FIELD DENSITY BY THE SAND CONE METHOD

(A Modification of AASHTO Designation T 191)

SCOPE

1. (a) This method is used to determine the density of compacted soils or aggregates by determining the weight and moisture content material removed from a test hole and measuring the volume of the test hole.

(b) This test method may involve hazardous material, operations, or equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of any regulatory limitations prior to use.

(c) See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

APPARATUS

2. Apparatus for this test procedure shall consist of the following:

(a) A balance or scale capable of measuring the maximum weight to be determined and conforming to the requirements of AASHTO M231, except the readability and sensitivity of any balance or scale utilized shall be at least 0.01 lbs or at least the nearest gram.

(a) Miscellaneous digging tools.

(b) Sand cone apparatus consisting of base plate, cone and sand jar.

(c) Standard sand. (Sand shall be kept dry and free flowing).

(d) Containers with air tight covers (cylinder molds are satisfactory).

(e) Oven, hot plate, stove or Speedy Moisture Tester.

NOTE: Calibration of the sand and sand cone apparatus shall be done in accordance with AZ 229.

PREPARATION OF TEST SITE

3. The surface of the area where the test is to be conducted shall be prepared as follows:

(a) Clean away all loose soil and rock from an area of about 3 feet square at the spot where the test is to be made. In areas compacted by 'Sheep's foot' rollers, it is necessary to get below the depth of the 'foot' imprints.

(b) The top of the material at the chosen location shall be prepared to a plane and level surface for an area slightly larger than the size of the base plate. The base plate shall then be placed on this level surface.

PROCEDURE

4. (a) A hole shall be dug approximately the diameter of the hole in the base plate and to the desired depth. (Usually 6 inches to 8 inches). While digging, especially using a hammer and chisel, care must be taken to avoid prying as this may deform the hole, disturb the surrounding material and give a false reading. All of the material removed from the hole shall be carefully recovered and put into a suitable container and covered with a lid or damp cloth, also making sure to get the hole as clean as possible. This operation shall be done as quickly as possible to avoid any excessive drying of the sample.

Suggested test hole volumes and corresponding moisture sample weights are given in Table 1. There will be occasions where the values listed in Table 1 will be difficult to arrive at or follow, such as in the case where we are limited to a shallow depth of compacted material. This table is offered as a guide and should be followed in most cases, however, deviations from theses values are allowable when conditions warrant. The 'Speedy' Moisture Method (AASHTO T-217) may be used to determine the moisture content. The 'Speedy' Method will give the percent moisture on the passing the No. 4 material. If the sample contains material retained on the No. 4 sieve the 'Speedy' results must be adjusted in accordance with the following formula to obtain the percent moisture of the total sample.

$$W = \frac{w(100 - R) + R}{100}$$

Where:

W = % moisture in total sample
w = % moisture in Pass No. 4 material
R = % rock (Plus No. 4 sieve)

An example of this formula is shown under Calculations in this procedure.

Table 1

Maximum Particle Size Retained	Minimum Test Hole Volume cu ft	Minimum Moisture Content Sample grams
No. 4 sieve	0.060	100
½ in.	0.060	250
1 in.	0.075	500
2 in.	0.100	1000
2-1/2 in.	0.135	1500

(b) Weigh the filled sand cone apparatus and place over the base plate with the cone down. A match mark on the cone of the apparatus and the base plate is required to ensure that the apparatus is placed on the base plate the same way every time.

(c) Make sure there is no construction equipment operating in the immediate vicinity as any vibrations will cause a false volume determination.

(d) Open the valve all the way and let the sand flow freely, being careful not to jar the apparatus while the sand is flowing. When the sand ceases to move in the bottle, close the valve and remove the apparatus.

(e) Weigh the sand cone apparatus with the remaining sand to determine the volume of the hole.

REFERENCE TO METHOD 'A' PROCTOR

5. If referencing to Method 'A' Proctor continue as follows:

(a) Weigh the material removed from the test hole.

(b) Screen over a 3" and No. 4 sieve.

(c) With a small brush clean as many fines from the rock as possible.

(d) If any rock is retained on the 3" sieve, verify this with a sieve analysis and call this the end point. This sieve analysis shall be reported with a note stating the density is not determinable due to the rock retained on a 3" sieve.

(e) Weigh and record the weight of the material retained on the No. 4 sieve.

(f) Immediately weigh a moisture sample from the passing No. 4 material to be run either by 'Speedy' or Hot Plate Method.

(g) Determine the percent of rock by the following equation.

$$\% \text{ Rock} = \frac{\text{wt. of +\#4 material}}{\text{total wt. of material removed from hole}} \times 100$$

(h) If the rock content is greater than 50% (or 60% in the case of Aggregate Base) report the sieve analysis with a note stating that the density is not determinable due to excess rock.

Note: When conditions prevent density determination in areas due to the presence of excessive rock or rock retained on the 3" sieve, an attempt shall be made to compact these areas comparable to those surrounding locations where the required compaction was found through testing to be satisfactory.

(i) If less than 50% (or 60% in the case of Aggregate Base) is retained on the No. 4 sieve, proceed with the following calculations.

