ATT-8/22 DENSITY, In-Place Balloon Method

1.0 SCOPE

This method describes the procedure for the determination of in-place field densities of fine grained soils, sand-base cement stabilized mixtures, asphalt or aggregate contaminated subgrades and granular base courses using the rubber balloon apparatus.

For this balloon method, water from a calibrated vessel is forced into a rubber balloon in a test hole where a soil sample was taken (see Figure 1 on page 2). The amount of water used to fill the balloon in the test hole equals the sample's in-place volume. Disadvantages to using the liquid method are that the balloon can break if there are sharp projections in the hole, or the water can freeze in colder temperatures.

2.0 EQUIPMENT

Calibrated Vessel - Volumeasure or Volutester designed to contain a liquid within a relatively thin, flexible, elastic membrane (rubber balloon) for measuring the volume of a test hole. The apparatus is equipped so that an externally controlled pressure can be applied to the contained liquid. There is a volume indicator for determining to the nearest 5 cc, any change in volume of the test hole.

Base Plate – A rigid metal plate machined with a recess to fit the base of the calibrated vessel.

Miscellaneous Equipment:
Square-nosed shovel or spade for levelling the test site; small picks, hammers and chisels, screwdrivers, garden trowels or spoon for digging test holes;

plastic bags, small plastic buckets with lids, or other types of containers that can be sealed to retain the moisture content of the soil taken from the test holes;

small scoops or spoons, and small paint brushes for removing and collecting all the soil from the test hole into a sealed container.

Electronic Balance – capable of reading to 0.1 g and having an accuracy of 0.01% of the sample mass, eg. For a 2,000 g sample weight, the balance must be accurate to 0.2 g. The balance must be operated and calibrated as per the manufacturers recommendations.

Drying Oven – A thermostatically controlled oven capable of maintaining a uniform temperature of 110 ± 5^{o}C throughout the drying chamber. A stove, microwave, or other apparatus proven suitable for drying soil or moisture samples may also be used (see ATT-15 Moisture Content).

Sieves: 20,000 µm and 5,000 µm
Data Sheet: Field Density Test (such as MAT 6-23)

3.0 PROCEDURE

3.1 Equipment Preparation

1. Assemble the Volutester as directed in the applicable manufacturer's equipment manual.

2. ***Calibrate the pressure gauge as directed in the Supplement section of this test method (ATT-8S).***

   NOTE: ***<u>The calibration is required at the start of the job, or whenever the calibration is in doubt, or whenever the balloon is changed.</u>***

3. Obtain the "Calibrated Pressure Gauge Reading" from the last pressure gauge calibration and record it in line "B".

4. Label and tare a density container including the container lid. Record the container number and the tare weight in line "Q" of the data sheet as shown in Figure 1.

5. The data sheet has 5 vertical columns for recording 5 tests per sheet. When more than one test will be performed in the field, label and tare the required number of plastic density containers and record the weights and numbers of the containers in line "Q", one per vertical column.

