ATT-23/22, MOISTURE-DENSITY RELATION, Standard Compaction, -5 000 µm Material

1.0 SCOPE

This method describes the lab compaction procedures for determining the relationship between the moisture content and dry density of ***-5,000 µm soil*** for a specified compactive effort. The compactive effort is the amount of mechanical energy that is applied to the soil mass. In the ***Standard Proctor Test***, the soil is ***compacted by a 2.5 kg (5.5 lbs.) hammer*** falling a distance of one foot into a soil filled mold. The mold is filled with ***three equal layers of soil***, and each layer is subjected to ***25 blows/lift*** of the hammer.

2.0 EQUIPMENT

Proctor Mold Assembly: Each mold consists of 3 pieces: a base plate, mold, and an extension collar. All are made of metal and constructed so they can be securely attached, and easily detached from the mold. The extension collar assembly shall have a height extending above the top of the mold of at least 50.8 mm (2.0”). The extension collar shall align with the inside of the mold. The bottom of the base plate and bottom of the centrally recessed area that accepts the cylindrical mold shall be planar.

Mold Specifications ASTM D 698	
Mold Height	116.4 ± 0.5 mm
Mold Diameter	101.6 ± 0.4 mm
Mold Volume	944 ± 14 cm^3

Manual Rammer: The mass of the rammer shall be 2.5 ± 0.01 kg, with a diameter of 50.80 ± 0.13 mm. The rammer shall be equipped with a guide sleeve that has sufficient clearance that the free fall of the rammer shaft and head is not restricted. The guide sleeve shall have at least four vent holes at each end (eight holes total) located with centres 19.0 ± 1.6mm (¾” ± 1/16”) from each end and spaced 90 degrees apart. The minimum diameter of the vent holes shall be 9.5mm (3/8”).

Electronic Balance: capable of reading to 0.1 grams.
The balance must be operated as per manufacturer's recommendations.
Balances must be inspected, cleaned, and calibrated annually.

Sample Extruder: (optional), for extruding compacted specimens from the proctor mold.

Conventional Oven: thermostatically controlled oven capable of maintaining a temperature of 110 ± 5^{o} C throughout the drying chamber.

Sieves: 5,000 µm.

Straightedge: A stiff metal straightedge of any convenient length but not less than 254 mm (10”). The total length of the straightedge shall be machined straight to a tolerance of ± 0.01 mm (± 0.005”). The scraping edge shall be bevelled if it is thicker than 3 mm (⅛”).

Water Bottle: Trigger spray bottle, hand pump sprayer with wand, or graduated water bottle with sprinkler top.

Mixing Tools: Miscellaneous tools such as a grinding mill, large mixing pan, putty knives, large butcher knife, sampling containers (plastic pails or plastic bags), mixing spoons, plastic cover sheets, grocer scoops (large & small), drying pans, etc.

Zero Air Voids Tables for Relative Densities of 2.65, 2.70 and 2.75

Data Sheet: Moisture-Density Test (MAT 6-22)

3.0 PROCEDURE

The following procedure is performed on -5 000 µm fine grained soils having a maximum of 7% oversize. Soils with more than 7% retained on the 5,000 µm sieve must be compacted as directed in ATT-19, MOISTURE-DENSITY RELATION, +5,000 µm Material.

3.1 Equipment Preparation

1. Install the concrete block and post as directed in ATT-13.

2. The sleeve of the tamper should be marked with three lines each corresponding to a of the mold volume. These marks should be checked, and if necessary, the sleeve should be re-marked as follows:

    a) Lay the mold collar on its side then place the tamper sleeve (also on its side) inside the collar.

    b) Match the bottom of the sleeve to the top of the recess at the base of the collar, then move the sleeve 6 mm away from the recess (towards the top of the collar), as shown in Figure 1.

    c) Make a mark on the sleeve, even with the top of the collar. This bottom line will be used as reference for the third lift.

    d) Measure 40 mm from the bottom line towards the top of the tamper sleeve. This middle line will be used as reference for the second lift.

    e) Measure 40 mm from the middle line towards the top of the sleeve. This top line will be used as reference for the first lift.

