8. FIELD DENSITY TEST BY SAND REPLACEMENT METHOD.
(IS : 2720 – PART – 28)

INTRODUCTION:

The dry density of the compacted soil or pavement material is a common measure of the amount of the compaction achieved during the construction. Knowing the field density and field moisture content, the dry density is calculated. Therefore field density test is importance as a field control test for the compaction of soil or any other pavement layer.

There are several methods for the determination of field density of soils such as core cutter method, sand replacement method, rubber balloon method, heavy oil method etc. One of the common methods of determining field density of fine-grained soils is core cutter method; but this method has a major limitation in the case of soils containing coarse-grained particles such as gravel, stones and aggregates. Under such circumstances, field density test by sand replacement method is advantageous, as the presence of coarse-grained particles will adversely affect the test results.

The basic principle of sand replacement method is to measure the in-situ volume of hole from which the material was excavated from the weight of sand with known density filling in the hole. The in-situ density of material is given by the weight of the excavated material divided by the in-situ volume.

Object:

To determination of field density by sand replacement method.

Apparatus:

a) Sand pouring cylinder equipment:

(i) Small pouring cylinder: suitable for fine and medium grained soils. This consists of a metal cylinder of capacity 3 liters, 100mm in diameter and 380 mm length with an inverted funnel or cone at one end and a shutter to open and close the entry of sand and a cap on the other end. Metal tray to excavate the hole with suitable shape and size. Calibration container of the small pouring cylinder (size 100X150mm)

(ii) Large pouring cylinder: suitable for fine, medium and coarse grained soils. This consists a metal cylinder of capacity 16.5 liters, 200mm in diameter and 610mm length with all arrangements mentioned above. Calibration container size 200X250mm

(iii) Medium pouring cylinder: suitable for fine, medium and coarse grained soils. This cylinder with 150mm diameter and length 450mm. The calibration container size is 150X200mm.

b) Tools for leveling and excavating: Hand tools such as scraper with handle for leveling the surface; a dibber or an elongated trowel for digging and excavating the material.

c) Containers: Metal containers of any convenient size (about 150mm diameter and 200mm depth) with removable lid for collecting the excavated material.

d) Sand: Dry and clean test sand of uniform gradation, passing 1.0mm and retained 600-micron sieve.

e) Balance: A suitable balance of capacity 15 or 30 kg accuracy 1.0 g and necessary set of weights.

Procedure:

The test may be conducted in two stages: (i) calibration of apparatus and (ii) measurement of field density.

(i) Calibration of apparatus:

The determination of volume of the excavated hole is based on the weight of sand filling the hole and the cone and the density of the sand. Calibration of apparatus includes (a) determination of density of test sand used in the experiment under identical height and pouring conditions of the sand into the test hole and (b) determination of the weight of the sand occupying the cone of the sand-pouring cylinder.

Clean and dry test sand passing 1.0mm sieve and retained 600-micron sieve is collected in sufficient quantity required for at least three to four sets of tests. The top cap of the sand-pouring cylinder is removed, the shutter is closed, the cylinder is filled with dry test sand up to about 10mm from the top and the cap is replaced. The weight of the cylinder with the sand is determined accurate to one gram and is recorded = W1. In all the subsequent tests for calibration as well as for the field density tests, every time the sand is filled into the cylinder such that the initial weight of the cylinder with sand is exactly W1. The sand pouring cylinder is placed over the calibration cylinder or one of the test holes already excavated, the shutter is opened and the sand equal to the volume of the calibration cylinder or the excavated test hole is allowed to flow out and the shutter is closed.

The sand pouring cylinder is now placed on a clean plane surface (glass or Perspex plate), the shutter is kept open till the sand fills up the cone fully and there is no visible movement of sand as seen from the top of the cylinder by removing the cap. The shutter is closed, the cylinder is removed and the sand which occupied the cone is carefully collected from the plate and weighed = W2.

The sand pouring cylinder is refilled with sand such that the initial weight is again W1. Now the cylinder is placed centrally on the top of the calibration container and the shutter is opened. When the sand fills up the calibration container and the cone completely and there is no movement of sand, the shutter is closed and the sand pouring cylinder and the remaining sand is weighed = W3.

The above steps are repeated three times and the mean values of W2 and W3 are determined such that the mean value of the weight of sand required to fill the calibration container up to the level top can be determined.

The volume of the calibrating container, V is determined either by measuring the internal dimensions or by filling with water and weighing. From the weight of sand Wa and its volume V in the calibrating container, the density of sand, is determined.