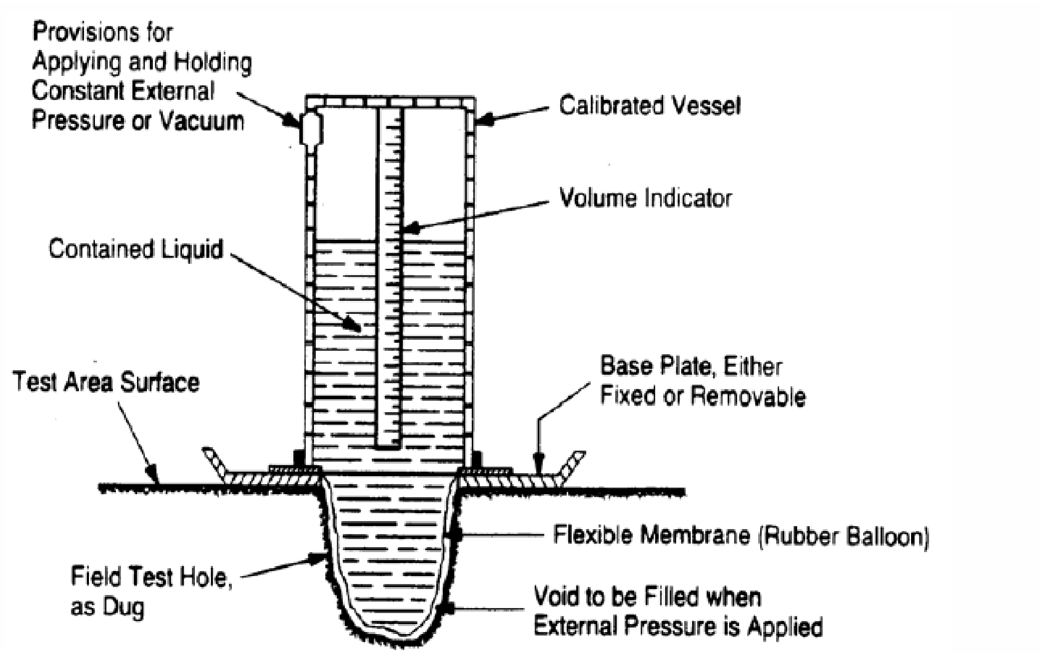

FIGURE 1 – Schematic Drawing of Calibrated Vessel

3.2 Volume of Hole

If a fine grained soil sample or a sand-base CSBC sample has less than 7% of the total sample weight retained on the 5,000 µm sieve, the volume of the test hole must be at least 1150 cm^3. When testing contaminated subgrade and base courses, use Table 1 (below) to determine the minimum volume of the density hole, according to the topsize of the aggregate being tested.

MINIMUM TEST HOLE VOLUMES
(BASED ON MAXIMUM PARTICLE SIZE)

MAXIMUM PARTICLE SIZE (µm)	MINIMUM TEST HOLE VOLUME (cm^3)
5 000	1 150
10 000	1 350
12 500	1 450
16 000	1 600
20 000	1 750
25 000	1 950
40 000	3 050

TABLE 1

1. Select the test location and record the station, location and depth below grade (or base course lift) and date in the appropriate lines of the heading portion of the data sheet, in the column corresponding to the number of the density jar to be used for the test.

2. Use the square nosed shovel and the garden trowel to remove any dried surface soil, until a representative moisture content is reached from an area larger than the density plate. Typically a 50 mm depth should be removed.

3. Prepare the surface of the test hole site with the square-nosed shovel so that it is reasonably plane and level. Depending on the moisture content and texture of the soil, the surface may be levelled using a grader, provided the test area is not deformed, compressed, torn, or otherwise disturbed.

4. Place the density base plate on the surface, then press down and slide the plate back and forth.

5. Remove the plate and trim any high spots with the garden trowel.

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6. Repeat steps 4 and 5 until the plate sits level and flat on the prepared site. This is very important at the point where the soil meets the edges of the hole in the density plate

7. Insert the Volumeasure or Volutester in the recess of the density plate and secure it in place (by tightening a clamping device to hold it to the plate, or by pressing down firmly on the top of the volutester with one hand). Mark the density plate and base plate so that the two can be realigned in the same position when taking the final reading.

8. Open the air release valve and insert the pump in the pressure position.

9. Pump the rubber bulb until a calibrated pressure dial reading (ATT-8S) is reached. Some base plates are equipped with holes in each corner, through which spikes can be nailed through to secure the base plate to the soil, and may have clamps to hold the pressure vessel to the base plate, as it is hard to manually hold the pressurized vessel down on the base plate and then read the water level, if no clamps are attached.

10. Close the air release valve. When the water level is stationary, lower your eye parallel to the surface of the water. Read the bottom of the meniscus and record the “Initial Cylinder Scale Reading at 3.0 Pressure” in line "A".

NOTE: Always read the water level the same way each time, that is, ***read the line at eye level parallel to the bottom of the meniscus***, on the same side of the cylinder.

