TEST 5: Measurement of Field Density by Sand Cone Method

Introduction:

The sand cone method employs the use of a uniformly graded sand to fill a test hole. The hole is hand excavated in the soil and all the material from the hole is saved in a container. The hole is filled with free-flowing sand of a known density, and the volume is determined. The wet density of the soil is calculated and by determining the water content of the material from the hole, the in-place dry density can be obtained.

Purpose and significance:

- To determine the in-place density/unit weight of soils of natural soil.
- To determine the density and water content of compacted soils. It often is used as a basis of acceptance for compacted soils.

Standard Reference:

ASTM D1556: Standard Test Method for Density and Unit Weight of Soil in Place by the Sand Cone Method.

Apparatus:

1- Sand-cone density apparatus, consisting of sand container, sand cone (funnel), and base plate.
2- Small digging tools (e.g., shovels, trowels).
3- Balance.
4- Large sealable plastic bag or airtight container.

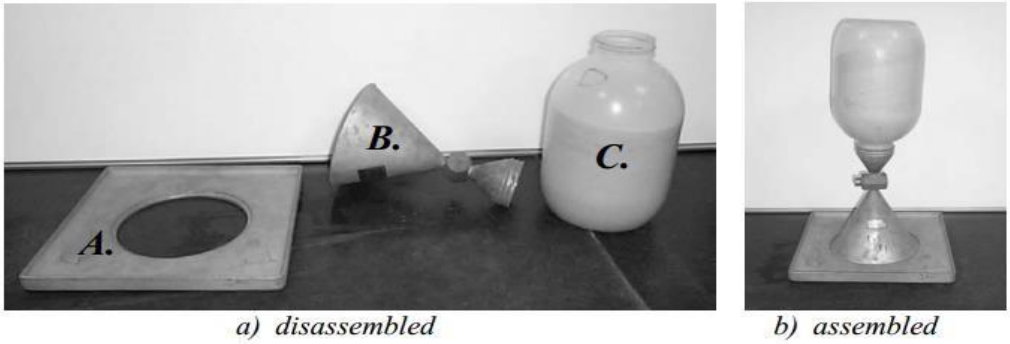

Fig.1—Sand cone device. Parts include A) base plate, B) funnel, and C) sand container

Specimen preparation:

The sand must be clean, dry, uniformly graded sand with a coefficient of uniformity ($C_u = \frac{D60}{D10}$) < 2, a maximum particle size < 2.0 mm and < 3 % by weight passing the 250 µm [No. 60] sieve size. The sand should consist of rounded particles rather than angular.

Calibration of the Sand Cone Apparatus:

1. Fill the sand cone container with dry sand by placing the funnel on the container. Record the mass of the filled sand cone device, $\boldsymbol{M1}$.
2. Place the base plate on a clean, flat surface and place the inverted sand cone device over the base plate.
3. Open the control valve fully and allow the sand to fill the base plate and funnel until the sand flow stops. Close the valve.
4. Remove the sand cone device from the base plate and record the mass of the device with the remaining sand, $\boldsymbol{M2}$.
5. Calculate the mass of sand used to fill the funnel and base plate as the difference between the initial and final mass, $\boldsymbol{M_{cone} = M1 - M2.}$
6. Refill the container and obtain the mass of the refilled device, $\boldsymbol{M_{N1}}$. Place the base plate over a calibration container of a known volume, $\boldsymbol{V1.}$ Many base plates are machined to tightly fit over a proctor mold.
7. Place the inverted sand cone device over the base plate, open the valve, and fill the chamber calibration, funnel and the base plate with sand. After the calibration chamber, base plate, and funnel are filled, close the valve. Remove the sand cone device from the base plate and weigh the sand cone device with the remaining sand, $\boldsymbol{M3}$.
8. Calculate the mass of the sand in the calibration chamber, $\boldsymbol{M4 = M_{N1} - M3 - M_{cone}.}$
9. Calculate the total unit weight of the sand, $\boldsymbol{\gamma_{sand} = \frac{M4}{V1}}$

Note: the calibration procedure should be repeated at least 3 times and the average value is considered.

Testing Procedure:

Select a location/elevation that is representative of the area to be tested, and determine the density of the soil in-place as follows:

1. Fill the sand cone device with the same type of sand used for the calibration. Obtain the mass of the filled sand cone, $\boldsymbol{W1}$.
2. Prepare the surface of the location to be tested, so that it is a level plane. Place the base plate on the surface.
3. Excavate a test hole through the center of the base plate. The shape of the test hole should approximate the shape of the calibration chamber. The base plate should not overhang the test hole, and the bottom of the test hole should be flat. Place all the excavated soil in a sealed plastic bag to be used for water content measurement.
4. Clean the flange of the base plate hole, invert the filled sand cone device over the excavated test hole. Open the valve and fill the test hole, base plate, and funnel with sand. Do not perform the test if there are significant ambient vibrations (e.g., heavy equipment operation), and take care not to move or shake the device during filling. When the sand stops flowing, close the valve.
5. Determine the mass of the sand cone with the remaining sand, $\boldsymbol{W2}$.
6. Determine and record the mass of the moist soil material that was removed from the test hole, $\boldsymbol{W_{sh}}$.
7. Mix the soil material thoroughly, and either obtain a representative specimen for water content determination $\boldsymbol{w}$, or use the entire sample.

Calculation:

1. Calculate the mass of sand used to fill the test hole, funnel and base plate:

$$W3 = W1 - W2$$

2. Calculate the mass of sand used to fill the test hole only:

$$W_{sand} = W3 - M_{cone}$$

3. Calculate the volume of the test hole as follows

$$V_h = \frac{W_{sand}}{\gamma_{sand}}$$

4. Calculate the in-place wet and dry unit weight/density of the material tested as follows:

$$\gamma_{wet)field} = \frac{W_{sh}}{V_h}$$

$$\gamma_{d)\,field} = \frac{\gamma_{wet}}{1 + w}$$

5. Calculate the relative compaction, if possible

$$R = \frac{\gamma_{d)field}}{\gamma_{d,\max)proctor}} \times 100$$

Discussion: Answer the following questions by referring to relevant references.

1. What are the advantages of measuring the field density of soils?
2. What types of soils that sand cone method is used for?

FIELD DENSITY MEASUREMENT BY SAND CONE METHOD
DATA SHEET

Date tested: Tested by:

Calibration	1	2	3	Measurements	
Mass of filled sand apparatus, M1(g)				Mass of filled sand apparatus, W1 (g)	
Mass of the apparatus after filling base plate and funnel, M2 (g)				Mass of the apparatus after filling base plate, funnel and test hole, W2	
Mass of sand filled the base plate and funnel, M_{cone} (g)				Mass of sand in the base plate, funnel and test hole, W3 (g)	
Mass of the refilled apparatus, M_{N1} (g)				Volume of the test hole, V_h (m^3)	
Mass of the refilled apparatus after filling base plate, funnel and calibration chamber, M3 (g)				Mass of moist soil excavated form the test hole, W_{sh} (g)	
Mass of sand in the calibration chamber, M4 (g)				Bulk unit weight of the in-place soil, $\gamma_{wet)\ field}$ (kN/m^3)	
Total unit weight of sand, γ_{sand} (kN/m^3)				Dry unit weight of the in-place soil, $\gamma_{d)\ field}$ (kN/m^3)	

Water Content Determination:

Specimen number	
Container and lid number	
Mass of container, w_c (g)	
Mass of container and wet specimen, w_{c+ws} (g)	
Mass of container and oven dry specimen, w_{c+ds} (g)	
Water content, w (%)	

Group names:

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