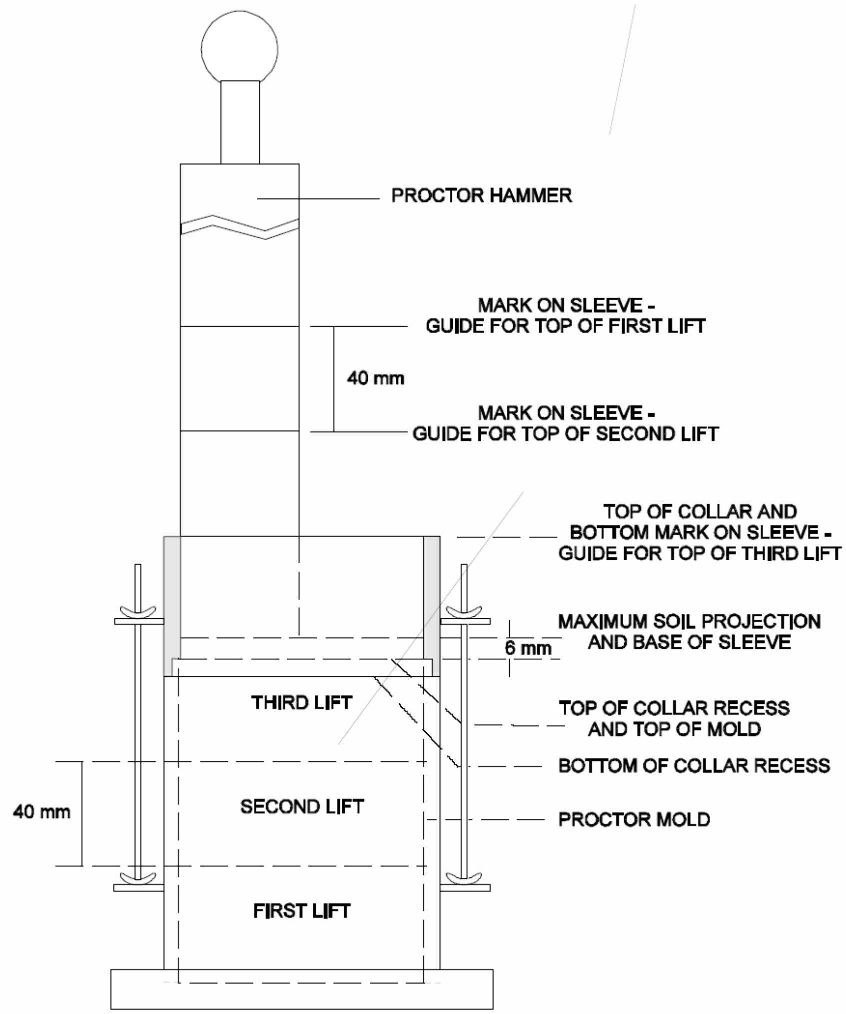


FIGURE 1

3.2 Sample Preparation

1. Obtain a sample of approximately 20 kg of representative soil.

2. Spread out the entire sample on the tarp and air dry until the material can be passed through the 5 000 µm sieve.

   NOTE: The sample may be oven dried but the oven temperature must not exceed 60^{o}C.

   DO NOT completely dry clay samples.

   DO NOT use a microwave oven to dry the material.

3. Weigh the entire sample in a tared mixing pan.

4. Pass the total sample through the 5 000 µm sieve. Put hard dry lumps through the grinding mill.

5. Weigh the material retained on the 5 000 µm sieve.

6. Calculate the "% Retained" on the 5 000 µm sieve using the formula:

$$\textit{\% Retained 5 000 } \mu m \textit{ sieve} = \frac{\textit{Wt. Passing 5 000} \mu m \textit{ Sieve}}{\textit{Total Wt. of Sample}} \textit{ x 100\%}$$

7. If the result is less than 7%, proceed with step 8.

   If the "% Retained" on the 5,000 µm sieve is more than 7%, proceed with ATT-19, Sections 3.1 and 3.2.

8. Discard the material retained on the 5,000 µm sieve.

9. Thoroughly mix the -5,000 µm material.

10. Add water to the entire sample as follows:

    a) Insert the sprinkler top into the mouth of the water bottle.

    b) Shake the bottle so that the water sprays out on the soil in the wash basin, at the same time working the soil so that no portion becomes excessively damp.

    c) Mix the soil thoroughly, by hand, until the moisture is uniformly distributed.

11. Repeat step 10 until the sample reaches the proper moisture content for the first run of the test, 4% below optimum. This moisture condition is approximately reached when a squeezed handful of soil barely holds together when dropped 0.5 metres onto the soil.

12. When the required moisture condition is reached, select approximately 12 kg of the wetted soil and place it in a large mixing pan.

