GEOTECHNICAL & SOILS LABORATORY
SOILS COMPACTION

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SOILS COMPACTION

Introduction

In general, the soil bearing capacity will be increased simultaneously with the increment of density or unit weight of the soil. The increment of soil density can be obtained via compaction process i.e. the process of mechanically reducing the air void.

Objective

Determine the maximum dry density at the optimum moisture content under laboratory conditions.

Theory

Soil compaction test is carried out in the laboratory in determining the ideal volume of water to be poured while compacting the soil on site so that the required compaction degree can be obtained. The important characteristics of soil compacted with an ideal compaction degree are:

a) High shear strength
b) Low permeability coefficient and capacity
c) Reduce settlement when additional load is applied

The moisture content recorded when the maximum dry unit weight is achieved is known as the optimum moisture content.

There are two types of compaction i.e.

a) Standard Proctor
b) Modified Proctor

Standard Proctor will be used in undertaking the experiment where the standard data are recorded as the following:

	Volume of Mould	**Mass of Hammer**	**Drop Distance**	**No. of Blows Per Layer**	**No. of Layer**
Standard Proctor	944 cm^3	2.5 kg	305 mm	25	3

Equipments

a) Sieve 5.00 mm
b) Weighing machine
c) Empty mould with inner diameter of 101.6 mm, inner height of 16.43 mm and volume of 944 cm^3 together with the base plate
d) Hammer with diameter of 50 mm and mass of 2.5 kg
e) Other equipment in determining the soil moisture content

Procedures

a) Use the Standard Proctor
b) Collect small soil sample from jobsite
c) Prepare 5 kg of dry soil passing through 4.75 mm sieve opening
d) Weigh empty mould, collar and base plate
e) Mix thoroughly the sample with water (approximately 9% of the total soil volume)

f) Compact the soil sample in the mould
g) Place the mould on a stable and solid base
h) Compact the sample in 3 layers
i) Distribute 25 blows uniformly over the surface and ensure that rammer always falls freely and is not obstructed by soil in the guide tube
j) Remove the attached collar when compaction completes
k) Trim the compacted soil using the straightedge until it is even with the top of the mould before proceed with the next layer's compaction
l) Remove the compacted soil from the mould and place it on the metal tray
m) Determine the compacted soil's sample unit weight by dividing the weight of the compacted soil in the mould with the soil sample volume (volume of the mould)
n) Take a small amount of compacted soil from the mould to determine its moisture content
o) Repeat the experiment with four varying water content
p) Compute the dry density by using the compacted soil's wet (bulk) density and the moisture content known
q) Plot the soil's dry density versus moisture content
r) The curve shows how the dry density of compacted soil varies as the moisture content increased

The relationship between the dry density and the percentage of air content is illustrated as:

$$\rho_d = \rho_w \frac{(1 - A)}{(1/G_s + m)}$$

Example

Table 1

No. of Test		**1**	**2**	**3**	**4**
Mass of empty mould	**kg**	4.38	4.54	4.65	5.25
Mass of mould + wet soil	**kg**	6.20	6.55	6.65	7.15
Mass of wet soil	**kg**	1.82	2.01	2.00	1.90
Volume of mould		9.433 x 10^{-4} m^3			
Bulk density (ρ_b)	**kg/m³**	1929.7	2130.8	2120.2	2014.2
Dry density (ρ_d)	**kg/m³**	1774.9	1894.0	1824.3	1681.7

Table 2

No. of Container		**1**	**2**	**3**	**4**
Mass of empty container	**g**	9.6	9.7	10.0	9.7
Mass of container + wet soil	**g**	25.8	27.7	31.5	30.9
Mass of container + dry soil	**g**	24.5	25.7	28.5	27.4
Mass of water	**g**	1.3	2.0	3.0	3.5
Mass of dry soil	**g**	14.9	16.0	18.5	17.7
Moisture content (m)	**%**	8.72	12.5	16.22	19.77

Table 3

$G_s = 2.65$ $\rho_w = 1000\, kg/m^3$

A = 0%					A = 5%			
M%	**10**	**15**	**20**	**25**	**10**	**15**	**20**	**25**
$\rho_d \left(kg/m^3\right)$	2094.86	1896.24	1732.02	1593.99	1990.15	1801.43	1645.42	1514.29

A = 0%				
M%	**10**	**15**	**20**	**25**
$\rho_d \left(kg/m^3\right)$	1885.38	1706.62	1558.82	1435.59

Calculation

Example for Test No. 1

From Table 1:

Mass of wet soil (M) = 1.82 kg

Volumef mould (V) = 9.433×10^{-4} m^3

Bulk density ρ_b = $\dfrac{1.82}{9.433x10^{-4}}$

= 1929 kg/m^3

Dry density ρ_d = $\dfrac{\rho_b}{1+m}$

From Table 2:

m = 8.72%

ρ_b = $\dfrac{1929.4}{1+0.0872}$

= 1774.9

From Table 3:

When A = 0%

ρ_d = $\rho_w \dfrac{(1-A)}{(1/G_s + m)}$

= $\dfrac{1000\,(1)}{(1/(2.65)+0.1)}$

= 2094.86 kg/m^3

By using the data from Table 1, Table 2 and Table 3, the graph of dry density versus moisture content as well as the lines of air content of 0%, 5% and 10% can be plotted as shown in Figure 1.

Data

Table 1

No. of Test		1	2	3	4
Mass of empty mould	kg				
Mass of mould + wet soil	kg				
Mass of wet soil, M	kg				
Volume of mould, V	m^3				
Bulk density $(\rho_b) = \frac{M}{V}$	kg/m^3				
Dry density $(\rho_d) = \frac{\rho_b}{1+m}$	kg/m^3				

Table 2

No. of Container		1	2	3	4
Mass of empty container	g				
Mass of container + wet soil	g				
Mass of container + dry soil	g				
Mass of water, M_w	g				
Mass of dry soil, M_s	g				
Moisture content , $m = \frac{M_w}{M_s}$	%				

Table 3

Gs = 2.70

$\gamma_w = 1000\ kg/m^3$

	A = 0%				A = 5%			
M%	10	15	20	25	10	15	20	25
$\rho_d\left(kg/m^3\right)$								

	A = 0%			
M%	10	15	20	25
$\rho_d\left(kg/m^3\right)$				

Calculation

Result

Maximum density (ρ_{dry}) = kg/ m^3

Optimum moisture content (V) = %

Question

Illustrate the soil phase diagram before and after soil compaction.