CALCULATIONS

6. (a) Weight of sand, in lbs., to fill hole and funnel (W_s):

$$W_s = \frac{W_o - W_f}{453.6 \text{ g/lb}}$$

Where:

W_o = original wt. of sand and apparatus, g.
W_f = final wt. of sand and apparatus, g.

Example:

$$W_s = \frac{(8560 \text{ g}) - (4314 \text{ g})}{453.6 \text{ g/lb}}$$

$$= \frac{4246 \text{ g}}{453.6 \text{ g/lb}}$$

$$= 9.36 \text{ lbs}$$

(b) Volume, in cubic feet, of hole (V):

$$V = \frac{W_s}{D_s} - V_c$$

Where:
W_s = wt. of sand to fill hole and funnel, lb.
D_s = density of sand, lb/cu. ft.
V_c = volume of cone and base plate

Example:

$$V = \frac{(9.36 \text{ lbs})}{(96.4 \text{ lb/cu ft})} - (.0407 \text{ cu ft})$$

$$= .0564 \text{ cu ft}$$

(c) Percent moisture of pass No. 4 material may be determined by utilizing the Speedy Test Method, (AASHTO T 217), or by oven-dry Method, (AASHTO T 265).

$$w = \frac{W_w - W_d}{W_d} \times 100$$

Where:

W_w = weight of wet soil, g.
W_d = weight of dry soil, g.
w = % moisture in pass No. 4 material

Example:

$$W = \frac{(322\text{ g}) - (289\text{ g})}{(289\text{ g})} \times 100 = \frac{33\text{ g}}{289\text{ g}}$$

$$= 11.4\ \%$$

(d) Moisture content of the total sample expressed in percentage shall be calculated as follows:

$$W = \frac{w(100 - R) + R}{100}$$

Where:
W = % moisture in total sample
w = % moisture in Pass No. 4 material
R = % rock (Plus No. 4 material)

Example:

w = 11.4 %
R = 29 %

$$W = \frac{11.4\ (100 - 29) + 29}{100} = \frac{838.4}{100} = 8.4\ \%$$

The formula assumes that the rock has a moisture content of 1% and is sufficiently accurate to use in most cases. If the moisture content of the rock is appreciably above 2% as on absorbent materials, the central laboratory should be contacted for instructions.

(e) Wet density, D_w in lb/cu. ft. of material:

$$D_w = \frac{W_t}{V}$$

Where:

W_t = weight of total sample, lb.

Example:

$$D_w = \frac{7.41 \text{ lbs}}{.0564 \text{ cu ft}} = 131.4 \text{ lb/ cu ft}$$

(f) Field dry density, D_d in lb/ cu. ft, of material:

$$D_d = \frac{D_w}{100 + W} \times 100$$

Example:

$$D_d = \frac{131.4 \text{ lb/ cu ft}}{100 + 8.4} \times 100 = 121.2 \text{ lb/ cu ft}$$

(g) $$\% \text{ compaction} = \frac{D_d \times 100}{\text{Maximum Density (Corrected)}}$$

Example:

Maximum Dry Density (pass No. 4 material) = 114.0 lb/ cu ft

Percent rock = 29 %

Corrected Maximum Dry Density = 122.0 lb/ cu ft

Note: Compaction shall be reported to the nearest whole percent

$$\% \text{ compaction} = \frac{121.2 \text{ lb/ cu ft} \times 100}{122.0 \text{ lb/ cu ft}}$$

$$= 99 \%$$

REFERENCE TO ALTERNATE METHOD 'D' PROCTOR

7. If referencing to Alternate Method 'D' Proctor continue as follows:

(a) Weigh the material removed from the test hole.

(b) Screen over a 3" and No. 3/4 sieve.

(c) With a small brush clean as many fines from the rock as possible.

(d) If any rock is retained on the 3" sieve, verify this with a sieve analysis and call this the end point. This sieve analysis shall be reported with a note stating the density is not determinable due to the rock retained on a 3" sieve.

(e) Weigh and record the weight of the material retained on the 3/4" sieve.

(f) Screen the material that passes the 3/4" sieve over the No. 4 sieve. Weigh the material that is retained on the No. 4 sieve and add this weight to the weight of the material retained on the 3/4" sieve.

(g) Immediately weigh a moisture sample from the passing No. 4 material to be run either by 'Speedy' or Hot Plate Method.

(h) Determine the percent of rock by the following equation.

$$\% \text{ Rock} = \frac{\text{wt. of +3/4" material}}{\text{total wt. of material removed from hole}} \times 100$$

(h) If the rock content is greater than 40% report the sieve analysis with a note stating that the density is not determinable due to excess rock.

Note: When conditions prevent density determination in areas due to the presence of excessive rock or rock retained on the 3" sieve, an attempt shall be made to compact these areas comparable to those surrounding locations where the required compaction was found through testing to be satisfactory.

(i) If less than 40% is retained on the 3/4" sieve, proceed with the following calculations.

CALCULATIONS

8. (a) The calculations are the same as those for referencing to a Method 'A' Proctor. Section 6.