13. Weigh 2,250 grams of the soil into each of the 5 wash basins, and cover each with a sheet of plastic to prevent evaporation.

    For the moisture content estimation, it is assumed that 250 grams of the soil in each run is water, and the remaining 2,000 grams is dry soil solids.

14. Mark the wash basins with run numbers 1 to 5.

15. Prepare the water bottles with water to be added to each run in 40 cm^3 increments as follows:

Run no. 1	40 cm^3	moisture added (+2% in moisture content)
Run no. 2	80 cm^3	moisture added (+4% in moisture content)
Run no. 3	120 cm^3	moisture added (+6% in moisture content)
Run no. 4	160 cm^3	moisture added (+8% in moisture content)
Run no. 5		no moisture added at this time.

No moisture is initially added to run no. 5 as this sample is kept until the other 4 runs have been compacted to see if the final point is required on the wet or the dry side of the moisture-density relation curve.

16. Add the water to runs 1, 2, 3 and 4 as directed in steps 10 (a) to (c), and cover each run with a sheet of plastic.

17. Allow time for the moisture to distribute evenly throughout each sample:

    a) A minimum of 12 hours for "highly plastic" silts (MH), clays (CI, CH), organic clays and silts (OH) and peat (Pt).

    b) A minimum of 3 hours for soils with low plasticity such as, clays (CL), silts (ML), organic silts and organic silty clays (OL), clayey gravels (GC) and clayey sands (SC).

    c) A minimum of 1 hour for silty gravels (GM) and silty sands (SM).

    d) There is no time requirement for clean gravels (GW, GP) and clean sands (SW, SP).

3.3 Compaction of Specimens

1. Weigh the mold and base plate excluding the collar. Record as “Wt. of Mold” on line "C" of the data sheet as shown in Figure 2. Also obtain the volume of the mold from the supplied zero air voids table folder and record it in line "A".

2. Place the collar on the mold and set it in the recess provided on the block. Be certain that the wing nuts on the base plate are tight.

3. Thoroughly mix the soil for run no.1 by hand.

4. Use the grocer scoop to place an amount of soil in the mold which, when compacted, will fill a of the mold.

NOTE: Use the lines on the sleeve as a guide in placing the material. Should the first or second lift be too thick or too thin, (±15 mm), the quantity of the soil placed for the following lift shall be adjusted to line up with the proper mark on the tamper. The final lift must extend a maximum of 6 mm above the top of the mold so that after trimming, no tamper foot imprints are evident. If the third lift extends by more than 6 mm, the run must be repeated.

5. Place the tamper sleeve on the surface of the soil.

6. Raise the tamper to the top of the sleeve, pause and let the tamper fall. Be certain that the tamper is vertical and that its fall is unrestricted.

7. Repeat step 6 for 25 blows, moving the tamper around the mold, keeping the sleeve close to or touching the walls of the mold.

8. Check the tamper sleeve after each lift to ensure that the tamper's fall is not restricted by soil adhering to either the sleeve or the hammer.

9. Scarify the soil surface before adding material for the next lift. Repeat steps 4 to 8 for the second and third lifts. The soil should completely fill the cylinder and the last compacted layer must extend slightly above the collar joint (6 mm). If the soil surface is below the collar joint at the completion of the drops, the test point must be repeated.

    NOTE: At any time up to 10 blows on the third lift, set the sleeve on the surface of the soil. If the bottom line on the sleeve is not at the same level or slightly above the top of the collar, add some more material to ensure the top lift will extend 6 mm above the top of the mold after compaction.

10. Loosen the collar of the mold from the soil by turning the collar without pulling upward.

    NOTE: Where the last lift of soil extends above the top of the mold, and especially with the drier runs, use a putty knife to trim a ring of soil away from the collar so that it can be more easily loosened.

11. To remove the collar without tearing away any of the projecting soil, place your fingers of one hand on top of the soil and with the other hand, turn the collar, at the same time lifting, until it is free. If the lifts have been properly proportioned, the soil should not extend more than 6 mm above the mold.

12. Set the mold in a wash basin.

13. Use the butcher knife to trim the soil projecting above the mold by cutting towards you, away from the center with the knife held a few degrees from the horizontal, leaving the soil in the center of the mold slightly high.

14. Use the straight edge to draw levelling lines across the soil.

15. Trim the high spots with the knife held as flat as possible to avoid gouging. Repeat the levelling and trimming until the surface is level with the mold. Fill in any small holes created during the trimming process, using some of the trimmed soil.

