RDSO/2020/GE: IRS-0004 & GE: G-2)

- (i) Details of cutting as per **Annexure –1** enclosed :
- (ii) Attach copy of designed & approved cutting profiles :
- (iii) Details of deviation, if any, to recommendation of Geologist investigation. :

## 10.0 BACKFILL BEHIND BRIDGE ABUTMENT/WING WALLS/ RETURN WALL

(As per Para 6.2.5, Chapter 6 of RDSO/2020/GE: IRS-0004)

- (i) Details of backfill behind bridge approach **Annexure –II** enclosed. :

## 11.0 GE LAB AT SITE (Para 6.2.8, Chapter 6 RDSO/2020/GE: IRS-0004)

- (i) Organization
  - a) In Charge :
  - b) Total Staff strength with particular :
  - c) Qualification and training of personnel :
- (ii) Period for which lab at site was in operation :
- (iii) Total number of tests carried out at site :
- (iv) Reference of record of tests :
- (v) Equipments (As per Annexure VIII attached) :

## 12.0 GENERAL SITE DETAILS

- (i) Pond/Ditches/ Borrow pits along the Alignment (distance from toe of bank) (As per para. 3.6, Chapter 3 of RDSO/2020/GE: IRS-0004) :

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- |  |   |                     |
|--|---|---------------------|
| (ii) Rain cuts on slope                              | : | Y/N (if Y chainage) |
| (iii) Cracks on formation and slope                  | : | Y/N (if Y chainage) |
| (iv) Details of benching in case of doubling         | : |                     |
| (v) Minimum center to center distance between tracks | : |                     |

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### 13.0 BRIEF DETAILS OF DEVIATIONS

S. No.	Nature of Deviations	Approved by	Reference of approval.
1.			
2.			
3.			
4.			

It is certified that the earthwork and blanketing from chainage ----- to chainage ----- i.e. -----km have been done strictly as per prescribed specification, stipulated in (as per RDSO Guideline & Specification No. RDSO/2020/GE: IRS-0004) under my active administrative and technical control except minor deviations as stated in para. 13.0 above for which approval of the component authority has been obtained and necessary precautions for ensuring safety on the account of deviation have been taken.

**Chief Engineer (Con)**

# ANNEXURE-I

## DETAILS OF CUTTING

Location Chainage/Km	Max Depth of Cutting	Geological investigation carried out	Details of Beam provided ( Not less than 4-5m)	Type of Rock/ soil strata	Side slope		Side Drain		Catch Water Drains				Other measures taken like gabions, R/walls, etc.
					Designed (Y/S)	Actual at site	Designed	Provided	Requ ired	Desi gned	Prov ided	Katcha /Lined	

**BACK FILL BEHIND BRIDGE ABUTMENT**

<b>Bridge No.</b>	<b>Boulder Shape</b>	<b>Boulder Size</b>	<b>Packing of Boulders</b>	<b>Thickness of Boulder packing</b>	<b>IS classification of back fill in triangular zone</b>	<b>Weep holes</b>	<b>Any special treatment like toe pitching, toe wall etc.</b>

# ANNEXURE- III

## FIELD COMPACTION TRIAL OBSERVATIONS & COMPUTATION SHEETS COMPACTION EQUIPMENT DATA

Project.....

Location.....

Date.....

Item		Roller - 1	Roller -2	Roller -3
Type of Roller				
Gross weight (tonnes)				
Drum Dimension (Roller Type)	Width (mm)			
	Diameter (mm)			
Foot (Sheep foot Type)	Type			
	Number			
	Length (mm)			
	Area (mm <sup>2</sup> )			
Contact Area (cm <sup>2</sup> ) (Sheep foot/Pneumatic Tyred/Vibratory Plate Type)				
Tyre Inflation Pressure(Kg/cm <sup>2</sup> )				
Nominal Amplitude(mm)				
Frequency(Hz)				
Dynamic Force(Kg)				
Operational Speed(Kmph)				
Static Linear Loads(Kg/cm)				
Contact Pressure(Kg/cm <sup>2</sup> )				

