Experiment No. 7

RELATIVE DENSITY TEST



Introduction

Relative Density principles apply to compaction of relatively clean, coarse-grained soils. Relatively clean, coarse-grained soil usually means less than 15 % fines. Compaction Tests are not commonly performed on soils with 15 % or fewer fines. Small percentage of fines means soilscannot easily hold water to examine range of water and effect on dry density.

Relative density can be found by the equation given below:

$$Dr(\%) = \frac{e_{max} - e_{measured}}{e_{max} - e_{min}} \times 100$$

According to the relative density values, soil can be classified using the chart given below:

Relative Density	State of compaction
0-15	Very loose
15-50	Loose
50-70	Medium dense
70-85	Dense
85-100	Very dense

Scope of the test

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

Standard References

ASTM D4254-16– Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.

ASTM D4253-16– Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.

Significance

Relative density and percent compaction are commonly used for evaluating the state of compactness of a given soil mass. The engineering properties, such as shear strength, compressibility, and permeability, of a given soil depend on the level of compaction.

Equipment

- Vibrating Table,
- Mold Assembly consisting of standard mold,
- guide sleeves,
- surcharge base-plate,
- surcharge weights,
- surcharge base-plate handle,
- dial-indicator gage,
- Balance,
- Scoop,
- Straightedge.

Test Procedure:

Minimum Density Index:

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

(2) Trim off the excess soil level with the top by carefully trimming the soil surface with a straightedge.

(3) After filling the mold, excess soil is carefully screed off. Knowing the weight of soil in the mold (M_{s1}), the dry density is easily computed.

Maximum Density Index:

(1) Again fill the mold with soil (do not use the same soil used in step 1) and level the surface of the soil by using a scoop or pouring device (funnel) in order to minimize the soil segregation. The sides of the mold may be struck a few times using a metal bar or rubber hammer to settle the soil so that the surcharge base-plate can be easily placed into position and there is no surge of air from the mold when vibration is initiated.

(2) Place the surcharge base plate on the surface of the soil and twist it slightly several times so that it is placed firmly and uniformly in contact with the surface of the soil. Remove the surcharge base-plate handle.

(3) Attach the mold to the vibrating table.

(4) Vibrate the mold assembly and soil specimen for 10 min.

(5) Determine and record the mass of the mold and soil (M_{S2}).

(6) Determine the decreased height, H′ of the soil to compute the decreased volume of the soil.

(7) Empty the mold and determine the weight of the mold.

(8) Determine and record the dimensions of the mold (i.e., diameter, D and height, H) in order to calculate the calibrated volume of the mold, V_c.

Analysis

(1) Calculate the minimum density index (ρ_{dmin}) as follows:

$$\rho_{d,min} = \frac{M_{s1}}{V}$$

where

Ms1= mass of tested-dry soil
= Mass of mold with soil placed loose – mass of mold
V = Calibrated volume of the mold

(2) Calculate the maximum density index (ρ_{dmax}) as follows:

$$\rho_{dmax} = \frac{M_{S2}}{V}$$

Where

Ms_2 = mass of tested-dry soil
= Mass of mold with soil after vibration – Mass of mold
V = Volume of tested-dry soil

(3) Calculate the maximum and the minimum-index void ratios as follows (use Gs value determined from Experiment 4; ρw=1 g/cm3):

$$e_{min} = \frac{\rho_w G_s}{\rho_{dmax}} - 1 \qquad e_{max} = \frac{\rho_w G_s}{\rho_{dmin}} - 1 \qquad e = \frac{\rho_s}{\rho_d} - 1$$

(4) Calculate the relative density as follows:

$$D_d = \frac{e_{max} - e}{e_{max} - e_{min}}$$

Calculate the void ratio of the natural state of the soil based on ρ_d and $\rho_s = G_S * \rho_w$ (G_s determined from Experiment 2) as follows:



(a) (b) (c)

(d) (e) (f)

Figure 7.1: Relative density test, (a) Measuring of soil before pouring, (b) Dimension of mold, (c) Pouring of soil at loosest state, (d) leveling of soil, (e) Initial reading and (f) Loaded sample before vibration

DATA SHEET

Experiment Name : **Relative Density Test**
Experiment Date :

Student's Name :
Student's ID :
Year/ Semester :
Section/ Group :

Visual Classification :

Mass of empty mold :
Diameter of empty mold :
Height of empty mold :
Mass of mold and soil (M_1) :
Mass of mold and soil (M_2) :

Calculations:

Result:
Relative Density of the soil is:

Course Teacher :
Designation :

Signature