FIGURE 2

VOLUTESTER CALIBRATION

Alberta Transportation

FIELD DENSITY TESTS

ATT-8, DENSITY, In-Place Balloon Method

PROJECT :	**Hwy 12:04**	CONTRACTOR:	**R. Roads**
CONTRACT NO. :	**11123**	DATE :	**Apr-01-2007**
ATT-8, DENSITY, In-Place Balloon Method		TECH :	**B. Good**

MAT 6-23/13

SITE LOCATION AND VISUAL DESCRIPTION					
TEST #	20				
STATION	10+816				
LOCATION	1.5m Rt.cl				
DEPTH BELOW GRADE (RANGE)	grade				
DATE TESTED	1-Apr-2007				
HAND METHOD SOILS CLASSIFICATION	CI				
ESTIMATED MOISTURE CONTENT	OPT				
ESTIMATED PERCENT COMPACTION	100+				

VOLUME OF HOLE (BALLOON METHOD)									
A.	CALIBRATED PRESSURE GAGE READING (ATT-8S)		cm^3	2.5					
B.	INITIAL CYLINDER SCALE READING		cm^3	90					
C.	FINAL CYLINDER SCALE READING		cm^3	1305					
D.	**FINAL CORR. READING FROM CYLINDER CALIB. CHART**		cm^3	**1278**					
E.	**INITIAL CORR. READING FROM CYLINDER CALIB. CHART**		cm^3	**83**					
F.	VOLUME OF HOLE	(D-E)	cm^3	**1195**					

WET DENSITY									
G.	WEIGHT OF WET SOIL + ROCKS + CONTAINER		g	2716.1					
H.	WEIGHT OF ROCKS FROM HOLE		g	26.0					
	% ROCKS	(100 H) / (G - J)	g	1.1					
I.	WEIGHT OF WET SOIL + CONTAINER	(G - H)	g	2690.1					
J.	WEIGHT OF CONTAINER		g	286.8					
K.	WEIGHT OF WET SOIL	(I-J)	g	2403.3					
L.	VOLUME OF ROCKS FROM HOLE	(H / 2.6)	cm^3	10.0					
M.	CORRECTED VOLUME	(F - L)	cm^3	1185.0					
N.	WET DENSITY	(1000 K) / M	kg/m^3	**2028**					

MOISTURE CONTENT AND DRY DENSITY									
O.	WEIGHT OF WET SOIL + PAN		g	504.5					
P.	WET OF DRY SOIL + PAN		g	442.1					
Q.	WEIGHT OF PAN		g	127.1					
R.	WEIGHT OF WATER	(O - P)	g	62.4					
S.	WEIGHT OF DRY SOIL	(P - Q)	g	315					
T.	MOISTURE CONTENT	(100 R / S)	%	**19.8**					
AA.	DRY DENSITY	(100*N) / (100+T)	kg/m^3	**1693**					

PERCENT COMPACTION									
BB.	OPTIMUM MOISTURE CONTENT		%	19.4					
CC.	MAXIMUM DRY DENSITY		kg/m^3	1679					
DD.	% COMPACTION	(100*AA) / CC	%	**100.8**					

REMARKS	COMPACTION AND CONSTRUCTION EQUIP.
SITE 1 - DARK BROWN SAND CLAY; MATERIAL FROM BP#5	2 - 1.5 m SHEEPSFOOT, 2 - BLADES, 1 - CAT & SCRAPER
SITE 2	
SITE 3	
SITE 4	
SITE 5	

FIGURE 3

Cylinder No. Example Only Water Temperature: 22ºC
Temperature Correction: 0.997724

