جامعة بيرزيت

BIRZEIT UNIVERSITY

Faulty of Engineering and Technology

Civil Engineering Department

Soil Lab

ENCE311

Experiment #5 :

" Standard Proctor Compaction Test "

Instructors :

Dr. Saheem Murshid

Eng. Maha Jarrar

Done by Group A :

Mohammad Al-Swaity	" 1181136 "
Mohammad Turshan	" 1181619 "
Samer Maali	" 1180360 "
Thaljea Shaabna	" 1182216 "
Mohammad Marbou	" 1180360 "
Laith Mashahra	" 1181614 "
Mohammad Homran	

Date of performing the experiment : 4/10/2020

Date of submitting the experiment : 11/10/2020

Contents :

Introduction :

Soil is used in projects such as roads, airports and other projects, but it cannot be used when it is in its natural state because it will be weak soil and cannot bear the load over it and therefore it must be compacted to improve its properties, however, the soil compaction increases the density, bearing capacity, Thus reducing voids, unwanted leveling and permeability.

Compaction is a process for densifying the soil mass by reducing air voids. The purpose of this laboratory pressure test is to determine the appropriate amount of water in which the weight of soil grains in a compacted volume unit is the maximum, and thus the amount of water is called the optimum moisture content. From the water content it should be taken and mixed with the fraction of soil that passes through the American sieve No. 4. After calculating the dry density corresponding to each water content, a curve will be produced from this point

- To calculate dry density the bulk density should be calculated first:

$$\gamma = \frac{w}{Vm}$$

Where: γ : bulk unit weight.

W: weight of the compacted soil in the mold.

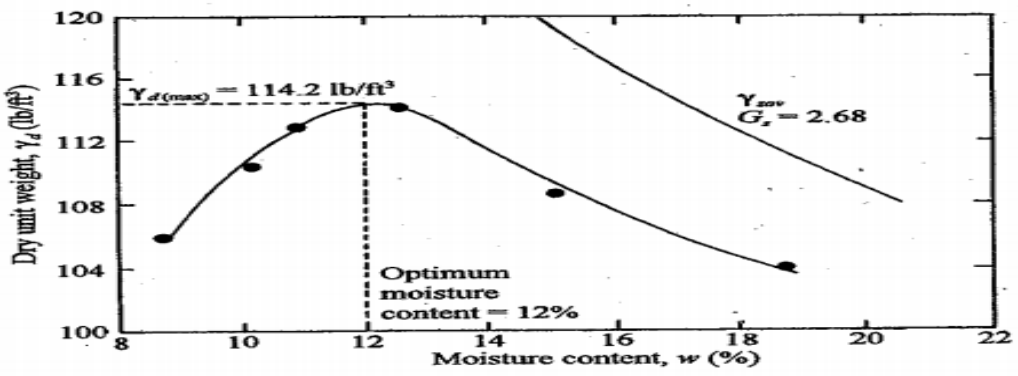
V_m : volume of the mold 2124 cm^3 .

- When using several water content then the dry density can be determined by:

$$\gamma d = \frac{\gamma}{1 + w(\%)/100}$$

Where: γd : dry density.

W(%): percentage of water content.



Relationship between water content and dry unit weight.

The relationship between the water content and the dry unit weight is a direct relationship and the reason is that the water acts as a softening agent on the soil particles, this is applied until the W (optimum) is reached, i.e. an increase in the moisture content tends to reduce the dry unit weight because the water takes up the spaces that would have been occupied. Soil particles

Assuming that all air in the voids of soil is removed a theoretical term will appear, for given moisture content and degree of saturation:

$$\gamma d = \frac{Gs * \gamma w}{1 + \frac{Gs * w}{s}}$$

Where: Gs: specific gravity of soil solids.

