EXPERIMENT NO. 2

Determination of maximum and minimum void ratios of granular soils (ASTM D 4253-93 and D 4254-00)

2.1 Purpose

This experiment is performed to determine the relative density of cohesion less, free draining soil using a vibrating table. The relative density of soil is expressed as a percentage of the difference between maximum index void ratio and field void ratio of cohesion less, free draining soil; to the difference between the maximum and minimum index void ratios.

2.2 Reference

- ASTM D 4253- Standard test method for maximum index density and unit weight of soil using vibratory table
- ASTM D 4254- Standard test method for minimum index density and unit weight of soil

2.3 Apparatus

- Vibrating Table
- Mould and Assembly
- Surcharge base plate
- Surcharge weights
- Surcharge base plate handle
- Dial gauge , balance
- Straight edge

Fig 1.3 Vibrating Table Apparatus

2.4 Related Theory

2.4.1 Maximum Index Dry Density/Unit Weight γ_{dmax}

It is the reference dry density or unit weight of a soil in the densest state of compactness that can be attained using a standard laboratory compaction procedure that minimizes particle segregation and breakdown.

2.4.2 Maximum Index Void ratio e_{max}

It is the reference void ratio of a soil at the minimum index dry density or unit weight.

2.4.3 Minimum Index Dry Density/Unit Weight γ_{dmin}

It is the reference dry density or unit weight of a soil in the loosest state of compactness at which it can be placed using a standard laboratory procedure that prevents bulking and minimizes particle segregation

2.4.4 Minimum Index Void ratio e_{min}

It is the reference void ratio of a soil at the maximum index dry density or unit weight.

2.4.5 Relative Density D_r

Granular soils are relatively porous and well drained. As a result, their compaction characteristics are less affected by water content and it is not common to see classical compaction curve as in case of cohesive soils.

The grain size distribution plays a key role in the geotechnical behavior of coarse grained soils. For the same grain size distribution, the soils can exhibit quite different strength and stiffness characteristics, depending upon how closely the grains are packed. Generally the strength (i.e. friction angle) and stiffness (e.g. Young's modulus) increase with the packing density. The density of packing at the void ratio *e* is quantified through a term known as *relative density* D_r that lies within the range of 0 to 100%.

The relative density of soil is expressed as a percentage of the difference between maximum index void ratio and field void ratio of cohesion less, free draining soil; to the difference between the maximum and minimum index void ratios.

$$D_r = \frac{e_{max} - e_f}{e_{max} - e_{min}} \times 100$$

e_{max} = maximum index void ratio

e_{min} = minimum index void ratio

e_f = field void ratio

The term relative density is meaningless in cohesive soils. Dry unit weight and void ratio are related as

$$\gamma_d = \frac{G_s \gamma_w}{1+e}$$

Relative density in terms of dry unit weight is expressed as:

$$D_r = \frac{\frac{1}{\gamma_{dmin}} - \frac{1}{\gamma_{df}}}{\frac{1}{\gamma_{dmin}} - \frac{1}{\gamma_{dmax}}} \times 100$$

$$D_r = \frac{\gamma_{dmax}}{\gamma_{df}} \times \frac{\gamma_{df} - \gamma_{dmin}}{\gamma_{dmax} - \gamma_{dmin}} \times 100$$

2.4.6 Classification of Granular Soils on the basis of Relative Density

2.4.7 Relation between Relative Density & Relative Compaction

Relative density and relative compaction are related as;

Rc = 80 + 0.2 Dr

Where Rc is relative compaction and Dr is relative density.

2.5 Procedure

- Fill the mold with the soil (approximately 0.5 inch to 1 inch above the top of the mold) as loose as possible by pouring the soil using a scoop or pouring device (funnel). Spiraling motion should be just sufficient to minimize particle segregation

- Trim off the excess soil level with the top by carefully trimming the soil surface with a straight edge.
- Determine the mass of the mold and soil for determining the minimum dry density
- Attach the mold to the vibrating table.
- Determine the initial dial reading by inserting the dial indicator gauge holder in each of the guide brackets with the dial gage stem in contact with the rim of the mold (at its center) on the both sides of the guide brackets. Obtain six sets of dial indicator readings, three on each side of each guide bracket. The average of these twelve readings is the initial dial gage reading, Ri. Record Ri to the nearest 0.001 in. (0.025 mm).
- Firmly attach the guide sleeve to the mold and lower the appropriate surcharge weight onto the surcharge base-plate. (See Fig 1.5)
- Vibrate the mold assembly and soil specimen for 8 min at frequency of 60 Hz.
- Determine the dial indicator gage readings. The average of these readings is the final dial gage reading, Rf.
- Remove the surcharge base-plate from the mold and detach the mold from the vibrating table.
- Determine mass of the mold and soil. Determine and record the dimensions of the mold (i.e., diameter and height) in order to calculate the volume of the mold, V. Also, determine the thickness of the surcharge base-plate, Tp.