Scale Reading	Actual Volume	Scale Reading	Actual Volume	Scale Reading	Actual Volume	Scale Reading	Actual Volume	Scale Reading	Actual Volume	Scale Reading	Actual Volume
10	9	510	493	1010	985	1510	1478	2010	1972	2510	2468
20	18	520	503	1020	995	1520	1488	2020	1982	2520	2478
30	28	530	513	1030	1005	1530	1498	2030	1992	2530	2488
40	37	540	522	1040	1015	1540	1509	2040	2002	2540	2498
50	46	550	532	1050	1025	1550	1519	2050	2012	2550	2508
60	55	560	542	1060	1035	1560	1529	2060	2022	2560	2518
70	64	570	551	1070	1045	1570	1539	2070	2032	2570	2528
80	74	580	561	1080	1055	1580	1549	2080	2042	2580	2538
90	83	590	571	1090	1065	1590	1559	2090	2053	2590	2548
100	92	600	581	1100	1075	1600	1569	2100	2063	2600	2559
110	102	610	591	1110	1084	1610	1579	2110	2072	2610	2568
120	111	620	601	1120	1094	1620	1589	2120	2082	2620	2578
130	121	630	611	1130	1104	1630	1598	2130	2092	2630	2588
140	130	640	621	1140	1114	1640	1608	2140	2102	2640	2598
150	140	650	631	1150	1124	1650	1618	2150	2111	2650	2608
160	149	660	641	1160	1133	1660	1628	2160	2121	2660	2618
170	159	670	651	1170	1143	1670	1637	2170	2131	2670	2628
180	169	680	661	1180	1153	1680	1647	2180	2140	2680	2638
190	178	690	671	1190	1163	1690	1657	2190	2150	2690	2648
200	188	700	681	1200	1172	1700	1667	2200	2160	2700	2658
210	198	710	690	1210	1182	1710	1677	2210	2170	2710	2668
220	207	720	700	1220	1192	1720	1687	2220	2180	2720	2678
230	217	730	710	1230	1203	1730	1697	2230	2190	2730	2688
240	227	740	719	1240	1213	1740	1707	2240	2200	2740	2698
250	237	750	729	1250	1223	1750	1717	2250	2210	2750	2708
260	247	760	739	1260	1233	1760	1727	2260	2220	2760	2718
270	257	770	749	1270	1243	1770	1737	2270	2230	2770	2728
280	267	780	758	1280	1253	1780	1747	2280	2240	2780	2738
290	276	790	768	1290	1263	1790	1757	2290	2250	2790	2747
300	286	800	778	1300	1273	1800	1767	2300	2260	2800	2757
310	296	810	788	1310	1283	1810	1777	2310	2269	2810	2767
320	306	820	798	1320	1292	1820	1787	2320	2279	2820	2777
330	315	830	808	1330	1302	1830	1797	2330	2289	2830	2787
340	325	840	819	1340	1312	1840	1807	2340	2299	2840	2797
350	334	850	829	1350	1321	1850	1817	2350	2309	2850	2807
360	344	860	839	1360	1331	1860	1826	2360	2319	2860	2817
370	354	870	849	1370	1341	1870	1836	2370	2329	2870	2826
380	363	880	860	1380	1350	1880	1846	2380	2339	2880	2836
390	373	890	870	1390	1360	1890	1856	2390	2349	2890	2846
400	382	900	880	1400	1370	1900	1866	2400	2359	2900	2856
410	393	910	890	1410	1379	1910	1875	2410	2369	2910	2866
420	403	920	899	1420	1389	1920	1885	2420	2379	2920	2876
430	413	930	909	1430	1399	1930	1894	2430	2389	2930	2886
440	423	940	918	1440	1409	1940	1904	2440	2398	2940	2896
450	433	950	928	1450	1419	1950	1914	2450	2408	2950	2906
460	443	960	937	1460	1429	1960	1923	2460	2418	2960	2916
470	453	970	947	1470	1439	1970	1933	2470	2428	2970	2927
480	463	980	956	1480	1448	1980	1942	2480	2438	2980	2937
490	473	990	966	1490	1458	1990	1952	2490	2448	2990	2947
500	483	1000	975	1500	1468	2000	1961	2500	2458	3000	2957

FIGURE 4

11. Remove the pump and insert it in the vacuum position.

12. Open the air release valve; then pump the balloon back up into the graduated cylinder; then close the air release valve.

13. Loosen the clamping devices (or remove your hand which was providing the pressure to keep the volutester from lifting).

14. Remove the Volutester from the density plate. Set it aside in the upright position. Leave the density base plate in place.