γw: Unit weight of water

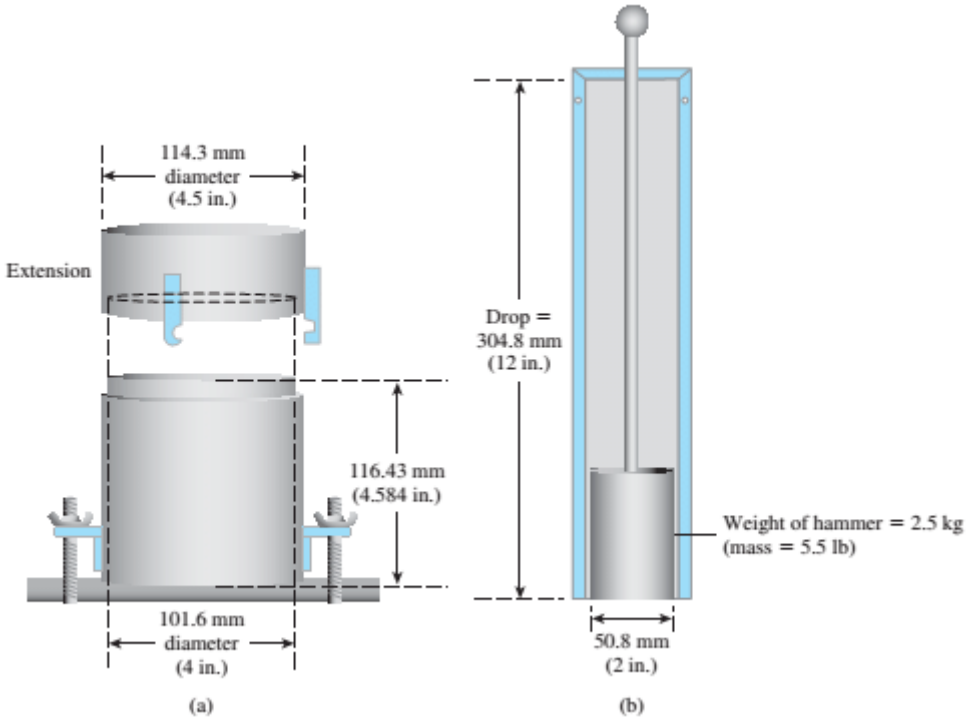
W (%): moisture content

S: degree of saturation

So it can be defined as the maximum theoretical unit weight the soil can be reached to it ,at a given moisture content when there is no air in the voids that's mean that all voids in the soil is filled with water only.

- There are two methods to defined the optimum moisture content:

1. Standard proctor test that has:
   - Volume: 943.9 cm^3.
   - Diameter of mold: 101.6 mm.
   - 3layers ,each layers 56blows.
   - Hammer has a mass of 2.49 kg and has a drop of 304.8 mm.

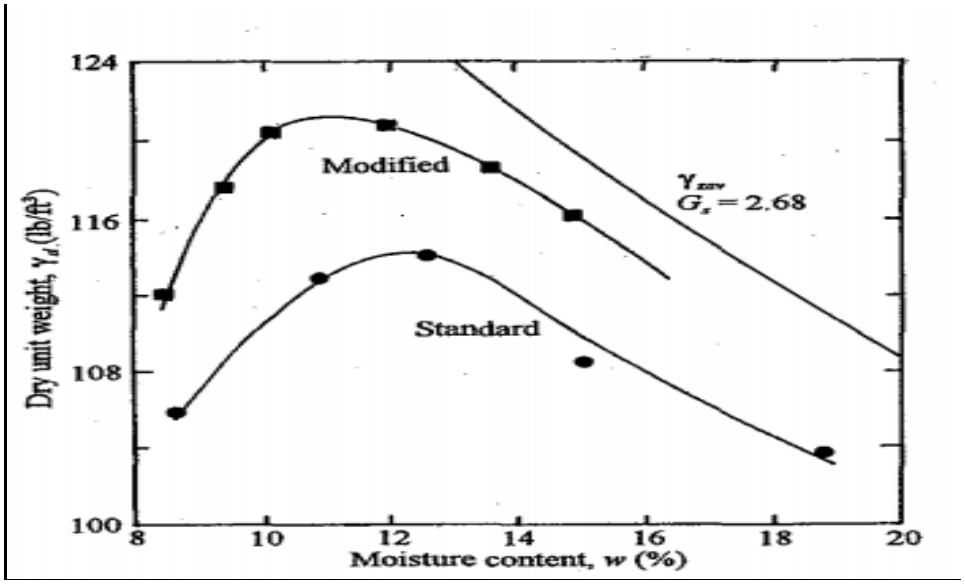


Equipment for Standard Proctor Test.

Modified proctor test that has:

- Volume of the mould: (1/13.33 ft^3) 2124 cm3.
- 5 layers each layers 25 blows, but in this experiment 5 layers, 56 blows.
- Hammer has a mass of 4.54 kg and has a drop of 457.2 mm.

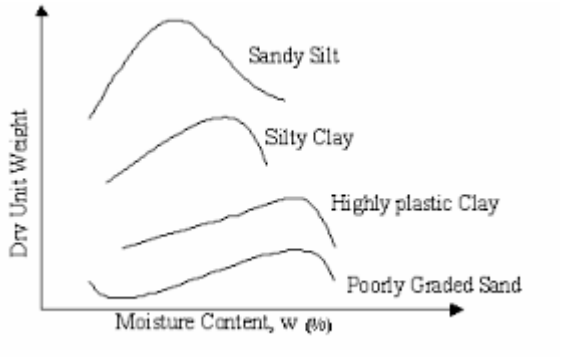
The modified proctor test has a dry density greater than the standard proctor test because the modified test has a compactive effort more than the standard therefore the modified proctor test used for big project like airport because it Exposed to large loads .



compaction test results for the soil reported.

There are many factors affecting on the degree of compaction the most important is :

- the type of soil :



- ✓ Important for calculation:
  - ➢ To determine the bulk unit weight: $\gamma = \frac{w2 - w1}{v}$

Where: γ : bulk unit weight .

w_1: weight of mold(g).

w_2 : weight of mold with weight of moist compacted soil (g).

v : volume of mold (cm^3).

  - ➢ to determine the moisture content: $w(\%) = \frac{A - B}{B - C} * 100$

Where :

A: mass of can with moist soil (g).

B: mass of can with dry soil (g).

C: mass of moisture (g).

  - ➢ To determine the dry unit weight :

$$\gamma d = \frac{\gamma}{1 + \frac{w(\%)}{100}}$$

Where : γ_d : bulk unit weight

W(%) : moisture content (%).

It is difficult to obtain the result in the field like the result in the lap therefore it is required to achieve a compacted field dry unit weight (90-95)% of the maximum dry unit weight obtained in the lap :

$$R(\%) = \frac{\gamma d.field}{\gamma d.\max.lab} * 100$$

Where : R(%):relative compaction.

Purpose :

The aim of this experiment is to determine the maximum dry density at optimum moisture content for a given soil sample by modified Proctor Test and take this value as a reference to find the value in the field .

Materials and Equipment's :

Look at the **" Table 1 "** that show the equipment we used in this experiment :

Equipment	The name of it :	Equipment	The name of it :
 Figure 1	**Compaction mold with an extension**	 Figure 2	**Modified proctor test**
 Figure 3	**Moisture cans**	 Figure 4	**Straight edge steel**
 Figure 5	**Balance**	 Figure 6	**Oven**

 Figure 7	**Graduated Cylinder**	 Figure 8	**Sieve (3/4) In**

" Table 1 "

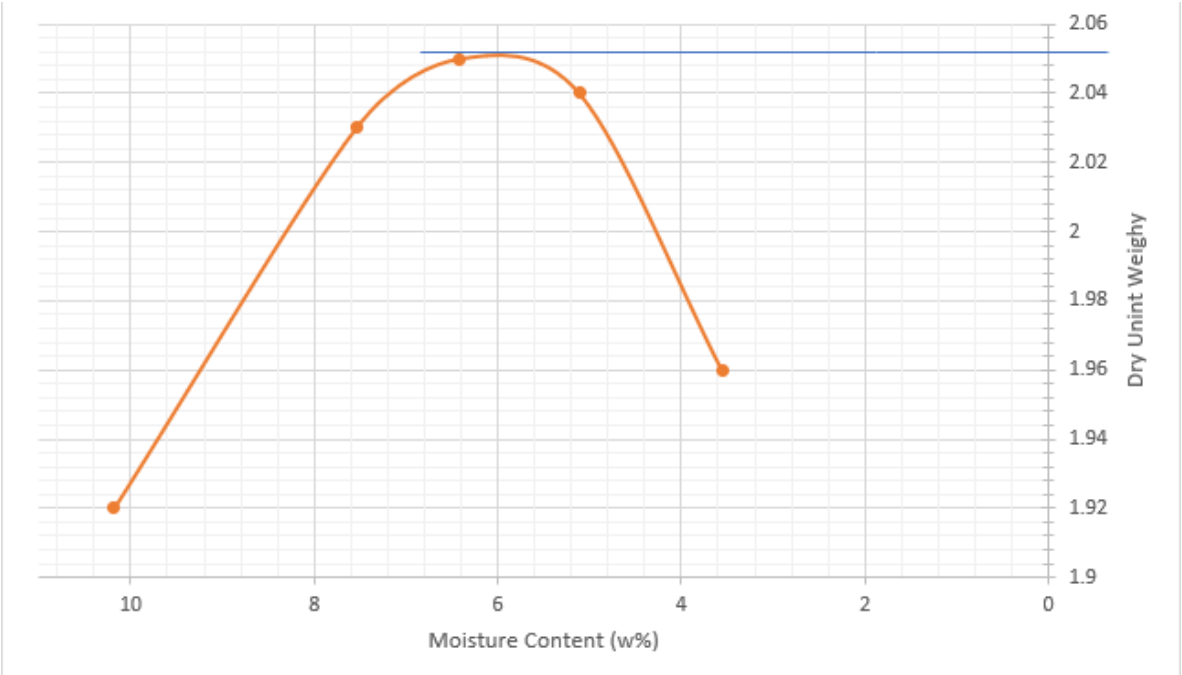
Procedure :

- Obtain about 9 kg dry soil.
- Sieve the soil on a No.4 sieve. Collect all of soil that have been sieved in a large pan.
- Add enough water to the soil and mix it in thoroughly to bring the moisture content up to about.
- attach mold the extension to the top of the mold next to the pan
- Pour the moist soil into the mold in five equal layers. Each layer should be compacted uniformly by the standard Proctor hammer 54 times before the next layer of loose soil is poured into the mold.
- Remove the top attachment from the mold. Be careful not to break off any of the compacted soil inside the mold while removing the top attachment.
- Using a straight edge, trim the excess soil above the mold. Now the top of the compacted soil will be even with the top of the mold.
- If any large compacted soil come out after using straight edge, we sieve on No 4 To close this void.
- Determine the weight of the mold + base plate +- compacted moist soil in the mold.
- Remove the base plate from the mold.
- Take a moisture can and determine its mass and put it in a small can.
- Place the moisture can with the moist soil in the oven to dry to a constant weight.
- Break the rest of the compacted soil (to No.4 size) by hand and mix it with the left- over moist soil in the pan. Add more water and mix it to raise the moisture content by about 2%

Data and Calculations :

(Gs = 2.68)

item	Test No.				
	1	**2**	**3**	**4**	**5**
Can No.	60	2	95	89	64
Mass of can , (W_1) (g)	28	24.9	27.5	28	27.8
Mass of can + wet soil , (W_2) (g)	208.7	99	120.3	143.5	88.4
Mass of can + dry soil , (W_3) (g)	202.5	95.4	114.7	135.4	82.8
Mass of moisture ,W_2 - W_3 (g)	6.2	3.6	5.6	8.1	5.6
Mass of dry soil , W_3 - W_1 (g)	174.5	70.5	87.2	107.4	55
Moisture content , w (%) $= \frac{w2-w3}{w3-w1}$ **X 100**	3.553	5.106	6.422	7.542	10.182
Mass of compacted soil and mold , W_5 (g)	7184	7434	7524	7529	7380.5
Mass of mold , W_6 (g)	2683.5	2683.5	2683.5	2683.5	2683.5
Volume of mold (cm^3)	2221	2221	2221	2221	2221
Moist unit weight, $= \frac{w5-w6}{V}$ **,(g/cm^3)**	2.03	2.14	2.18	2.182	2.115
Dry unit weight of compaction, γ_d (g/cm^3)	1.96	2.04	2.05	2.03	1.92



Optimum moisture content = 6%

Maximum dry density = 2.052 g/cm^3

Results and Conclusion :

Results :

Optimum moisture content = 6%

Maximum dry density = 2.052 g/cm^3

Conclusion :

The compaction curve of our report looks very good and the result is also good .

We can conclude that the maximum dry unit weight and the optimum moisture content depend on the degree of compaction, the higher the energy of compaction, the higher is the maximum dry unit weight. the higher the energy of compaction, the lower is the optimum moisture content

Sources of errors :

- The number of strokes the sample was subjected to in one of the experiments was more than 65 strokes, which led to a decrease in the percentage of blanks
- The multiplication mechanism on the sample is wrong, so you free fall on the sample
- The amount of water added to the sample is not accurate to 180 mm per trial

References :

- Soil lab manual
- https://www.researchgate.net/figure/Standard-Proctor-test-equipment-a-mould-b-hammer_fig1_325778992
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- https://civilseek.com/modified-proctor-test/