(ii) Measurement of field density:

The site where the field density test is to be conducted is cleaned and leveled using a scraper for an area of about 450 mm square. The metal tray central hole is placed on the prepared surface. Using this central hole as pattern, the soil/material is excavated using a dibber or a trowel up to a required depth and the loose material removed is carefully collected in the metal container and is weighed = W. The sand-pouring cylinder is refilled with sand such that its weight is again W1. The metal tray with central hole is removed and the sand-pouring cylinder is placed centrally over the excavated hole. The shutter is opened till the sand fills the excavated hole and the cone completely and there is no further movement of sand in the cylinder. The shutter is closed and the cylinder is weighed again = W4, so that the weight of sand filling the excavated hole alone = Wb can be found.

The moisture content of the excavated soil, w% is determined by taking a sample of soil from it in a moisture content dish, weighing, drying in oven at 110^0C and re-weighing. Alternatively, the moisture content (w%) is determined by placing the entire excavated soil collected from the hole (of weight W) in the oven and finding its dry weight = Wd.

The above steps for the determination of the weights of excavated soil, the weight of the sand filling the hole and the weights of samples for the moisture content determination are repeated at least three times and the average values taken for the determination of field density (wet and dry) values.

Calculations and Results:

W1 = weight of sand pouring cylinder and sand filled up to 10mm from top edge, g
W2 = weight of sand in the cone, mean value, g
W3 = weight of cylinder and sand after pouring into the calibration container and cone, g
W4 = weight of cylinder and sand after pouring into the excavated hole and cone, g
Va = volume of the excavating container, cm^3
W = weight of the soil from the excavated hole, g
Wd = oven dry weight of the soil excavated from the hole, g
w = moisture content of the soil, %

The weight of sand filling the calibrating container only = Wa = (W1 – W3 – W2), g

(i) Bulk density of sand, $\bullet_s = \frac{Wa}{Va}$, g/cm^3

Weight of sand filling the excavated hole alone = Wb = (W1 – W4 – W2), g

Volume of sand filling the excavated hole alone = V = $\frac{Wb}{\bullet_s}$, cm^3

(ii) In-situ bilk density of the wet excavated soil, $\bullet \bullet = \frac{W}{V}$, g/cm^3

(iii) Moisture content of soil, $w\% = \frac{100(W - Wd)}{Wd}$, %

(iv) In-situ dry bulk density of the excavated soil, $\bullet_d = \frac{\bullet\ Wd}{W} = \frac{100\ \bullet\bullet}{(100 + W)}$, g/cm^3

The results are reported as the average value of at least three sets of tests in the following:

(i) In-place wet density of soil in g/cm^3, correct to second decimal place or in kg/m^3, correct to nearest whole number.

(ii) In-place dry density of soil in g/cm^3 or in kg/m^3 (as above).

(iii) Moisture content of the soil in percent, correct to first decimal place.

TEST : FIELD COMPACTION TEST BY SAND REPLACEMENT METHOD
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Frequency of Tests	
Embankment	**1Tests / 1000m^2**
Subgrade	
Granular Sub Base	**1Test / 500m^2**

Permissible Limits	
Embankment	**Min. 95 %**
Subgrade	**Min. 97 %**
Granular Sub Base	**Min. 98 %**

Lab Ref No :________________ Date of Sampling :____________

Type of Material :________________ Date of Testing :____________

Location :Km_____________

Determination of Weight of Sand in Cone

S.No	Test No. :		1	2	3
a	Intial weight of container and sand	(gms)			
b	Final weight of container and sand after filling cone	(gms)			
c	Weight of sand in cone = (a) - (b)	(gms)			
	Average Value	(gms)			

Note : 1. Before test, remove from initially filled container a vplume of sand approximately equal to that of the calibrating cylinder.
2. Use density plate in each test.
3. Place container with cone on level ground / glass plate.

Determination of Bulk Density of Sand :

S.No	Test No. :		1	2	3
c	Weight of sand in cone	(gms)			
d	Weight of sand before pouring	(gms)			
e	Weight of sand after pouring	(gms)			
f	Weight of sand in calibration cylinder [(d) - (c) - (e)]	(gms)			
g	Volume of calibration cylinder	(cc)			
h	Bulk density of Sand (f) / (g)	(gms/cc)			
Average Value		**(gms / cc)**			

Remarks :____

Tested by :______________________ Checked by :_______________ _______________
(For Contractor) (For Contractor) (For Engineer)