15. Use the excavating utensils to dig the density test hole as follows:

    a) Use the trowel or chisel and hammer to shape a circle approximately 6 mm inside the density plate opening. Hold the trowel or chisel vertically. Where rocks are firmly seated in the hole, they may have to be pried loose.

    b) Use the trowel or chisel and mixing spoon to loosen the soil, working outward and upward from the middle of the circle to the edge shaped in 15a.

    c) Use the mixing spoon to **transfer all the loosened soil and rocks** from the test hole into the empty labelled container, taking care not to lose any material. Position the container over the density plate when transferring soil, so that any spilled material will fall on the plate and can be retrieved.

    d) Place the lid on the density container between soil transfers to prevent moisture loss through evaporation.

    e) Use the paint brush to brush material on the density plate into the hole and brush the sides of the hole to remove loosened material to the bottom.

    f) Repeat steps (b) to (e) until the walls of the excavation are relatively smooth and the volume of the hole meets the minimum required size shown in Table 1.

    NOTE: ***Never pry the digging tools against the edge of the hole.*** This will cause the sides of the hole to compress and distort, resulting in an erroneous volume.

16. After the test hole has been dug, place the Volutester in the recess of the density plate and secure it in place (by tightening the two clamping devices or by pressing down on the top cap). ***The mark on the density plate should match with the line on the base of the volutester***, so that the vessel is in the exact same position as during the initial reading.

17. Insert the pump in the pressure position and open the air release valve.

18. Allow the balloon to fall into the hole until the water level is stationary.

19. Pump the two-way rubber bulb until the pressure gauge reading reaches the value determined by ATT-8S Calibration of Pressure Gauge (also recorded as “Calibrated Pressure Gauge Reading” on line "B").

20. Close the air release valve.

21. When the water level remains stationary, lower your eye parallel to the surface of the water. Read the bottom of the meniscus and record as Final Cylinder Scale Reading (line "C").

22. Reverse the pump, open the valve and pump the balloon back up into the graduated cylinder. Close the valve.

23. Loosen the clamping devices, or remove your hand pressure from the top of the cylinder, and remove the apparatus from the hole.

24. Replace all the testing equipment back into the equipment box.

25. Use the “Final Cylinder Scale Reading” (line "C") and the Cylinder Calibration Chart to obtain the “Final Corrected Actual Volume from Calibration Chart” (line "D"). Ensure that the cylinder number on the chart matches the actual number on the cylinder.

26. Use the ‘Initial Cylinder Scale Reading” (line "A") and the Cylinder's Calibration Chart to obtain the “Initial Corrected Actual Volume from Cylinder Calibration Chart” (line "E").

27. Calculate the “Volume of the Hole” in cm^3 (line "F") as follows:

Volume of Hole (cm^3) = Final Corr. Actual Volume - Initial Corrected Actual Volume

Where the cylinder is graduated in cubic feet (1/10,000 ft^3 increments) determine the volume in cubic centimetres using the formula:

Volume (cm^3) = Volume (ft^3) x 28,317 cm^3/ ft^3

3.3 Soils Classification

1. Use the garden trowel to excavate a strip of soil from along the side from the top to the bottom of the density hole.

2. Identify the soil as directed in ATT-29, SOILS IDENTIFICATION, Hand Method.

3. In the “Remarks” section of the form, on the numbered line corresponding to the vertical test column number being used, record:

   a) The results of the hand method test.

   b) A description of soil, in common terms,
   e.g., Dark Brown, Sandy Clay, with some small white pebbles.

c) A description of the origin of the soil,
e.g., "common excavation at station 21+090", or
"material from B.P.#5".

d) A description of the soil structure,
e.g., stratified, fissured, friable or blocky, lensed.

e) Problems with the density test, e.g., rocks, broken balloons, etc.