### LIST OF EQUIPMENT FOR FIELD TRIALS/MONITORING

S. No.	Equipment	No. Req'd.	No. available
1.	Field density apparatus complete: a) Sand replacement b) Core cutter with dolly and hammer	4 Sets 4 Sets	
2.	Balance: a) Electronic balance – 20 kg capacity (with 2.0 gm Least Count ) b) Electronic balance – 500 gm capacity (with 0.1 gm Least Count )	1 Set 1 Set	
3.	Straight edge 300mm long	4 Nos.	
4.	Frying Pan	1 No.	
5.	Containers plastic (about 500g capacity)	8 Nos.	
6.	Enamel plates: 6 inch dia. 8 inch dia. 10 inch dia.	10 Nos. 3 Nos. 3 Nos.	
7.	Uniform clean sand (Ottawa Sand) (bags of 50 Kg)	10 Bags	
8.	Measuring tape (3M/5M)	1 No.	
9.	Measuring tape (15 M/30M)	1 No.	
10.	Kerosene oil stove	1 No.	

Signature of  
Monitoring Official \_\_\_\_\_  
Name \_\_\_\_\_  
Designation \_\_\_\_\_  
Date \_\_\_\_\_

Signature of  
Project Official \_\_\_\_\_  
Name \_\_\_\_\_  
Designation \_\_\_\_\_  
Date \_\_\_\_\_

**FIELD COMPACTION TRIAL OBSERVATION  
TABLE- 1**

Project \_\_\_\_\_

Date \_\_\_\_\_

Location \_\_\_\_\_

Strip No.	Location on the ramp	Moisture content before watering				Moisture content after adding the water			
		Container No.	Weight of wet soil.(gms)	Weight of dry soil.(gms)	Moisture content (%)	Container No.	Weight of wet soil.(gms)	Weight of dry soil.(gms)	Moisture content (%)
1	2	3	4	5	6	7	8	9	10
J	1								
	2								
	3								
	4								
K	1								
	2								
	3								
	4								
L	1								
	2								
	3								
	4								
M	1								
	2								
	3								
	4								
Signature of Monitoring official_____						Signature of Project Official_____			
Name_____						Name_____			
Designation_____						Designation_____			
Date _____						Date _____			

# ANNEXURE- V

## FIELD COMPACTION TRIAL OBSERVATION TABLE- 2

Project \_\_\_\_\_ Location: \_\_\_\_\_ Date \_\_\_\_\_  
 STRIP No. \_\_\_\_\_ OMC \_\_\_\_\_ % MDD \_\_\_\_\_ gms/cc Volume of core cutters: \_\_\_\_\_ C.C.

No. of roller passes	Location of the Ramp	In-situ bulk density					Moisture content				Dry density of soil	Percent of MDD	Remark
		Core cutter No.	Wt. Of empty core cutter (gm)	Wt. of wet soil with core cutter (gm)	Wt. of wet soil (gm)	Bulk density of soil (gm/cc)	Container No.	Wt. of wet soil (gms)	Wt. of dry soil (gms)	Moisture content (%)			
1	2	3	4	5	6	7	8	9	10	11	12	13	14
4	1												
	2												
	3												
	4												
6	1												
	2												
	3												
	4												
8	1												
	2												
	3												
	4												
10	1												
	2												
	3												
	4												
12	1												
	2												
	3												
	4												
14	1												
	2												
	3												
	4												

Signature of monitoring official \_\_\_\_\_  
 Name \_\_\_\_\_  
 Designation \_\_\_\_\_  
 Date \_\_\_\_\_

Signature of project official \_\_\_\_\_  
 Name \_\_\_\_\_  
 Designation \_\_\_\_\_  
 Date \_\_\_\_\_

