SAND REPLACEMENT (INSITU-DENSITY) METHOD (IS 2720-PART-28-1974) Reaffirmed-2010

THEORY:

Sand replacement method is used to determine the in-situ density of soil. The in-situ density is defined as the density of soil measured at its actual depth on the field. The in-situ moisture content of soil varies with time, resulting in variable in-situ bulk density. To avoid variation with time, the in-situ density should be reported in terms of the dry density with moisture content.

NEED & SCOPE:

In-situ density of the soil is needed for the determination of following:

- Bearing capacity of soils
- Stability analysis of slopes and earth retaining structures
- Determination of pressures on underlying strata for the calculation of settlement and the design of underground structures

Where soil compaction is required (projects like embankment and earth dam construction), sand replacement method can be used as a quality control test to evaluate the degree of compaction.

APPARATUS REQUIRED:

1. Sand pouring apparatus
2. Calibration cylinder
3. Glass plate
4. Vernier calliper
5. Standard sand-graded between 300 micron and 600 micron
6. Soil tray with a central hole
7. Digging tools like chisels
8. Balance of 20 kg capacity
9. Containers for moisture content determination
10. Sensitive balance accurate to 0.01gm
11. Oven controlled at 105˚ C

PROCEDURE:

Weight of Sand Occupying the Cone of the Sand Pouring Apparatus

1. Pour sand into the sand pouring apparatus with valve closed and determine weight of apparatus filled with sand (W_1).
2. Place the apparatus on a smooth glass plate and open the valve to fill the conical portion. After the sand stops running from apparatus, close the valve sharply, and weight the remaining sand with the apparatus (W_2).
3. The weight ($W_1 – W_2$) represents the weight of sand required to fill the cone of the apparatus.

Density of Sand

1. Fill the Sand Pouring Apparatus again with valve closed and determine weight of apparatus filled with sand (W_3).
2. Place the sand pouring apparatus concentrically on top of the calibrating cylinder. Open the shutter and allow the sand to drain out. When no further movement of sand takes place in the apparatus, close the shutter and weight the apparatus with remaining sand (W_4).
3. The weight (W_3-W_4) represents the quantity of sand used in filling calibrating cylinder as well as cone of the apparatus.
4. Weight of sand required to fill the calibrating cylinder can be calculated as [(W_3-W_4) – (W_1 – W_2)].
5. Volume (V_c) of the cylinder may be determined either by measuring its internal dimensions or by filling it with water and determining the volume of water required to fill the cylinder.
6. Density of sand can be computed using mass of sand filled in cylinder and volume (V_c) of the cylinder.

Density of Soil

1. Prepare the surface of the location to be tested so that it is a level plane. Keep the soil tray firmly on the surface.
2. Excavate with hand tools a hole with diameter equal to that of the hole of the plate and about 10 cm in depth with smooth walls and rounded bottom edges.
3. Place the extracted soil from hole in a container being careful to avoid losing any material and determine the weight of extracted soil.
4. Place the already weighed sand pouring apparatus filled with sand (W_5) on the hole of the tray. Open the valve and after the sand has stopped flowing close the valve.
5. Weigh the apparatus with remaining sand (W_6) and determine the weight of sand occupying the cavity [(W_6-W_5) - (W_1-W_2)].
6. Take three representative sample from the extracted soil for moisture content determination.

OBSERVATIONS & RECORDINGS:

From the known density of sand and the weight of sand occupying the hole, calculate the volume of hole.

From the weight of the soil scooped out of hole whose volume is now known and the value of moisture content, calculate the wet and dry density of soil.

Dimensions of Calibration Cylinder

Internal diameter of calibration cylinder = cm

Height of calibration cylinder = cm

Volume of calibration cylinder from the dimensions = cc

Volume of calibration cylinder from the weight of filled water = cc

I) DENSITY OF STANDARD SAND

a) Sand Occupying Cone	
Weight of sand pouring cylinder + sand before opening shutter (Glass Plate) (W_1)	
Weight of sand pouring cylinder + sand after opening shutter (Glass Plate) (W_2)	
Weight of sand in cone (W_1-W_2)	
b) Sand Occupying Calibrating Cylinder	
Weight of sand pouring cylinder + sand before opening shutter (W_3)	
Weight of sand pouring cylinder + sand after opening shutter (W_4)	
Weight of sand in Calibrating Cylinder W_c= (W_3-W_4) – (W_1 – W_2)	

Density of the standard sand $\gamma_s = W_c/V_c$

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II) In-situ Density using Sand Replacement Method:

No.	Particulars	
1.	Bulk density of standard sand, γ_s (gm/cc)	
2.	Weight of sand pouring apparatus +sand before experiment (W_5), gm	
3.	Weight of sand pouring apparatus + sand after experiment (W_6), gm	
4.	Weight of sand drained out (W_6-W_5), gm	
5.	Weight of sand occupying cone (W_1-W_2), gm	
6.	Weight of sand occupying cavity [Ws= (W_6-W_5) – (W_1-W_2)], gm	
7.	Volume of cavity (V= W_s/ γ_s), cc	
8.	Weight of soil scooped out from the cavity (W), gm	
9.	Bulk density (γ_t = W/V), gm/cc	
10.	Moisture content, w%	
11.	Dry density, [γ_d = γ_t /(1+w)], (gm/cc)	

Moisture Content Percent:

CONTAINER No.			
Wt. of container, W_t (gm)			
Wt. of container + Wet soil, W_w (gm)			
Wt. of container + Dry soil , W_d (gm)			
Wt. of water, W_w-W_d (gm)			
Wt. of dry soil, W_d-W_t (gm)			
Moisture content, w % = (W_w-W_d / W_d-W_t) * 100			
Average moisture content, w%			

- Average Moisture Content of the Soil Layer = %
- Average Dry Density of the Soil Layer = gm/cc