4. In the "Visual Description" portion of the form, on the numbered line corresponding to the test column number being used, enter:

a) Based on the hand test results, record the unified soil type in the Hand Method Soils Classification line.

b) Make an estimation of the moisture content of the in-place soil expressed as a relationship between the actual moisture content and the estimated optimum moisture content based on the plastic limit test, e.g., 1% above opt, 2% below opt, etc. Enter the results on the Estimated Moisture Content line.

c) Based on the ease with which the hole was excavated and knowing the relative moisture content of the soil, estimate the percent compaction of the in-place soil. Record the value on the Estimated Percent Compaction line.

Make this estimation by mentally comparing the ease with which the hole was dug to the ease with which each run of the Moisture-Density Relation test could be cleaned from the proctor mold. Attempt to mentally match the in-place moisture content with the corresponding Moisture-Density Relation test run number.

3.4 Wet Density

Determine the wet density of the test site using one of the following methods:

a) Proceed with Section 3.4.1 if testing -5,000 µm materials containing less than 7% oversize. These materials include fine grained soils from grading and subgrade preparation projects and sand-base cement stabilized mixtures.

b) Proceed with Section 3.4.2 if testing -5,000 µm materials containing more than 7% retained on the 5,000 µm sieve, such as asphalt or aggregate contaminated subgrade.

c) Proceed with Section 3.4.2 if testing +5,000 µm materials, such as granular base course mixtures.

3.4.1 Minus 5,000 µm Material

The following procedure is performed on soils containing less than 7% retained on the 5,000 µm sieve.

1. Weigh the density container, contents and lid.
   Record as "Weight of Wet Soil + Rocks + Container" (line "G").

2. Calculate the total weight of the wet sample as follows:

   Wt. of Wet Soil & Rocks = Wt. of Wet Soil, Rocks & Container – Container Wt.

3. Dump the contents of the container into a wash basin.

4. If the sample contains any rock, separate the rocks larger than 5,000 µm in diameter as follows:

   a) visually, if the sample is composed mostly of clay or silt and is too wet to be sieved, or

   b) by sieving the entire sample through the 5,000 µm sieve, if the sample is sandy.

5. Weigh the material retained on the 5,000 µm sieve in a tared container.

6. Calculate the "% Rocks (+ 5,000 µm)" on line "H" using the formula:
   100 x Line "H" / (Line "G" - Line "J")

$$\% \text{ Rocks } (+\,5000\mu m) = \frac{\text{Wt. Retained on the 5000 } \mu m \text{ Sieve}}{\text{Wt. of Wet Soil \& Rocks}} \times 100$$

7. If the result is less than 7%, proceed with step 8 below. If the sample has more than 7% oversize, add the +5,000 µm rocks to the sample and proceed with Section 3.4.2, step 3.

8. Soak the +5,000 µm rocks in water and wash the rocks until they are clean. If the rocks are slightly dirty, just brush the rocks until clean.

9. Dry the washed rocks to a constant weight. Record the "Weight of Rocks from Hole" in line "H". Discard the +5,000 µm rocks.

10. Calculate the "Volume of Rocks from the Hole" in cm^3 encountered in the density sample (line "L"), knowing the average density of rock (2.6 g/cm^3) as follows:

$$\text{Volume of } +5{,}000\,\mu m \text{ Rocks } (cm^3) = \frac{\text{Wt. of } +5000\,\mu m \text{ Aggregate}}{2.6}$$

11. If the density soil did not contain rocks larger than 5 000 µm:
    a) Transfer the "Volume of Hole" (line "F") to the "Corrected Volume" on line (line "S").
    b) Transfer the "Wt. of Wet Soil + Rocks + Container" (line "G") to "Wt. of Wet Soil + Container" line (line "I").
    c) Proceed to step 14.