16. Clean off the outside and base of the mold.

17. Weigh the mold, base plate, and contents and record as “Wt. of Wet Sample + Mold” on line "B" of the form, in the vertical column corresponding to run number 1.

MAT 6-22/13

MOISTURE - DENSITY TEST

FIELD TEST PROCEDURE ATT 23/13

Project :	Hwy 58:02	Test No. :	10
Contract # :	12354	Date :	6-Sep-1995
Source :	Borrow Pit #3	Tech :	M. Smith

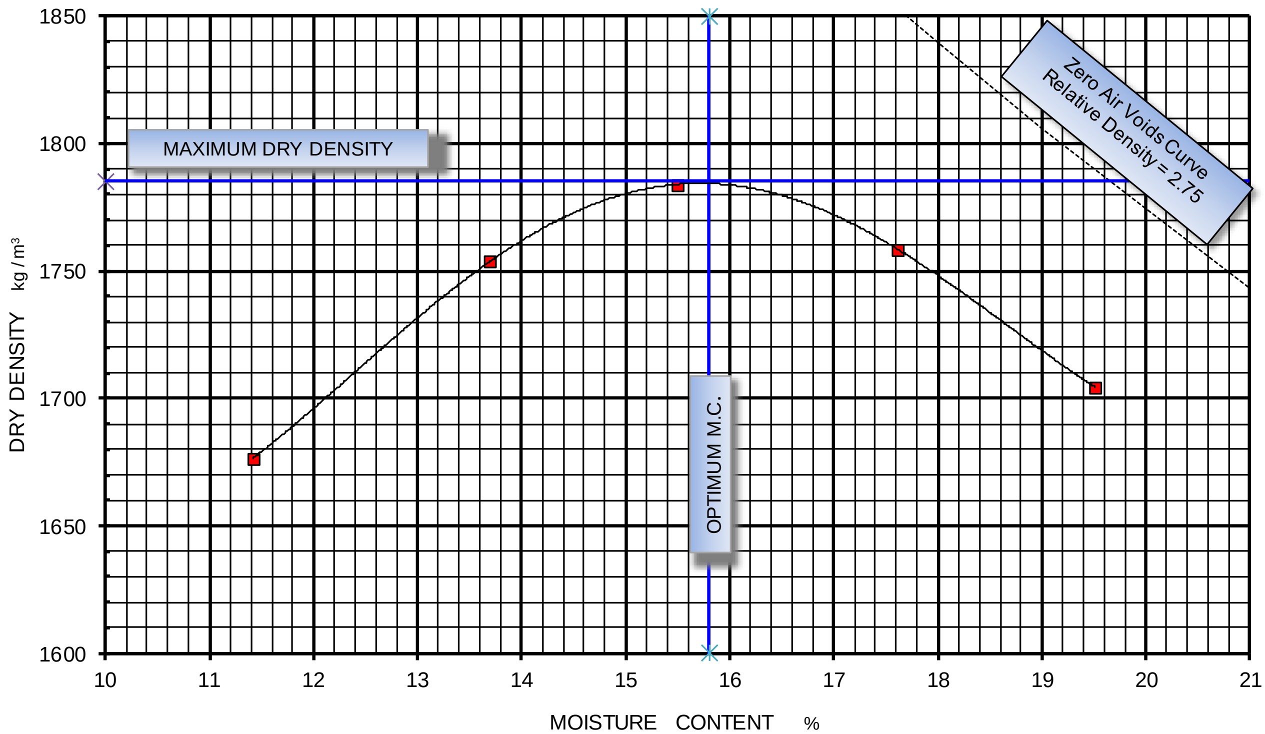
DENSITY	A. VOLUME OF MOLD		cm^3	942	942	942	942	942	
	B. Wt OF WET SAMPLE + MOLD		g.	5923.8	6042.6	6105.0	6112.6	6083.1	
	C. Wt OF MOLD		g.	4164.3	4164.3	4164.3	4164.3	4164.3	
	D. Wt OF WET SAMPLE	B - C	g.	1759.5	1878.3	1940.7	1948.3	1918.8	
	E. WET DENSITY	(D/A) x 1000	kg / m^3	1868	1994	2060	2068	2037	
	F. DRY DENSITY	(100 x E) / (100+N)	kg / m^3	**1676**	**1754**	**1784**	**1759**	**1704**	
MOISTURE CONTENT	G. MOISTURE ADDED / RUN NO.			0 g / run 1	40 g / run 2	80 g / run 3	120 g / run 4	160 g / run 5	
	H. CONTAINER NO.			A	B	C	D	E	
	I. Wt OF WET SAMPLE + TARE		g.	375.9	387.9	400.3	405.5	406.8	
	J. Wt OF DRY SAMPLE + TARE		g.	341.3	345.6	351.7	350.5	346.3	
	K. TARE OF CONTAINER		g.	38.2	36.8	37.9	38.2	36.3	
	L. Wt OF WATER	I - J	g.	34.6	42.3	48.6	55.0	60.5	
	M. Wt OF DRY SOIL	J - K	g.	303.1	308.8	313.8	312.3	310.0	
	N. MOISTURE CONTENT	(L / M) x 100	%	**11.4**	**13.7**	**15.5**	**17.6**	**19.5**	

