EXPERIMENT 1

RELATIVE DENSITY DETERMINATION

Purpose:

This lab 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 D 4254 – Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.

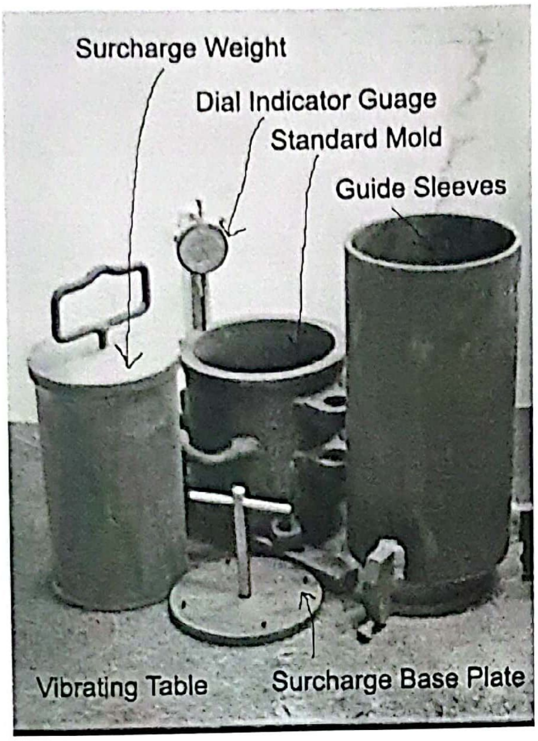
ASTM D 4253 – Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.

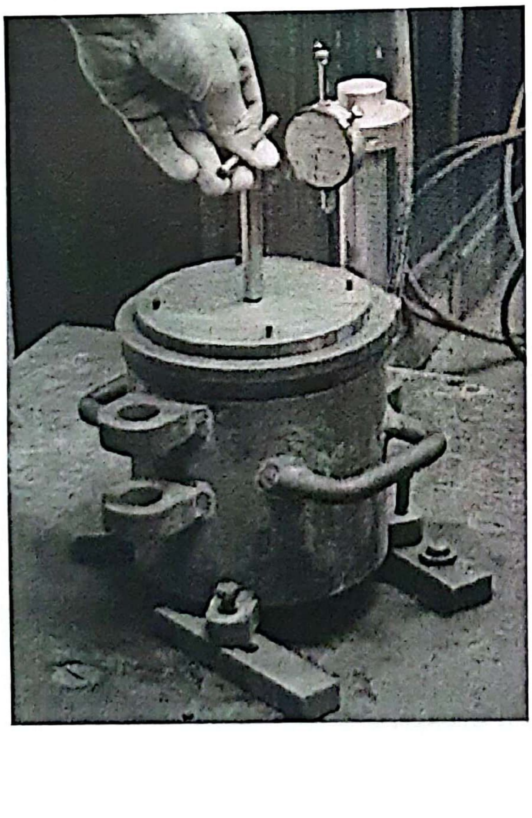
Significance:

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, and dial-indicator gage, Balance, Scoop, Straightedge.


Surcharge Weight
Dial Indicator Guage
Standard Mold
Guide Sleeves
Vibrating Table
Surcharge Base Plate



Test Procedure:

(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) Determine and record the mass of the mold and soil. Then empty the mold (M_1). See Photograph on Page 2.

(4) 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.

(5) 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.

(6) Attach the mold to the vibrating table.

(7) 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 sideof each guide bracket. The average of these twelve readings is theinitial dial gage reading, R_i. Record R_i to the nearest 0.001 in. (0.025mm). See Photograph on Page 2.

(8) Firmly attach the guide sleeve to the mold and lower the appropriate surcharge weight onto the surcharge base-plate. See Photograph on Page 35.

(9) Vibrate the mold assembly and soil specimen for 8 min.

(10) Determine and record the dial indicator gage readings as in step (7). The average of these readings is the final dial gage reading, R_f.

(11) Remove the surcharge base-plate from the mold and detach the mold from the vibrating table.