**FIELD COMPACTION TRIAL-COMPUTATION SHEET  
TABLE- 3**

Project\_\_\_\_\_

Location\_\_\_\_\_

S. No	Lift thickness (mm)	Moisture content %	Dry density of soil(gm/cc)						Remarks
			Nos. of the roller passes						
			4	6	8	10	12	14	
1.	225								
2.	300								
3.	375								
4.	450								

Computed by_____	Checked by _____
Name _____	Name_____
Designation_____	Designation_____
Date _____	Date_____

**A) DETAILS OF BORROW SOIL/ FORMATION SUBGRADE/PREPARED SUBGRADE**

S. no	Date of taking sample	Location layer Ch./Km	Soil type				Soil classification	LL	PL	PI
			Gravel %	Sand %	Silt %	Clay %				
1	2	3	4	5	6		7	8	9	10

CBR value	Whether of dispersive nature	Suitable/ Non suitable	Signature and name of Engineer's representative	Signature and name of contractor representative	Remarks
11	12	13	14	15	16

**B) QUALITY OF BLANKET MATERIAL**

1. Type of material:                      Manufactured/Naturally available
2. Source location:

S.no	Date of taking sample	Location of laying	Soil type			C <sub>u</sub>	C <sub>c</sub>	Abrasion Value
			Gravel %	Sand %	Fines passing 75 micron sieve %			
1	2	3	4	5	6	8	9	10

CBR value	Signature and name of Rly official	Signature and name of contractor	Remarks
11	12	13	14

## (C) PROFORMA FOR FIELD COMPACTION RECORD

Chainage / km from ..... to .....

Soil Classification:

Height of bank: OMC:

Type of roller being used: Lab. MDD/ Field Trial MDD:

### CORE CUTTER METHOD

Date of Laying	Layer no.	location coordinate for check	Placement moisture content (%)	No. of passes	Wt. of core cutter+ wet soil ( $W_s$ ) (g)	Wt. of core cutter ( $W_c$ ) (g)	Wt of wet soil ( $W_s - W_c$ ) (g)	Vol. of core cutter ( $V_c$ ) (cc)	Bulk density, $\gamma_b = \frac{(W_s - W_c)}{V_c}$ (g/cc)
1	2	3	4	5	6	7	8	9	10

Moisture content of compacted layer (w) (%)	Dry Density( $\gamma_d$ ) = $\gamma_b / 1+w$ * 100 (g/cc)	Degree of compaction (%)	Sig. and name of Rly officer	Sig. and name of contractor	Remarks
11	12	13	14	15	16

- Note:**
1. In case of compaction of blanket material, percentage of fines should also be mentioned in a column.
  2. Determination of Dry Density, ( $\gamma_d$ ) of soil in above table is done as per IS: 2720 Pt 29 – 1975 (latest version) titled as Determination of Dry Density of Soils In-Place By The Core-Cutter Method

## (D) PROFORMA FOR FIELD COMPACTION RECORD

Chainage /km from .....

to.....

Soil Classification:

Height of embankment:

### SAND REPLACEMENT METHOD

Location	Bulk density of sand, ( $\gamma_s$ ) g/cum	Wt of wet soil from hole, $W_w$ (g)	Wt of Cylinder + Sand, before pouring $W_1$ (g)	Wt of sand + Cylinder after pouring $W_2$ (g)	Mean weight of sand in cone $W_3$ (g)	Wt of sand in hole $W_b = W_1 - W_2 - W_3$	Bulk Density of soil $\gamma_b = (W_w / W_b) * \gamma_s$
1	2	3	4	5	6	7	8

Moisture content of soil ( $w$ ), %	Dry Density of soil $\gamma_d = \gamma_b / 1 + w$	Relative Density $I_D$	Sign. and name of Rly Official	Sign and name of contractor	Remarks
9	10	11	12	13	14

**Ref:** IS: 2720 (Pt 28)1974 (latest version)

(Determination of dry density ( $\gamma_d$ ) of soils in-place, by the sand Replacement method)

- Note:** 1. *Density Index (Relative Density) shall be find out as per IS 2720 (Part 14) - 1963 – (latest version).*  
2. *The density index,  $I_d$  (relative density) expressed as a percentage should be calculated as follows:*

$$\text{Relative density (ID)} = \gamma_{\max} (\gamma_d - \gamma_{\min}) / \gamma_d (\gamma_{\max} - \gamma_{\min}) \times 100$$

$\gamma_{\max}$  (from lab as per IS 2720 (Part 14) .....

$\gamma_{\min}$  (from lab as per IS 2720 (Part 14) .....

$\gamma_d$  determined in field as shown in above table by the sand Replacement method.

**LIST OF EQUIPMENTS FOR FIELD LAB**  
**Table-1**

S N.	Description of Equipment	Reference of I.S. Code (latest version to be used)	UNIT
1	IS set of sieves with base & top lid 20mm, 19mm, 10mm, 4.75mm, 2mm 600mic, 425mic, 212mic, 75mic, .	IS-460	sets
2	Hand operated sieve shaker for above sieves.		1 no.
3	BALANCE i) Pan balance/ <b>Electronic weighing machine</b> - 10 kg capacity (with 1.0 gm Least Count)		1 no. 1 no.
4	ii) Electronic balance - 500 gm capacity (with 0.1 gm Least Count ) iii) <b>Electronic weighing machine</b> <b>200gm(LC-0.01g)</b>		2 sets 5 sets
5	Field density apparatus complete. sand replacement core cutter with dolly	2720-1974 part-XXVIII 2720-1975 part-XXIX 2720 part-8-1983	2 sets 1 set
6	Heavy Compaction Test apparatus full unit.	2720 part-16-1987	2 sets
7	Laboratory California Bearing Ratio(CBR) <b>Test Apparatus &amp; it's required accessories</b>	2386 part-4	1 no.
8	Abrasion Test Apparatus	IS 2720 Part-5-1985	1 no.
9	Liquid Limit apparatus hand operated with counter & grooving tools.	IS 2720 Part-6-1972	3 no.
10	Shrinkage limit apparatus		4 no.
11	Stainless steel spatula - 25cm long		6 no.
12	Porcelain bowl for LL - 15cm dia.		
13	Aluminium dish with lid – 5cm dia. Wash bottle - 1 lit. capacity		2 no. 2 no.
14	500ml capacity		3 no.
15	Glass plate 10mm thick 50x50 cm		3 no.
16	Ground glass 5mm thick 50x50 cm		10 no.
	Enameled trays 45x30cm		10 no.
	20x20cm		10 no.
	&		
	Enameled plates 6inch dia		3 no.
	8 inch dia.		2 no.
17	10 inch dia.		3 no.
18	Frying pans		3 no.
19	Stove janta		1 no.
20	Straight edge 300mm long		2 no.
21	Sample Tube (Size Dia-150mm, Length-450mm)		5 no.

**LIST OF EQUIPMENT FOR FIELD LAB**  
**Table-2**

S. NO.	DESCRIPTION OF EQUIPMENT	REFERENCE OF I.S. CODE (latest version to be used)	UNIT
22	Grain size analyser of fines a) Hydrometer b) Thermometer 0 to 50 c c) Glass cylinder 1000cc capacity with 60mm dia. d) Nomogram chart e) Stop Watch	IS-2720 part-4-1985	2 no. 2 no. 5 no. 1no. 1no.
22	Desiccators as IS -6128		2 no.
23	Gallon of 10 litter capacity for distilled water		3 no.
24	Wooden mortar and pestle.		1 no.
25	Specific gravity test apparatus.		2 no.
26	Density bottle-50ml capacity		2 no.
27	Glass cylinder 100 cc capacity (for Free Swell index test)		1 no.
28	Oven- thermostatically controlled to maintain a temperature 105-110c		
29	Relative Density test Apparatus	IS-2720 Part-14-1983	1 no.
30	Standard Penetration Test (SPT) Appratus	IS- 2131- 1981 (Reffeed- 1997)	1 no.
31	Nuclear Moisture Density Gauge (NMDG) Apparatus		
32	<b>Note</b> -Preparation of dry soil samples for various test	Follow IS-2720 Part-1- 1983	
33	<b><u>Consumable Item</u></b>		
34	Sieve brush		
35	Wire brush		
36	Sodium carbonate		
37	Sodium hexa meta phosphate.		
38	Kerosene		
39	Mercury		
40	<b>Additional Equipment</b> Hand auger 150mm dia with extension rod Sampling tube 100mm dia. And 450mm length		
41	All machines and equipments should have Calibration Certificate.		