ESTIMATED SOIL CLASSIFICATION CI

(USCS modified by PFRA)

OPTIMUM MOISTURE 15.8 %

MAX. DRY DENSITY 1785 kg / m^3



REMARKS :	Material in Borrow Pit # 3 is at 20% MC and requires drying.	Degree of Saturation = 80.4 %
		Soil Relative Density = 2.75 %

FIGURE 2

18. Remove the base plate. Label and tare a drying pan. Record the pan number as Container (line "H") and the pan weight as Tare of Container (line "K") in the column for run number 1.

19. Secure a moisture content sample of at least 250 grams net wet weight, representing a cross-section from top to bottom of the compacted sample.

    If an extruder is available, obtain the moisture sample as follows:

    a) Remove the specimen from the mold by centering the mold in the extruder's base plate which is centered on the jack. Jack the assembly up until the top of the mold is just about touching the top fixed steel plate. Line the inside circumference of the top of the mold up with the hole cut on the top plate, then jack the specimen up through the hole, as straight as possible.

    b) Use a knife to obtain a moisture content sample from the middle of the compacted sample.

    c) Cut off a thin slice of compacted material from top to bottom, as close to the center of the compacted specimen as possible.

    d) Break the sample into pieces smaller than 15 mm, for faster and thorough drying.

    If an extruder is not available, obtain the moisture content sample as follows:

    a) Set the mold in a wash basin or drying pan.

    b) Starting from one side, use the putty knife to cut diagonally across to the other side, down approximately 40 mm.

    c) From the exposed surface, remove a representative moisture content sample cutting down half-way through the compacted sample, and transfer the sample to the tared drying pan.

    d) Invert the mold and repeat (b) and (c) to secure the remainder of the sample.

    e) Break the sample into pieces smaller than 15 mm.

20. Weigh the moisture content sample immediately, and record as "Wt. of Wet Sample + Tare" on line "T". Mark the drying container with "Run #1" and place it in either:

    a) a conventional oven, set at 110 ± 5^{o} C, and dry to constant weight,

    b) or a microwave oven, and dry the sample for the calibrated length of time (see ATT-15).

    Remove any soil remaining in the mold, and thoroughly clean the mold.

21. Repeat steps 2 through 20 for runs 2, 3 and 4.

22. Calculate the wet density for these four runs, as directed in Section 3.4, steps 1 and 2.

23. If the wet density of run number 4 is higher than the wet density of run number 3:

    a) Add 200 grams of water to run number 5, as directed in Section 3.2, step 10 (a) to (c),

    b) Cover the sample with a sheet of plastic.

    c) Allow the moisture to distribute for the minimum time shown in Section 3.2, step 17 (a) to (d),

    d) Compact run number 5 as directed in steps 2 to 20 above.

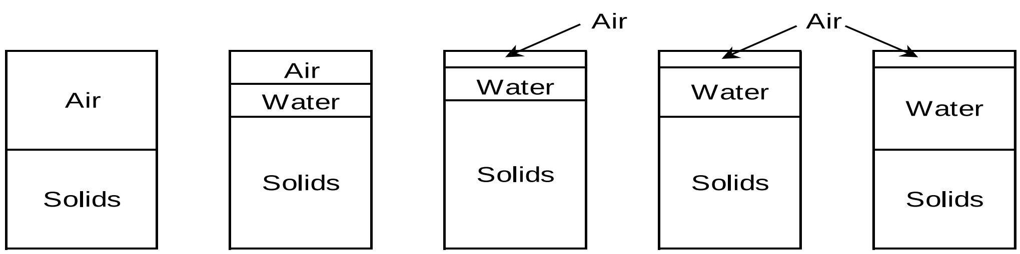
    If the wet density of run number 4 is lower than or the same as the wet density of run number 3, compact run number 5 without additional water added, (at the estimated 4% below optimum) as described in steps 2 to 20.