12. Calculate the "Volume of the -5,000 µm Soil" in cm^3 (line "M") as follows:

    Volume of -5,000 µm Soil (cm^3) = Volume of Hole - Volume of +5000 µm Rocks

13. Determine the "Weight of Wet Soil and Tare (line "I") using the formula:

    Wt. of Wet Soil & Tare (g) = Wt. of Wet Soil, Tare & Rocks - Wt. of +5,000µm Rocks

14. Calculate the "Weight of -5,000 µm Wet Soil" (line "K") as follows:

    Wt. of Wet Soil (g) = Wt. of Wet Soil & Tare - Wt. of Tare

15. Calculate the "Wet Density" in kg/m^3 (line "N") of the -5,000 µm material using the formula:

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

3.4.2 Contaminated Subgrade or Granular Base Course

1. Weigh the density container, contents and lid.
   Record as "Wt. of Wet Soil + Rocks + Container (line "G").

2. Calculate the weight of wet sample as follows:

   Wt. of Wet Soil & Rocks (g) = Wt. of Wet Soil, Rocks & Tare - Wt. of Tare

3. Sieve the entire sample through a 20,000 µm sieve into a tared large mixing pan.

4. Weigh the material passing the 20,000 µm sieve.

5. Calculate the percent passing the 20,000 µm sieve using the formula:

$$\text{\% Passing the 20,000 µm Sieve} = \frac{\text{Wt. Passing the 20,000 µm Sieve}}{\text{Wt. of Wet Soil \& Rocks}} \times 100$$

6. If the percent passing the 20,000 µm sieve is at least 70%, proceed with step 7, below. If the result is lower than 70%, discontinue the field density procedure.

7. Soak the +20,000 µm rocks in water and wash the rocks until they are clean. If the rocks are slightly dirty, just brush the rocks until clean.

8. Dry the washed rocks to a constant weight. Weigh and record as "Wt. of Rocks from Hole" (line "H"). Discard the +20,000 µm rocks.

9. Calculate the "Volume, in cm^3, of the +20,000 µm Rocks" encountered in the density sample (line "L"), using an average density of rock as 2.6 g/cm^3, as follows:

$$\textbf{Volume of +20,000}\,\mu\textbf{m Rocks (cm}^3\textbf{)} = \frac{\textbf{Wt. of +20,000}\,\mu\textbf{m Rocks (g)}}{\textbf{2.6 g/cm}^3}$$

10. If the density soil did not contain rocks larger than 20,000 µm:

    a) Transfer the "Volume of Hole" (line "F") to the "Corrected Volume" line (line "M").

    b) Transfer the "Wt. of Wet Soil + Rocks + Container" (line "G") to "Wt. of Wet Soil + Container" line (line "I").

    c) Proceed to step 13.

11. Calculate the "Corrected Volume, in cm^3, of the -20,000 µm Soil" (line "M") as follows:

$$\textbf{Volume of -20,000}\,\mu\textbf{m Soil (cm}^3\textbf{) = Volume of Hole - Volume of +20,000}\,\mu\textbf{m Rocks}$$

12. Determine the "Weight of Wet Soil and Tare" (line "I") using the formula:

Wt. of Wet Soil & Tare (g) = Wt. of Wet Soil, Tare & Rocks - Wt. of +20,000µm Rocks

13. Calculate the Weight of Wet -20,000 µm Soil (line "Q") as follows:

Wt. of Wet Soil & Tare (g) = Wt. of Wet Soil & Tare - Wt. of Tare

14. Calculate the Wet Density in kg/m^3 (line "T") of the -20,000 µm material using the formula:

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

3.5 Moisture Content

1. Label and tare a container. Record the pan number and tare weight as "Weight of Pan" (line "Q").

2. A soon as the +5,000 or +20,000 µm rocks have been separated from the soil, select from the wash basin a representative moisture content sample as follows:

    a) If testing -5,000 µm materials, obtain at least 250 g of fine grained soil, or take a 1000 g minimum sample of sand-base cement stabilized base course mixture.

    b) If testing +5,000 µm material, take at least 500 g of contaminated subgrade, or obtain a 1000 g minimum sample of granular base course mixture.

3. Weigh the container and the wet soil and record as “Wt. of Wet Soil + Pan” (line "O").

4. Oven dry the fine grained soil or contaminated subgrade sample as directed in ATT-15, MOISTURE CONTENT, Oven Method as follows:

   a) Use the conventional oven set at 110EC∀5EC to dry the sample to a constant weight (ATT-15, Part I, Soil and Aggregate), or

   b) Use the microwave oven to dry the sample for a calibrated length of time for the particular soil type (ATT-15, Part IV, Microwave Method). Do not use the microwave to dry a sample contaminated with asphalt.