**LIST OF RELEVANT I.S. CODES**  
**Table-L.1**

SN	I.S. CODE NO.	DISCRIPTION
1.	IS: 2720 -1983 Part-1 (Reaffirmed 2010)	Methods of test for soils. Preparation of dry soil samples for various tests.
2.	IS: 2720-1973 Part-2 (Reaffirmed 2015)	Determination of water content Methods of test for soils.
3.	IS: 2720-1980 Part-3 Section 1 (Reaffirmed 2011)	Methods of test for soils. Determination of specific gravity. Fined grained soils
4.	IS: 2720-1980 Part-3 Section 2 (Reaffirmed 2011)	Methods of test for soils. Determination of specific gravity. Section 2 Fine, Medium and coarse-grained soils.
5.	IS: 2720-1985 Part-4 (Reaffirmed 2015)	Methods of test for soils. Grain size analysis.
6.	IS: 2720-1985 Part-5 (Reaffirmed 2015)	Methods of test for soils. Determination of liquid and plastic limits.
7.	IS: 2720-1972 Part -6 (Reaffirmed 2011)	Methods of test for soils. Determination of shrinkage factors.
8.	IS: 2720-1980 Part-7 (Reaffirmed 2011)	Methods of test for soils. Determination of water content-dry density relation using light compaction.
9.	IS: 2720-1983 Part-8 (Reaffirmed 2015)	Methods of test for soils. Determination of water content-dry density relation using heavy compaction.
10.	IS: 2720-1992 Part-9 (Reaffirmed 2011)	Methods of test for soils Determination of dry density –moisture content relation by constant weight of soil method.
11.	IS: 2720-1991 Part-10 (Reaffirmed 2010)	Methods of test for soils. Determination of unconfined compressive strength.
12.	IS: 2720-1993 Part-11 (Reaffirmed 2011)	Methods of test for soils. Determination of the shear strength parameters of a specimen tested in unconsolidated undrained triaxial compression without the measurement of pore water pressure.
13.	IS: 2720-1981 Part-12 (Reaffirmed 2011)	Methods of test for soils. Determination of shear strength parameters of soil from consolidated undrained triaxial compression test with measurement of pore water pressure.
14.	IS: 2720-1986 Part-13 (Reaffirmed 2011)	Methods of test for soils. Direct shear test
15.	IS: 2720-1983 Part-14 (Reaffirmed 2015)	Methods of test for soils. Determination of density index (Relative density) of cohesionless soils.