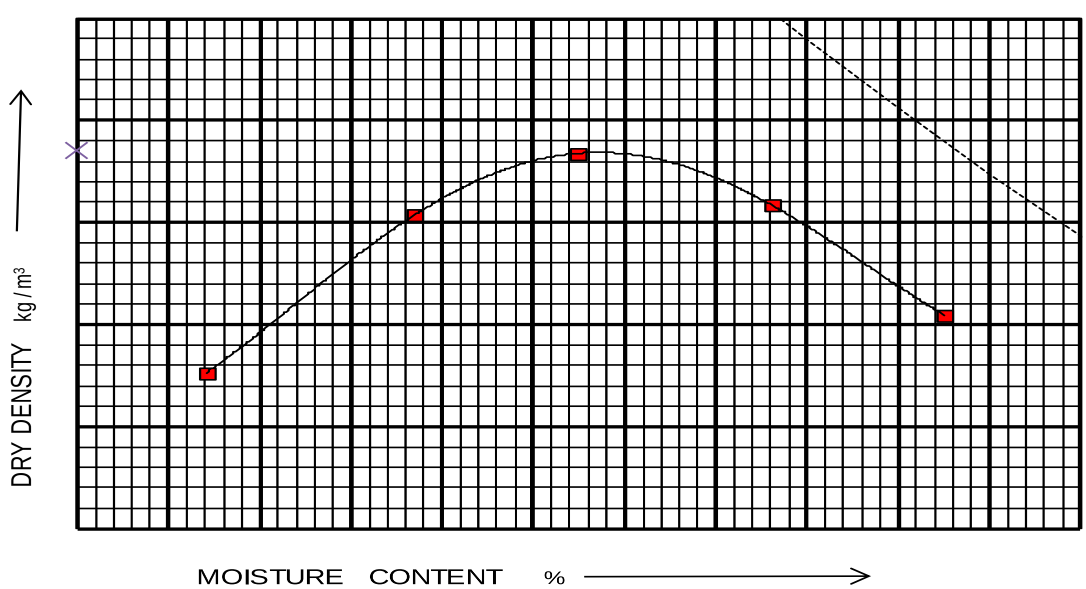
NOTE: The ideal 5 point curve should have 2 points on the dry side of optimum, 2 points on the wet side of optimum, and the middle point at, or near, optimum. Run number 5 is left until the other four runs have been compacted for this reason.

3.3.1 SOIL BEHAVIOR

Because soil consists of solids, water and air, its behavior during compaction is very important. When used as a construction material, the significant engineering properties of soil are its shear strength, its compressibility, and its permeability. Soil compaction generally increases its shear strength, decreases its compressibility, and decreases its permeability.

With any compactive effort, the dry density of a soil will vary with its moisture content. A soil compacted dry will reach a certain dry density. If this same soil is re-compacted, but by gradually increasing the moisture content, and with the same compactive effort, the dry density will be higher, since the water provides lubrication of the soil grains and allows them to slide together to form a denser structure. Air is forced out of the soil, leaving more space for the soil solids and the additional water. With an even higher moisture content, a still greater dry density may be reached since yet more air is being expelled. However, there is a limit when most of the air in the mixture has been removed, and adding more water to the mixture before compaction will only result in a lower dry density, since the added water merely takes the place of some of the soil solids. This is demonstrated in the graphic below.





3.4 Calculations

1. Calculate the weight of the “Wt. of Wet Sample” in the mold (line "D") as follows:

   Wt. of Wet Sample = (Wt. of Wet Sample & Mold) - (Wt. of Mold)

2. Calculate the “Wet Density” of the compacted specimen (line "E") using the formula:

$$\text{Wet Density } (kg/m^3) = \frac{\text{Wt. of Wet Sample (g)}}{\text{Volume of Mold } (cm^3)} \times 1000$$

3. Record the dry weights of the moisture content samples as “Wt. of Dry Sample + Tare” on line "J", in the columns corresponding to the appropriate run numbers.

4. Determine the “Weight of Water” removed (line "L") as follows:

   Wt. of Water (g) = (Wt. of Wet Sample & Tare) - (Wt. of Dry Sample & Tare)

5. Determine the dry weight of the moisture content sample (line "M") as follows:

   Wt. of Dry Soil (g) = (Wt. of Dry Sample & Tare) - (Tare of Container)

6. Determine the “Moisture Content” in percent (line "N") of the compacted specimen using the formula:

$$\text{Moisture Content (\%)} = \frac{\text{Wt. of Water}}{\text{Wt. of Dry Soil}} \times 100\%$$

7. Calculate the Dry Density of the compacted sample (line "F") as follows:

$$\text{Dry Density } (kg/m^3) = \frac{\text{Wet Density } (kg/m^3)}{100\% + \text{Moisture Content in \%}} \times 1000$$

3.5 Plotting

1. On the graph, on the bottom of the data sheet, set up a moisture content scale in increments of 1% horizontally and a dry density scale in increments of 25 kg/m^3 vertically, as shown in Figure 2. Select a range of numbers for the scales so that all points plot on the graph.

2. Plot the Dry Density and Moisture Content co-ordinates for each run.

3. Connect the points with a smooth flowing curve.

4. The peak of the curve represents the maximum dry density and optimum moisture content. Record these values at the top of the graph portion of the data sheet.

   The optimum moisture content is the moisture content that results in the greatest density for a specified compactive effort. The maximum dry density will be used to determine the percent compaction of the road tests performed on the same material, while the optimum moisture content will be used to control the moisture content of this material on the road.

3.6 Zero Air Voids Curve

A zero-air-voids curve is a theoretical moisture content versus density curve based on the assumption that all the voids are filled with water. To assist in drawing the moisture-density curve, and as an indication of the maximum theoretically possible density, the zero-air-voids (ZAV) curve is plotted.

The following rules regarding the ZAV curve can be used to assist in plotting the compaction curve.

a) ***No point can be above the ZAV line***. Therefore, errors are obvious.

b) The slope of the moisture-density curve on the wet side of optimum moisture content should be parallel to the ZAV curve. This is very helpful in drawing the curve where test results are erratic, as is commonly the case with some soils, such as sands.

1. Classify the moisture-density relation test soil using:

   a) The hand method of soils identification and bottle test as directed in ATT-29, and

   b) The origin of the soil in conjunction with the soils profile.

   Record the estimated Unified Soil Classification System (USCS) Group Symbol at the top of the data sheet graph (eg. CI)

2. The zero air voids table, as shown in Table 1 below, shows the relationship between moisture content and theoretical maximum dry density of a soil, 100% saturated, and compacted using standard compaction. The table is divided into 3 groups of soils, according to the soil's relative density.

   Choose the zero air voids table which best fits the soil type. Following are the approximate relative densities of various soil types.

SOIL TYPE	USCS SYMBOL	RELATIVE DENSITY
Organic Materials	OL, OH, Pt	1.30 - 1.90
Rock		2.65
Gravel	GW, GP, GM, GC	2.65
Sand	SW, SP, SM, SC	2.65
Silt, low plasticity	ML	2.65
Silt, inorganic	MH	2.67 - 2.69
Clay, low plasticity	CL	2.70 - 2.72
Clay, med plasticity	CI	2.72 - 2.75
Clay, high plasticity	CH	2.75 - 2.80

3. Pick off the table the maximum dry densities at the corresponding moisture contents and plot them on the graph. Use a range of moistures above optimum, ensuring they cover the entire wet side of the moisture-density relation curve and the densities fit the allotted scale.

4. Connect the points with a smooth flowing curve.

5. The zero air voids curve is plotted as a check on the moisture-density relation curve. The shape of the moisture-density relation curve is normally parabolic. On the wet side of the optimum moisture content, the moisture-density relation curve should be asymptotic to the zero air voids curve.

6. If any point of the moisture-density relation curve touches or crosses the zero air voids line, an error has probably been made.

If you have tested the soil, and the Relative Density is different than what is shown in Table 1, points for the ZAV curve can be calculated with this equation:

$$\text{ZAV } \rho D = \frac{\rho w}{\frac{1}{RD} + w}$$

***ρw* =** density of water **=** 1000 kg/m^3
***w* =** moisture content

Example: If RD (GS) = 2.72, and w = 10%.

$$\text{ZAV } \rho D = \frac{1000 \text{ kg/m}^3}{\frac{1}{2.72} + 0.10} = 2138 \text{ kg/m}^3$$

ZERO AIR VOIDS TABLE

RELATIVE DENSITY 2.65	
MOISTURE CONTENT %	MAXIMUM DRY DENSITY kg/m^3
6	2286
9	2235
9	2186
9	2140
10	2095
11	2052
12	2011
13	1971
14	1933
15	1896
16	1861
17	1827
18	1794
19	1763
20	1732
21	1703
22	1674
23	1646
24	1620
25	1594
26	1569
27	1545
28	1521
29	1498
30	1476
31	1455
32	1434
33	1414
34	1394
35	1375

RELATIVE DENSITY 2.70	
MOISTURE CONTENT %	MAXIMUM DRY DENSITY kg/m^3
6	2324
7	2271
8	2220
9	2172
10	2126
11	2082
12	2039
13	1999
14	1959
15	1922
16	1885
17	1851
18	1817
19	1785
20	1753
21	1723
22	1694
23	1666
24	1638
25	1612
26	1586
27	1562
28	1538
29	1514
30	1492
31	1470
32	1448
33	1428
34	1408
35	1388

RELATIVE DENSITY 2.75	
MOISTURE CONTENT %	MAXIMUM DRY DENSITY kg/m^3
6	2361
7	2306
8	2254
9	2204
10	2157
11	2111
12	2068
13	2026
14	1986
15	1947
16	1910
17	1874
18	1839
19	1806
20	1774
21	1743
22	1713
23	1685
24	1657
25	1630
26	1603
27	1578
28	1554
29	1530
30	1507
31	1484
32	1463
33	1442
34	1421
35	1401

TABLE 1

3.7 Checking the Accuracy of Curve Results

At the optimum moisture content, the soil should be between 80% and 90% saturated. Sands have a tendency to be closer to 80% while clays will be nearer or slightly above 90%. The degree of saturation (S) in percent (%) can be calculated using the formula:

$$S\ (\%) = \frac{V_W}{V_V}$$

V_W = Volume of Water
V_V = Volume of Voids

$$S\ (\%) = \frac{(\text{Moisture Content in } \%) \times (\text{Dry Density in g/m}^3) \times \text{Relative Density}}{\text{Relative Density - Dry Density (g/cm}^3)}$$

e.g.

Optimum Moisture Content	= 19.4%
Maximum Dry Density	= 1663 kg/m^3 or 1.663 g/cm^3
Relative Density	= 2.70

$$S\ (\%) = \frac{19.4\% \times 1.663 \times 2.70}{2.70 - 1.663} = 84\ \%$$

The OMC at which maximum density is obtained is the moisture content at which the soil becomes sufficiently workable under a given compactive effort to cause the soil particles to become so closely packed that most of the air is expelled. For most soils, except cohesionless sands, when the moisture content is less than optimum, the soil is more difficult to compact. Beyond the OMC, most soils are not as dense under a given effort because the water interferes with the close packing of the soil particles. Beyond optimum, and for the stated conditions, the air content of most soils remains essentially the same, even though the moisture content is increased.

4.0 HINTS AND PRECAUTIONS

1. If a compacted specimen falls short of the top of the mold after compaction of the final lift, the soil must be broken up and the run repeated.

2. Observe the action of the soil in the mold during compaction, as the moisture content increases. Also, handle small amounts of the material from each run, at the different moisture contents. Since the same soil may be compacted on the road under a variety of moisture conditions, familiarization during the moisture-density relation test of both appearance and handling characteristics will be a valuable aid later in density testing and material correlation. Similarly, when cleaning out the mold, observe how the material behaves when compacted, at each moisture content.

3. Save a medicine bottle soil sample, and a 0.5 kg sample of each soil. These are used to correlate road densities to the corresponding maximum dry density.

4. Make sure the proctor mold is securely fastened to the proctor base plate. Tighten the wing nuts evenly so that the mold is held flat against the base plate.

5. Ensure that the proctor mold and proctor hammer have been calibrated, on a yearly basis, and is in specification as per ASTM D 698. Molds that meet the requirements should be labelled with the calibration date, mold volume, and calibration technologist. Proctor hammers should be labelled to show the calibration date, and calibration technologist.

6. A book should be available with all the equipment calibrations in each lab recorded. Equipment used in testing materials must be calibrated for accuracy on a regular basis to assure the equipment is producing reliable results. Equipment and apparatus that may be affected by movement must be re-calibrated after relocation.

7. If the incorrect zero air voids curve data is used, a curve parallel to the true one will result. If the shift is towards the wet side of the moisture-density relation curve, points on the wet side of the curve will plot closer to the zero air voids curve and may appear incorrect.