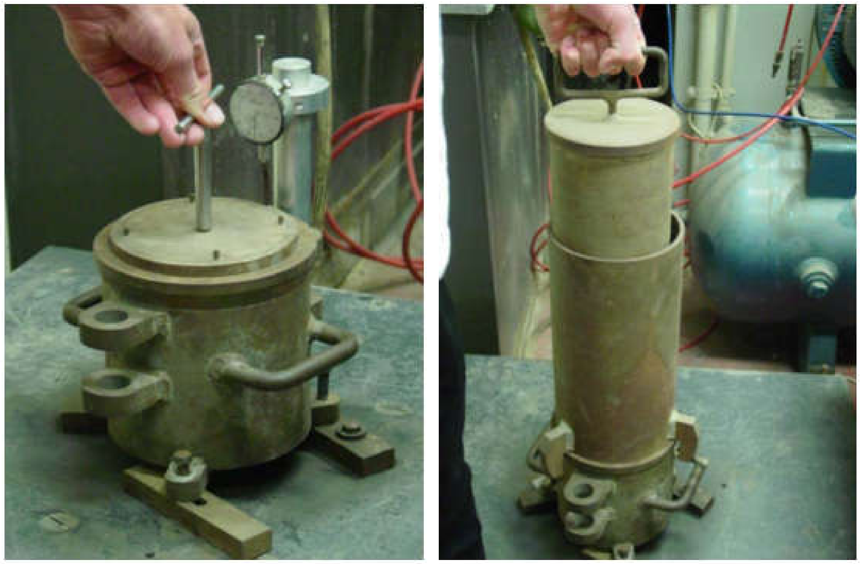

Fig 1.5

2.6 Observations & Calculations

Diameter of mold D = 6.1 in = 15.494 cm

Height of mold H = 6.0 in = 15.240 cm

Volume of mold V_1= 175.348 in^3 = 2873.439 cm^3

Specific gravity of soil solids Gs = 2.65

Surcharge base plate weight + surcharge weight = 25060 g

Surcharge base plate thickness Tp = 13.82 mm = 1.382 cm

Sample No.	1	2	3
Initial D/R Reading	0	0	0
Final D/R Reading	1.156	1.597	1.119
Difference ΔH (cm)	1.156	1.597	1.119
H'=ΔH + Tp (cm)	2.538	2.979	2.501
Vol V_2=V_1-A*H' (cc)	2394.909	2311.761	2401.886
Weight of Sample Ws (g)	4054	3799	4038
Minimum Index Density γ_{dmin} =Ws/V_1 (g/cc)	1.411	1.322	1.405
Maximum Index Density γ_{dmax} = Ws/V_2 (g/cc)	1.693	1.643	1.681
Maximum Index Void Ratio e_{max}	0.878	1.004	0.886
Minimum Index Void Ratio e_{min}	0.565	0.613	0.576

Difference ΔH = (Final D/R – Initial D/R) * Least count of Dial Gauge

In ASTM standards depth is measured using a dial gauge but here we have used Vernier calipers for measuring the depth so we take initial D/R as zero and no need to multiply with least count.

A = inner cross sectional area of mold

Minimum Index density $\gamma_{dmin} = Ws/V_1$

Maximum Index density $\gamma_{dmax} = Ws/V_2$

Maximum void ratio $e_{max} = Gs\gamma_w/\gamma_{dmin} - 1$

Minimum void ratio $e_{min} = Gs\gamma_w/\gamma_{dmax} - 1$

2.7 Precautions

- Soil should be poured into the mold with the help of a pouring device (scoop or funnel etc.) according to the standard.
- Particle segregation and particle breakdown should be prevented while pouring the soil into the mold.

2.8 Comments