16.	IS: 2720-1965 Part-15 (Reaffirmed 2011)	Methods of test for soils. Determination of consolidation properties.
17.	IS: 2720-1987 Part-16 (Reaffirmed 2011)	Methods of test for soils. Methods of test for soil. Laboratory determination of CBR.
18.	IS: 2720-1986 Part-17 (Reaffirmed 2011)	Methods of test for soils. Laboratory determination of permeability.
19.	IS: 2720-1992 Part-18 (Reaffirmed 2011)	Methods of test for soils. Determination of field moisture equivalent.
20.	IS: 2720-1992 Part-19 (Reaffirmed 2011)	Methods of test for soils. Determination of centrifuge moisture equivalent.
21.	IS: 2720-1992 Part-20 (Reaffirmed 2011)	Methods of test for soils. Determination of linear shrinkage. (with amendment No. 1)
22.	IS: 2720-1977 Part-21 (Reaffirmed 2016)	Methods of test for soils. Determination total soluble solids.
23.	IS: 2720-1972 Part-22 (Reaffirmed 2015)	Methods of test for soils. Determination of organic matter.
24.	IS: 2720-1976 Part-23 (Reaffirmed 2010)	Methods of test for soils. Determination of calcium carbonate.
25.	IS: 2720-1976 Part-24 (Reaffirmed 2015)	Methods of test for soils. Determination of cation exchange capacity.
26.	IS: 2720-1982 Part-25 (Reaffirmed 2015)	Methods of test for soils. Determination of silica sesquioxide ratio.
27.	IS: 2720-1987 Part-26 (Reaffirmed 2011)	Methods of test for soils. Determination of pH value.
28.	IS: 2720-1977 Part-27 (Reaffirmed 2015)	Methods of test for soils. Determination of total soluble sulphate.
29.	IS: 2720-1974 Part-28 (Reaffirmed 2015)	Methods of test for soils. Determination of dry density of soils in -place by the sand replacement method.
30.	IS: 2720-1975 Part-29 (Reaffirmed 2015)	Methods of test for soils. Determination of dry density of soils in- place by the core cutter method.
31.	IS: 2720-1980 Part-30 (Reaffirmed 2011)	Methods of test for soils. Laboratory vane shear test.
32.	IS: 2720-1990 Part-31 (Reaffirmed 2010)	Methods of test for soils. Field determination of california bearing ratio.
33.	IS: 2720-1971 Part-33 (Reaffirmed 2010)	Methods of test for soils. Determination of the density in- place by the ring and water replacement method.
34.	IS: 2720-1972 Part-34 (Reaffirmed 2010)	Methods of test for soils. Determination of dry density of soil in- place by rubber balloon method.
35.	IS: 2720-1974 Part-35 (Reaffirmed 2010)	Methods of test for soils. Part-35 Measurement of negative pore water pressure.
36.	IS: 2720-1987 Part-36 (Reaffirmed 2010)	Methods of test for soils. Part-36 Laboratory determination of permeability of granular soils (constant head).

37.	IS: 2720-1976 Part-37 (Reaffirmed 2011)	Methods of test for soils. Part-37 Determination of sand equivalent value of soils and fine aggregates.
38.	IS: 2720-1976 Part-38 (Reaffirmed 2011)	Methods of test for soils. Part-38 Compaction control test (Hilf method).
39.	IS: 2720-1977 Part-39 Section 1 (Reaffirmed 2011)	Methods of test for soils. Direct shear test for soils containing gravel. Section 1 Laboratory test.
40.	IS: 2720-1979 Part-39 Section 2 (Reaffirmed 2011)	Methods of test for soils. Direct shear test for soils containing gravel. Section 2 in-situ shear test.
41.	IS: 2720-1977 Part-40 (Reaffirmed 2011)	Methods of test for soils. Determination of free swell index of soils.
42.	IS: 2720-1977 Part-41 (Reaffirmed 2011)	Methods of test for soils. Measurement of swelling pressure of soils.
43.	IS: 2810-1979 (Reaffirmed 2011)	Glossary of terms relating to soil dynamics.
44.	IS: 4434-1978 (Reaffirmed 2011)	Code of practice for in-situ vane shear test for soils.
45.	IS: 4968-1976 Part 1 (Reaffirmed 2011)	Method of subsurface sounding for soils. Part I Dynamic method using 50mm cone without bentonite slurry.
46.	IS: 4968-1976 Part 2 (Reaffirmed 2011)	Method of subsurface sounding for soils. Part II Dynamic method using cone and bentonite slurry.
47.	IS: 4968-1976 Part 3 (Reaffirmed 2011)	Method of subsurface sounding for soils. Part III Static cone penetration test.
48.	IS: 5249-1992 (Reaffirmed 2015)	Method of test for determination of in-situ dynamic properties of soils.
49.	IS: 460-1985 Part 1 (Reaffirmed 2013)	Specification of test sieves. Wire cloth test sieves.
50.	IS: 460-1985 Part 2 (Reaffirmed 2013)	Specification of test sieves. Perforated plate test sieve.
51.	IS: 460-1985 Part 3 (Reaffirmed 2011)	Specification of test sieves. Part III Methods of examination of apertures of test sieves.
52.	IS: 1498-1970 (Reaffirmed 2011)	Classification and identification of soils for general engineering purposes.
53.	IS: 1607-2013	Methods for test sieving.
54.	IS: 4616-1968 (Reaffirmed 2017)	Specification for Sheep Foot roller.
55.	IS: 5421-2013	Glossary of terms relating to test sieves and tests sieving.
56.	IS: 5500-2004 (Reaffirmed 2015)	Vibratory Roller - General Requirements
57.	IS: 5501-1969 (Reaffirmed 2017)	Specification for pneumatic tyred roller.
58.	IS: 5502-1988 (Reaffirmed 2017)	Specification for smooth-wheeled diesel road roller.