   Use the stove burners to dry the cement stabilized mixture or granular base course aggregate to a constant weight at a temperature, while not exceeding 150ºC, as directed in ATT-14, MOISTURE CONTENT, Open Pan Method.

5. Weigh the hot dry sample and record as “Wt. of Dry Soil + Pan” (line "P").

6. Calculate the “Weight of Water” removed (line "R") as follows:

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

7. Determine the “Weight of Dry Soil” (line "S") as follows:

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

8. Calculate the “Moisture Content” in % (line "T") of the soil using the formula:

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

3.6 Dry Density

1. Calculate the “Dry Density”, in kg/m^3 (line "AA"), of the soil using the formula:

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

3.7 Percent Compaction

Compare the road dry density obtained on -5,000 µm materials with less than 7% oversize to the maximum dry density obtained using ATT-23 or ATT-20 (fine-grained soils). In these procedures the material is compacted in a 102 mm diameter mold and given 25 blows per lift.

Compare the road dry density obtained on +5,000 µm materials, with less than 30% retained on the 10,000 µm sieve, to the maximum dry density obtained using ATT-19 (asphalt or aggregate contaminated subgrade). In these procedures the material is compacted in a 152 mm diameter mold and given 56 blows per lift.

For all tests, the standard tamper (2.5 kg and 305 mm drop) is used and the material is compacted in 3 lifts.

1. Obtain from the corresponding Moisture-Density Relation test the Curve No., the Optimum Moisture Content and Maximum Dry Density and record the values in lines "BB", "CC" and "DD" respectively.

2. Determine the Percent Compaction (line "EE") using the formula:

$$\text{Percent Compaction (\%)} = \frac{\text{Road Dry Density}}{\text{Maximum Dry Density}} \times 100$$

4.0 HINTS AND PRECAUTIONS

1. Do not allow unprocessed density test samples to sit in the sealed density container for extended periods of time. With some soil types, a large amount of moisture from the sample will condense on the inside of the pail leading to erroneous moisture contents.

2. Ensure that all in-place densities correlate with actual conditions on the road. Never report to the contractor unrealistic or erroneous test results. In any case the section must be re-tested.

3. Do not press down too tightly on the volumeasure or volutester during either the initial or final readings, as this may disturb the soil. Hold the unit down just enough to prevent the unit from rising.

4. When taking the final cylinder reading on the density hole, pump the balloon to the calibrated pressure. If this pressure is exceeded when testing cement stabilized base courses and soft wet materials, the excess pressure exerted by the balloon may deform the test hole to such an extent as to give an erroneous volume.

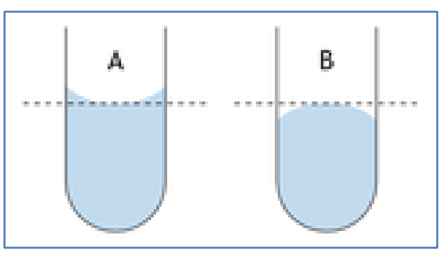
5. **Ensure the cylinder number matches the cylinder number on the calibration chart.**

6. The size of the hole and the care used in preparing the test hole will influence the accuracy of the volume measurement.

7. A test hole with irregular surfaces will cause the volume measurement to be less accurate than a hole with smooth surfaces.

8. A couple drops of food coloring can be put into the water to increase the readability of the water level in the volutester.

9. Always read the volume indicator scale in a position parallel to the water level. When you read a scale on the side of a container with a meniscus, such as a graduated cylinder or volumetric flask, it's important that the measurement accounts for the meniscus. Measure so that the line you are reading is at eye level even with the center of the meniscus. For water and most liquids, this is the bottom of the meniscus (see example A below). Mercury has a higher surface tension than the walls of the graduated cylinder which produces a convex meniscus (see example B below).



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