RELATIVE DENSITY OF COHESIONLESS SOIL
(IS 2720-PART 14-1983) Reaffirmed-2006

THEORY:

Relative density or density index is the ratio of the difference between the void ratios of a Cohesionless soil in its loosest state and existing natural state to the difference between its void ratio in the loosest and densest states. Porosity of a soil depends on the shape of grain, uniformity of grain size and condition of sedimentation. Hence porosity itself does not indicate whether a soil is in loose or dense state. This information can only be obtained by comparing the porosity or void ratio of the given soil with that of the same soil in its loosest and densest possible state and hence the term, relative density is introduced.

$$\textbf{Relative Density} = \frac{\mathbf{e_{max} - e}}{\mathbf{e_{max} - e_{min}}}$$

Where, e_{max} = void ratio of coarse grained soil (Cohesionless) in its loosest state

e_{min} = void ratio of coarse grained soil (Cohesionless) in its densest state

e =void ratio of coarse grained soil (Cohesionless) in its natural existing state in the field.

We have $e=V_v/V_s$ &

$\gamma_d = G_s\gamma_w/(1+e)$;

$e = G_s\gamma_w/\gamma_d - 1$.

So, void-ratio e is inversely proportional to the dry-density of the material (soil) under consideration.

NEED &SCOPE:

To determine the relative density of given coarse grained material. Relative density is an arbitrary character of sandy deposit. In real sense, relative density expresses the ratio of actual decrease in volume of voids in a sandy soil to the maximum possible decrease in the volume of voids i.e. how far the sand under investigation can be capable to the further densification beyond its natural state. Determination of relative density is helpful in compaction of coarse grained soils and in evaluating safe bearing capacity in case of sandy soils. For very dense gravelly sand, it is possible to obtain relative density greater the one. This means that such natural dense packing could not be obtained in the laboratory.

APPARATUS REQUIRED:

1. Cushioned steel vibrating deck 75x75 cm size, R.P.M: 3600; under a 115 kg load, electrical, 3 phase supply
2. Two cylindrical metallic moulds, 3000 cc and 15000 cc.
3. 10 mm thick surcharge base plate with handle separately for each mould.
4. Surcharge weights, one for each size having a weight equal to 140 gm/cm^2
5. Dial gauge holder, which can be slipped into the eyelets on the moulds sides.
6. Guide sleeves with clamps for each mould separately
7. Calibration bar 75 x 300 x 3 mm

SAMPLE PREPARATION:

1. Dry the soil sample in a thermostatically controlled electric oven.
2. Cool in the sample in a desiccator.
3. Segregate soil lumps without breaking individual particles and sieve through the required sieve size.

PROCEDURE:

1. Measure inside diameter of mould at different depths using a bore gauge and take the average.
2. Keep the mould on a flat surface or flat plate. Measure the height at different positions and take the average (accuracy = 0.025 mm).
3. Calculate the volume.
4. Fill the mould with distilled water till over flowing takes place.
5. Slid thick glass plate over the top surface of mould.
6. Weigh the water filling the mould and note down the temperature of the water.
7. Obtain density of water for the above temperature from physical tables and calculate the volume of the mould which is weight of water filling the mould /density of water.

CALCULATIONS:

Minimum Density:

The mould is weighed accurately (W). Pour the dry pulverized soil into the mould through a funnel in a steady stream. The spout is adjusted so that the free fall of soil particle is always 25 mm. While pouring soil the spout must have a spiral motion from the rim to the center. The process is continued to fill up the mould with soil up to about 25mm above the top. It is then leveled, with the soil and weight is recorded (W_1).

Volume of mould =V cc =

Mass of dry soil M_s = (W_1-W) gm

=

=

$(\gamma_d)_{min} = M_s / V$ **gm/cc**

=

$e_{max} = G_s\gamma_w/(\gamma_d)_{min} - 1$

=

=

Maximum Density:

Weigh the empty mould (W). Put the collar on top of the mould and clamp it. Fill the mould with the oven dried soil sample till 1/2 or 2/3 of the collar is filled. Place the mould on the vibrating deck and fix it with nuts and bolts. Then place the surcharge weight on it. The vibrator is allowed to run for 8 minutes. Then mould is weighed with the soil and weight is recorded (W_2).

Volume of mould =V cc =

Mass of dry soil M_s = (W_2-W) gm

=

$(\gamma_d)_{max} = M_s / V$ **gm/cc**

=

$e_{min} = G_s\gamma_w/(\gamma_d)_{max} - 1$

=

=

Natural Density:

Weigh the mould with dry soil. Knowing the volume of the mould and weight of dry soil, natural density, γ_d, can be calculated as follows:

$e = G_s\gamma_w/\gamma_d - 1$

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$$\textbf{Relative Density} = \frac{e_{max} - e}{e_{max} - e_{min}}$$

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