59.	IS: 1888-1982 (Reaffirmed 2011)	Method of load test on soils.
60.	IS: 1892-1979 (Reaffirmed 2011)	Code of practice for site investigations for foundations. (With amendment no. 1)
61.	IS: 2131-1981 (Reaffirmed 2011)	Method for standard penetration test for soils.
62.	IS: 2132-1986 (Reaffirmed 2011)	Code of practice for thin walled tube sampling of soils.
63.	IS: 10074-1982 (Reaffirmed 2010)	Specification for compaction mould assembly for light and heavy compaction test for soils.
64.	IS: 10077-1982 (Reaffirmed 2010)	Specification for equipment for determination of shrinkage factors.
65.	IS: 10379-1982 (Reaffirmed 2010)	Code of practice for field control of moisture and compaction of soils for Embankment and sub-grade.
66.	IS: 10837-1984 (Reaffirmed 2010)	Specification for moulds and accessories for determination of density index (relative density) of cohesionless soils.
67.	IS: 11196-1985 (Reaffirmed 2010)	Specification for equipment for determination of liquid limit of soils-cone penetration method.
68.	IS: 11229-1985 (Reaffirmed 2010)	Specification for shear box for testing of soils.
69.	IS: 11209-1985 (Reaffirmed 2010)	Specification for mould assembly for determination of permeability of soils.
70.	IS: 4081-2013	Code of Safety for Blasting and Related Drilling Operations
71.	IS: 3764-1992 (Reaffirmed 2012)	Code of Safety for Excavation Work
72.	IS: 2386 Part 4 – 1963 (Reaffirmed 2016)	Methods of test for aggregates for concrete – Mechanical Properties
73.	IS: 15869	Open weave Coir Bhoovastra specification
74.	IS: 15872	Application of Coir Geotextile
75.	IS: 14986 (Reaffirmed 2018)	Guidelines for Application of Jute Geotextile for Rain Water Erosion Control in Road and Railway Embankments and Hill Slopes

**Note:** Latest version of IS codes shall be referred to.

भारत सरकार (GOVERNMENT OF INDIA)  
रेल मंत्रालय (MINISTRY OF RAILWAYS)  
रेलवे बोर्ड (RAILWAY BOARD)

No. 2011/CE-II/Form/Spec

New Delhi, dated 09.09.2020

**Executive Director/GE  
RDSO  
Lucknow**

**Sub: Comprehensive Guidelines and Specification for Railway Formation**

**Ref: RDSO's letter no. GE/GEN/185/Vol-I dated 02.07.2020**

Vide letter under reference above, the final draft of "Comprehensive Guidelines and Specifications for Railway formation" has been forwarded by RDSO for Board's approval.

Having considered the various recommendations of RDSO regarding the above Guidelines, Competent Authority has approved the above final draft for adoption in Zonal Railways with following decisions on specific issues referred by RDSO -

SN	Specific issues/provisions of the guidelines	Board's decision
(i)	Fitment of existing railway formation for 22.9T/25T axle load operations for speed upto 100 kmph and passenger train (19.5T axle load) operation for speed upto 160 kmph assuming 350 mm ballast cushion and 60 kg rail section (Appendix-I)	Approved.
(ii)	Provisions for Gauge conversion/doubling/Cess repair work in case of existing formation (Chapter-9)	Approved.
(iii)	Methods of Formation Rehabilitation (Chapter 10)	Approved.
(iv)	Erosion control of slopes (Chapter 8)	Approved.
(v)	Quality control of Earthwork (Chapter 7)	<p>Approved with following modification.</p> <ul style="list-style-type: none"> <li>The note marked as "*" of Table 7.2 to be modified as under:</li> </ul> <p>"Additionally this test can also be done by third party (i.e IIT, NIT, Govt. Labs or any NABL approved Lab) having testing facilities, to cross check the results achieved at site. Frequency of testing in this case shall be decided/approved at the level of Chief Engineer (Con). In PSU's, frequency of such tests shall be decided as per existing delegations for testing."</p> <ul style="list-style-type: none"> <li>In Para 7.4.1.c, in case of PSU, existing provision of Equivalent authority for acceptance criteria shall continue.</li> </ul>

SN	Specific issues/provisions of the guidelines	Board's decision
(vi)	Modified checklist of certification of quality of Earthwork in Railway Projects (Appendix-M)	Approved.
(vii)	Para 2.2 (ii) for suitability of subsoil	Approved.
(viii)	Para 2.3.5 for Ground Improvement for expansive soils	Approved.
(ix)	Para 2.4.1 for Use of Geo-composite drain	Approved.
(x)	Para 2.4.4 for Geo-synthetics encapsulated Stone column	Approved.
(xi)	Para 3.4 for Cross Slope of Formation	Approved.
(xii)	Para 3.7 for Soils to be normally avoided	Approved.
(xiii)	Table 3.3 to 3.6 regarding filter criterion	Approved.
(xiv)	Chapter 4 regarding applications of geo-synthetics in railway formation and Appendix C- specification of geo-synthetic products	Approved.
(xv)	Para 5.1 regarding requirement of flatter slope	Approved.
(xvi)	Para 5.1.1 & 5.1.2 regarding provision of berm	Approved.
(xvii)	Appendix B of Illustrative Examples for providing minimum thickness of Formation Layers	Approved.
(xviii)	Newly added test procedures for Nuclear Moisture Density Gauge	Approved.
(xix)	Appendix J regarding Proforma for Reporting Unstable Formation	Approved.

RDSO shall circulate the final draft to Zonal Railways/PSUs. Zonal Railways/PSUs shall take necessary action for adoption of above guidelines and for closely monitoring the implementation for a period of two years and to furnish feedback/suggestions to RDSO for improvement, if any.

North Central Railway & Western Railway are nominated for field validation for fitment of existing formation for passenger train operations at 160 kmph and South Eastern Railway & East Coast Railway for field validation for fitment of existing formation for 22.9t/25t axle load operation at 100 kmph.

Any deviation to above guidelines/specifications based on logic/local conditions can be permitted with approval of PCE/CAO(C) only.

  
 (Pradeep Nagar)  
 Director Civil Engg. (Plg.)  
 Railway Board

Copy for necessary action to:

- (i) PCEs/All Zonal Railway
- (ii) CAO(C)/All Zonal Railway
- (ii) MD/KRCL, RVNL, IRCON, DFCCIL, RITES, MRVC.