(12) Determine and record the mass of the mold and soil (M_2)

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

(14) Determine and record the dimensions of the mold (i.e., diameter and height) in order to calculate the calibrated volume of the mold, V_c. Also, determine the thickness of the surcharge base-plate, T_p.

Analysis:

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

$$\rho_{dmin} = \frac{M_{S1}}{V_C}$$

where

M_{s1}= mass of tested-dry soil

= Mass of mold with soil placed loose – mass of mold

V_c= Calibrated volume of the mold

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

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

where

M_{s2} = mass of tested-dry soil

= Mass of mold with soil after vibration – Mass of mold

V = Volume of tested-dry soil

= $V_c - (Ac*H)$

Where

Ac = the calibrated cross sectional area of the mold

$H = |R_f - R_i| + T_p$

(3) Calculate the maximum and the minimum-index void ratios as follows (use G_s value determined from Experiment 4; ρ_w=1 g/cm^3):

$$e_{min} = \frac{\rho_w G_s}{\rho_{dmin}} - 1$$

$$e_{max} = \frac{\rho_w G_s}{\rho_{dmin}} - 1$$

(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 (Experiment 3) *and* $\rho_s = G_s \cdot \rho_w$ (Gs determined from Experiment 4) as follows: $e = \frac{\rho_s}{\rho_d} - 1$]

EXAMPLE DATA

RELATIVE DENSITY DETERMINATION
DATA SHEET

Date Tested: September 10, 2018

Tested By: CEMM315 Class, Group A

Project Name: CEMM315 Lab

Sample Number: B-1, ST-1, 2'-3.5'

Sample Description: Brown sand

Mass of empty mold:	9.878 Kg
Diameter of empty mold:	15.45 cm
Height of empty mold:	15.50 cm
Mass of mold and soil (M_1):	14.29 Kg
Average initial dial gauge reading (R_i):	0.88 inches
Average final dial gauge reading (R_f):	0.40 inches
Thickness of surcharge base plate (T_P):	0.123 inches
Mass of mold and soil (M_2):	14.38 Kg

Calculations:

$$M_{s1} = 14.29 - 9.878 = 4.412 \text{ kg} = 4412 \text{ g}, \quad M_{s2} = 14.38 - 9.878 = 4.502 \text{ kg} = 4502 \text{ g}$$

$$A_c = \frac{\pi(15.45)^2}{4} = 187.47 \text{ cm}^2, \quad H = (0.88 - 0.4 + 0.123) \times 2.54 = 1.53 \text{ cm}$$

$$V_c = \frac{\pi(15.45)^2 15.5}{4} = 2905.88 \text{ cm}^3, \quad V = 2905.88 - (187.47 \times 1.53) = 2618.75 \text{ cm}^3$$

$$\rho_{dmin} = \frac{4412}{2905.88} = 1.52 \frac{g}{cm^3}, \quad \rho_{dmax} = \frac{4502}{2618.75} = 1.72 \frac{g}{cm^3}$$

Gs = 2.65 (Based on Experiment – 4 conducted using the soil)

$$e_{min} = \frac{1 \times 2.65}{1.72} - 1 = 0.54, \quad e_{max} = \frac{1 \times 2.65}{1.52} - 1 = 0.74$$

$$\rho d = 1.65 \frac{g}{cm^3}$$ (Based on Experiment – 3 conducted using this soil)

$$e = \frac{2.65}{1.65} - 1 = 0.61$$

$$D_d = \frac{0.74 - 0.61}{0.74 - 0.54} x100 = 65\%$$

BLANK DATA SHEETS

RELATIVE DENSITY DETERMINATION
DATA SHEET

Date Tested:

Tested By:

Project Name:

Sample Number:

Sample Description:

Mass of empty mold: ______________
Diameter of empty mold: ______________
Height of empty mold: ______________
Mass of mold and soil (M_1): ______________
Average initial dial gauge reading (R_i): ______________
Average final dial gauge reading (R_f): ______________
Thickness of surcharge base plate (T_P): ______________
Mass of mold and soil (M_2): ______________

Calculations: