UNIVERSITY OF MUSTANSIRIYAH-COLLEGE OF ENGINEERING –CIVIL ENGINEERING DEPARTMENT

Highway Pavement Lab2

Soil compaction

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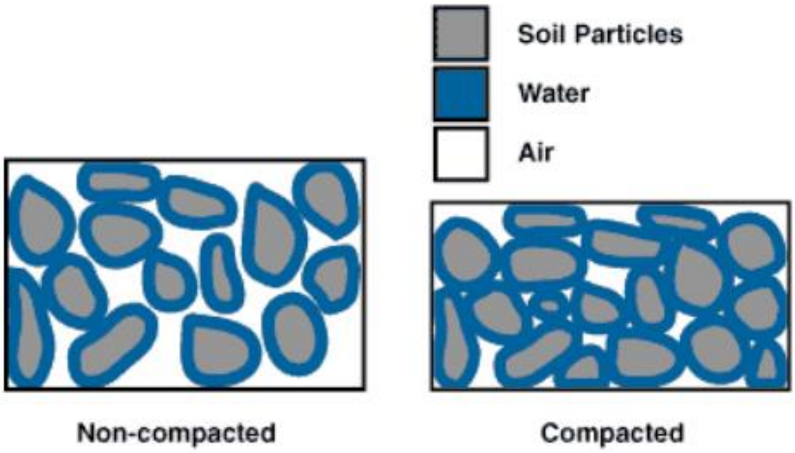
Lab of Highway Pavement

Specific Gravity and Moisture-Density Relationship

Soil placed as road bases is compacted to a dense state to obtain satisfactory engineering properties such as shear strength, compressibility, or permeability.



In field

Laboratory tests

Laboratory compaction tests provide the basis for determining the percent compaction and moulding water content needed to achieve the required engineering properties, and for controlling construction to assure that the required compaction and water contents are achieved. Two tests are required: Specific gravity determination and Moisture-Density relationship

1. ***Specific Gravity***

Specific gravity is the weight of a given volume of soil in air divided by the weight of equal volume of water at 4^oC

Specific gravity of soil is used to show the relationship of air, water, and solid in a given volume of soil. It indicates how much heavier or lighter a material is than water.

Purposes of this test:

1. In computation of many Lab. Tests on soils particularly void ratio
2. Particle size analysis
3. Degree of saturation

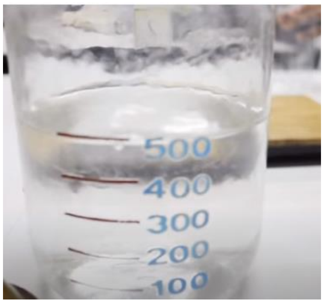
Apparatus

1. Pycnometer (500 ml) 	2. Heater and thermometer 
3. (125-150) gm of soil sample passing sieve No. 4 	4. Balance  or 

Procedure:

1. Put the pycnometer on heater for 10 min. to remove the bubbles
2. Oven dry soil for at least 24 hours

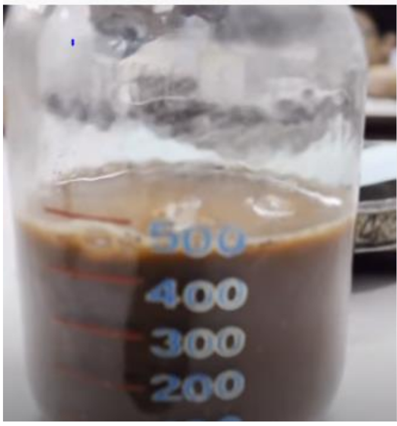

3. Put 500 ml of water inside the pycnometer

4. Record the weight of pycnometer +water (Wa)

5. Weigh 125 to 150gm of soil sample (Wo)

6. Put the soil sample inside the pycnometer and add water to reach 500 ml, then mix thoroughly



7. Weigh the water + soil + pycnometer (Wb)

Calculation:

Specific gravity (Gs) $= \frac{Wo\ Gt}{Wo + (Wa - Wb)}$

Where:

Wo = weight of sample of oven-dry soil,

Gt Relative density of water (given from table based on the recorded temperature at lab)

Wa = weight of pycnometer filled with water

Wb = weight of pycnometer filled with water and soil

Gs= 2.65- 2.85 for most soil types

Gs<2 for organic soil

Gs >3.0 for heavy material (iron)

2. Compaction test (Moisture – Density Relation) of soil and soil aggregate mixture

It is also called Protector Compaction test. This experiment is conducted to determine the relationship between moisture content and the dry density of soil (compaction curve)
This test method apply only to soils (materials) that have 30 % or less by mass of particles retained on the 3⁄4-in. (19.0-mm) sieve and have not been previously compacted in the laboratory; that is, do not reuse compacted soil.

Purposes:

1. To get optimum moisture-content (O.M.C) and γd max.
2. The compaction of soil means :
   a. Decrease further settlement
   b. Decrease permeability
   c. Increase shear strength

Two tests can be used based on the soil gradation, condition of the field work, and the requirement of the engineering project. These tests are:

1. Standard protector compaction test (ASTM D 698). In this test, the soil sample is compacted in a 4 or 6-in. (101.6 or 152.4-mm) diameter mold with a 5.50-lbf (24.5-N) rammer dropped from a height of 12.0in. (305 mm) producing a compactive effort of 12 400 ft-lbf/ft3 (600 kN-m/m3).
   https://www.youtube.com/watch?v=Tc3r9f_h5Uc
   https://www.youtube.com/watch?v=tqHNK67IgG4

2. Modified protector compaction test (ASTM D1557). In this test, the soil sample is compacted in a 4- or 6-in (101.6- or 152.4-mm) diameter mold with a 10.00-lbf. (44.48-N) rammer dropped from a height of 18.00 in. (457.2 mm) producing a compactive effort of 56 000 ft-lbf/ft3 (2700 kN-m/m3).
   https://www.youtube.com/watch?v=jdsWaXPysew
   https://www.youtube.com/watch?v=KQMeozBRSbg

Methods: (from ASTM D1557)

Three alternative methods are provided. The method used shall be as indicated in the specification for the material being tested. If no method is specified, the choice should be based on the material gradation.

1.3.1 *Method A*:

1.3.1.1 *Mold*—4-in. (101.6-mm) diameter.
1.3.1.2 *Material*—Passing No. 4 (4.75-mm) sieve.
1.3.1.3 *Layers*—Five.
1.3.1.4 *Blows per layer*—25.
1.3.1.5 *Usage*—May be used if 25 % or less by mass of the material is retained on the No. 4 (4.75-mm) sieve. However, if 5 to 25 % by mass of the material is retained on the No. 4 (4.75-mm) sieve, Method A can be used but oversize corrections will be required and there are no advantages to using Method A in this case.
1.3.1.6 *Other Use*—If this gradation requirement cannot be met, then Methods B or C may be used.

1.3.2 *Method B*:

1.3.2.1 *Mold*—4-in. (101.6-mm) diameter.
1.3.2.2 *Material*—Passing 3⁄8-in. (9.5-mm) sieve.
1.3.2.3 *Layers*—Five.
1.3.2.4 *Blows per layer*—25.
1.3.2.5 *Usage*—May be used if 25 % or less by mass of the material is retained on the 3⁄8-in. (9.5-mm) sieve. However, if 5 to 25 % of the material is retained on the 3⁄8-in. (9.5-mm) sieve, Method B can be used but oversize corrections will be required. In this case, the only advantages to using Method B rather than Method C are that a smaller amount of sample is needed and the smaller mold is easier to use.
1.3.2.6 *Other Usage*—If this gradation requirement cannot be met, then Method C may be used.

1.3.3 *Method C*:

1.3.3.1 *Mold*—6-in. (152.4-mm) diameter.
1.3.3.2 *Material*—Passing 3⁄4-in. (19.0-mm) sieve.
1.3.3.3 *Layers*—Five.
1.3.3.4 *Blows per layer*—56.
1.3.3.5 *Usage*—May be used if 30 % or less by mass of the material is retained on the 3⁄4-in. (19.0-mm) sieve.
1.3.4 The 6-in. (152.4-mm) diameter mold shall not be used with Method A or B.

Apparatus

<table>
<tr>
<td>1. 4 in Mold, (Φ 4″ ,h=7″)
(Methods A or B)

6 in Mold (Φ 6″ ,h=7″)
(Method C)
</td>
<td>2. Containers
</td>
</tr>
<tr>
<td colspan="2">3. Hammer</td>
</tr>
<tr>
<td>a. Standard hammer for standard test method (Φ2″, Load 5.5 ib, 12 ″ drop)</td>
<td>b. Modified hammer for modified test method (Φ 2″, Load 10 ib, 18 ″ drop)</td>
</tr>
<tr>
<td colspan="2"></td>
</tr>
<tr>
<td>4. Oven
</td>
<td>5. Balance
</td>
</tr>
<tr>
<td>6. 5.0 Kg of soil sample passing sieve No. 4

</td>
<td>7. Mixing pan and tools (spoon or trowels)
</td>
</tr>
</table>

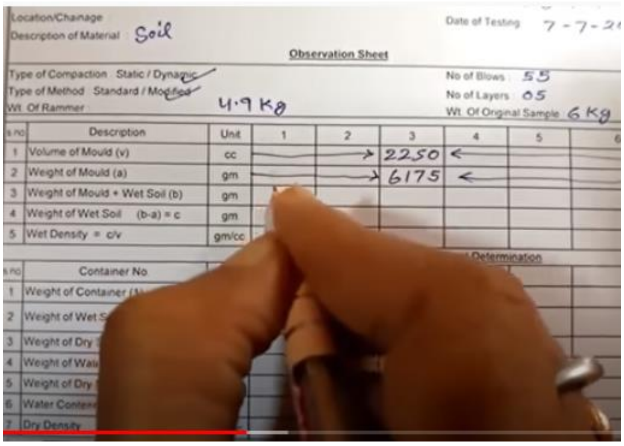
8. Cylinder, water 	9. Straight edge 

Procedure

1. Take about 5 kg of air-dried soil. Sieve it through 19mm (3/4 in), 9.5 mm (3/8 in) and 4.75mm sieve (No. 4), and calculate the retained on each sieve to select the suitable method.



2. Based on the selective method, the mold size will be selected.
3. Clean and dry the mould and the base plate. Grease them lightly.
4. Weigh the mould with the base plate to the nearest 1 gram. Record (the weight of the empty mold) and (the volume of the mold).



5. Add specific amount of water to the soil specimen to bring the water content to about 4% if the soil is sandy and to about 8% if the soil is clayey.

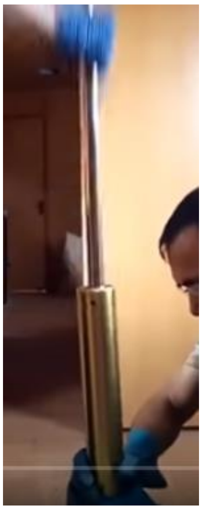
   Weight water used = %water *5000gm

6. Mix the soil thoroughly. Divide the processed soil into parts.

7. Attach the collar to the mold. Place the mold on a solid base.

8. Take an amount of the processed soil, and hence place it in the mold in 3 or 5 equal layers (based on the selected method). Take the first portion and compact it by giving 25 or 56 blows of the rammer (based on the selected method). The blows should be uniformly distributed over the surface of each layer.




9. The second layer should also be compacted by the same number of blows of rammer. Likewise, place the remaining layers and compact them.

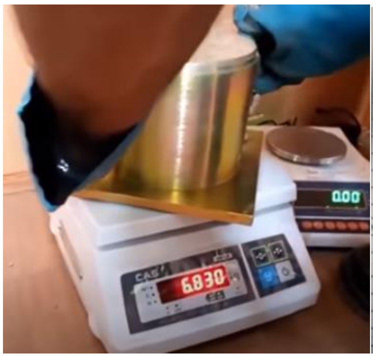
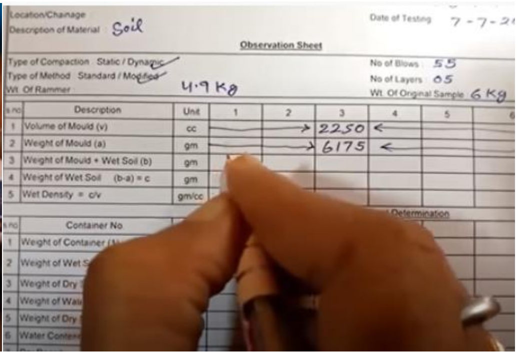
10. The amount of the soil used should be just sufficient to fill the mold leaving about 5 mm above the top of the mould to be struck off when the collar is removed.



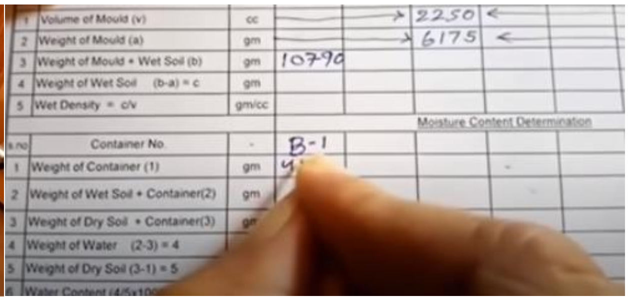
11. Remove the collar and trim off the excess soil projecting above the mould using a straight edge.



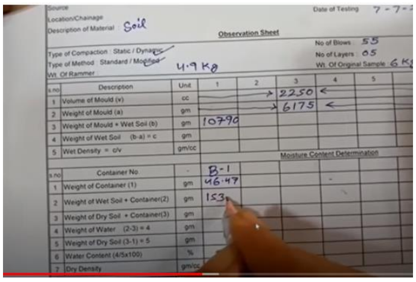
12. Weigh and record the (weight of mold +wet soil)

13. Weigh the empty container and record the weight in the lab sheet



14. Take the soil samples for the water content determination from the top, middle and bottom portions. Determine the water content. Record the (weight of container + wet soil)



Source
Location/Chainage
Description of Material Soil
Date of Testing 7-7-
Observation Sheet
Type of Compaction : Static / Dynamic
Type of Method : Standard / Modified
Wt. Of Rammer 4.9 Kg
No of Blows 55
No of Layers 05
Wt. Of Original Sample 6 Kg

S.no	Description	Unit	1	2	3	4	5
1	Volume of Mould (v)	cc	→	→	2250	←	
2	Weight of Mould (a)	gm	→	→	6175	←	
3	Weight of Mould + Wet Soil (b)	gm	10790				
4	Weight of Wet Soil (b-a) = c	gm					
5	Wet Density = c/v	gm/cc					

Moisture Content Determination

S.no	Container No	-	B-1				
1	Weight of Container (1)	gm	46.47				
2	Weight of Wet Soil + Container(2)	gm	153				
3	Weight of Dry Soil + Container(3)	gm					
4	Weight of Water (2-3) = 4	gm					
5	Weight of Dry Soil (3-1) = 5	gm					
6	Water Content (4/5x100)	%					
7	Dry Density	gm/cc					

MOISTURE DENSITY RELATIONSHIP (IS 2720 PART-7 & 8)

Source
Location/Chainage
Description of Material Soil
Date of Sampling 6-7-2018
Date of Testing 7-7-2018
Observation Sheet
Type of Compaction : Static / Dynamic
Type of Method : Standard / Modified
Wt. Of Rammer 4.9 Kg
No of Blows 55
No of Layers 05
Wt. Of Original Sample 6 Kg

Description	Unit	1	2	3	4	5	6
Volume of Mould (v)	cc	→	→	2250	←		
Weight of Mould (a)	gm	→	→	6175	←		
Weight of Mould + Wet Soil (b)	gm	10790	11060	11160	11045	10800	
Weight of Wet Soil (b-a) = c	gm						
Wet Density = c/v	gm/cc						

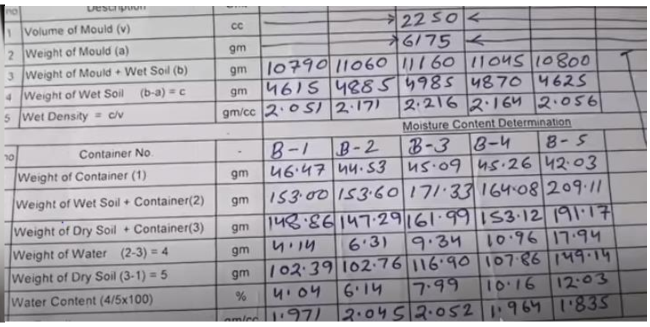
Moisture Content Determination

Container No	-	B-1	B-2	B-3	B-4	B-5	
Weight of Container (1)	gm	46.47	44.53	45.09	45.26	42.03	
Weight of Wet Soil + Container(2)	gm	153.00	153.60	171.33	164.08	209.11	
Weight of Dry Soil + Container(3)	gm						
Weight of Water (2-3) = 4	gm						
Weight of Dry Soil (3-1) = 5	gm						
Water Content (4/5x100)	%						

15. Add different water amount to a fresh portion of the processed soil, and repeat the steps 5 to 14.

16. Put the all the containers with the wet soil samples in the oven then record the (weight of container+ dry soil)

17. Calculate the wet density and water content



no	Description	Unit					
1	Volume of Mould (v)	cc	→		2250	←	
2	Weight of Mould (a)	gm	→		6175	←	
3	Weight of Mould + Wet Soil (b)	gm	10790	11060	11160	11045	10800
4	Weight of Wet Soil (b-a) = c	gm	4615	4885	4985	4870	4625
5	Wet Density = c/v	gm/cc	2.051	2.171	2.216	2.164	2.056
	Moisture Content Determination						
no	Container No.	-	B-1	B-2	B-3	B-4	B-5
	Weight of Container (1)	gm	46.47	44.53	45.09	45.26	42.03
	Weight of Wet Soil + Container(2)	gm	153.00	153.60	171.33	164.08	209.11
	Weight of Dry Soil + Container(3)	gm	148.86	147.29	161.99	153.12	191.17
	Weight of Water (2-3) = 4	gm	4.14	6.31	9.34	10.96	17.94
	Weight of Dry Soil (3-1) = 5	gm	102.39	102.76	116.90	107.86	149.14
	Water Content (4/5x100)	%	4.04	6.14	7.99	10.16	12.03
		gm/cc	1.971	2.045	2.052	1.964	1.835

Calculation

1. Calculate the volume of each mold

   The mold volume=$\left(\frac{Diameter}{2}\right)^2 \times \pi * (7 - hight\ of\ spacer\ disk) \times (2.5416)^3$

2. Wet density $\gamma_w = \frac{wt.comp\ soil}{Vol.mold}$

3. Dry density $\gamma_d = \frac{\gamma w}{1+\frac{w}{100}}$

4. $\%w = \frac{wt\ water}{wt\ dry\ soil} \times 100$

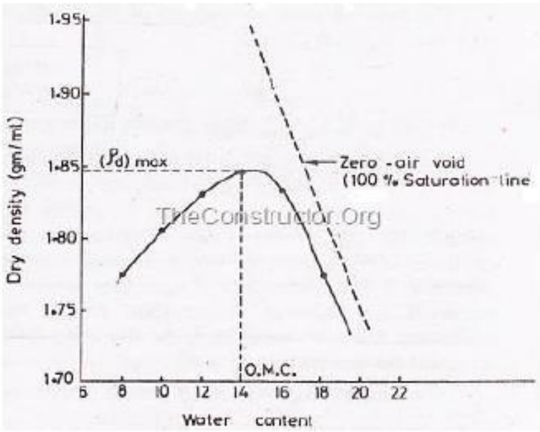
5. ZAVD (gm/cm^3) = $\frac{Gs}{1+(\frac{w}{100}\times Gs)}$

   ZAVD (Ib/ft^3) = $\frac{62.4\ Gs}{1+(\frac{w}{100}\times Gs)}$

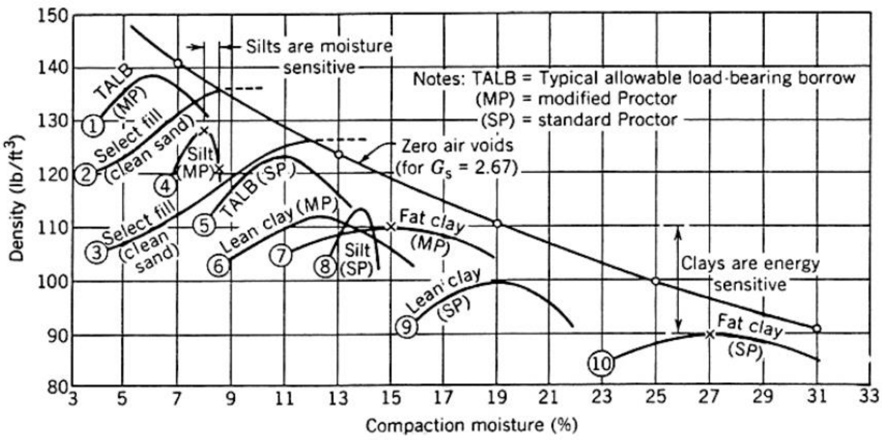
   ZAVD (KN/m^3) = $\frac{9.8\ Gs}{1+(\frac{w}{100}\times Gs)}$

6. Draw the relationship between the water content and dry density γ_d

7. determine the optimum moisture content (O.M.C) that produces the highest dry density



Example



Data sheet

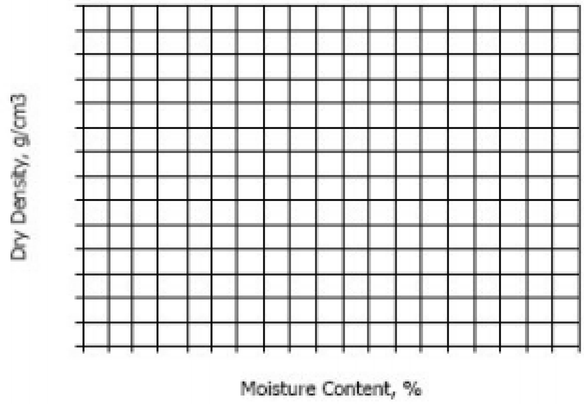
Contractor: ______________________________ Date: ____________
Station: ______________________________ Sample No.: ____________
Soil Description: ______________________________ Date Tested: ____________
Tested by: ______________________________
Test Designation: Part 7/ Part 8 (circle one) Specimen Preparation: single / separate (circle one)

WATER CONTENT DETERMINATION

Sample No.	1		2		3		4		5	
Moisture Can No.										
Wt. of Can+Wet Soil, g										
Wt. of Can+Dry Soil, g										
Wt. of Water, g										
Wt. of Can, g										
Wt. of Dry Soil, g										
Water Content, %										
Ave. Water Content, %										

DENSITY DETERMINATION

Wt. of Moist Soil+Mould, g					
Wt. of Mould, g					
Wt. of Moist Soil, g					
Vol. of Mould, cm3					
Wet Density, g/cm3					
Dry Density, g/cm3					



Diameter of mould, mm	
Weight of rammer, kg	
Height of fall, mm	
No. of blows	
No. of layers	
Optimum Moisture Content, %	
Maximum Dry Density, g/cm3	

Remarks: ______________________________
____