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| **No and Title of Test:** 5 (a) Determination of Dry Density of Soil (Water Displacement Method) | |
| **Year and Section:** 3rd year – Section 4 | **Lab. Group:** 3 |
| **SURNAME, Other names of student:** | |

**5 (a) Determination of Dry Density of Soil (Water Displacement Method)**

**Object of the Experiment:** To determine the dry density of a sample of natural/compacted soil by recording its mass and the amount of water it displaces after containing with a known volume of wax.

**Apparatus:**

-A cylindrical metal container fitted with a siphon tube

-A watertight container to act as a receiver for the water siphoning over from the container fitted with a siphon tube.

-A balance readable and accurate to 1 gr.

-Parafin warmer.

-Apparatus for moisture content determination.

**Theory:**

Bulk density is defined as the mass of soil specimen divided by the total volume the specimen occupy. The total volume includes particle volume, inter-particle void volume and internal pore volume.

Bulk density of soil (ρ) = Ms/Vs

Moisture content, m, can simply be defined as the weight of water in a given soil mass and it is expressed by a percentage value.

In addition, a term dry density is defined in this experiment and the following formula is given to calculate this term ;

Dry density (ρd ) = 100ρ / (100+m)

Additional properties, namely; void ratio (e) and porosity (n) are defined as the ratio of volume of voids to solids, voids to specimen respectively. Furthermore, degree of saturation is calculated by the following formula;

Degree of saturation (Sr ) = m\*Gs / e , where Gs is the specific gravity of the soil particle.

**Method of Test:**

1. Trim the soil sample to be tested until a suitable specimen produced, approximately 10 cm in each dimension. Avoid sharp corners. Weigh this specimen to the nearest gram (Ms).
2. Warm the paraffin wax about 5°C above the melting point. Then, coat the specimen completely by repeated dipping in the molten wax. Allow the waxed specimen to cool, and weigh to the nearest gram (Mw).
3. Pour water into the metal container until the level of the liquid is well above the siphon tube. When the disturbed water surface has become still, release the clip on the rubber tube and allow the excess water to run to waste, shaking the rubber tube to remove any water held by surface tension. Then re-tighten the clip.
4. Weigh the container for receiving the water to the nearest gram (M1) and place this below the siphon outlet. Lower the waxed specimen into the container, taking care to see that no air bubbles are trapped underneath the specimen, and that no portion of the specimen projects above the level of the siphon. Wait for the disturbed water surface to become still; then release the clip on the siphon tube and allow the displaced water to siphon over the into the large receiver, shaking the tube as before to remove any water held by surface tension. Then re-tighten the clip, and weigh the receiver and water to the nearest gram.
5. Remove the specimen from the container, dry its surface, and then peel off the wax. Take a representative sample of the soil, completely free from paraffin wax, and determine its moisture content.

**Calculations:**

Mass of soil specimen (Ms) = 300.5 g

Mass of specimen after waxing (Mw) = 318.27 g

Mass of wax (M = Mw – Ms) =17.77 g

Mass of receiver + displaced water (M2) = 353.21 g

Mass of receiver empty (M1) = 192.64 g

Volume of specimen (Vs = M2 – M1 – M/0.903) = 140.89 ml

Bulk density of soil (ρ = Ms/Vs) = 2.13 g/ml

Mass of box + wet soil (M3) = 20.92 g

Mass of box + dry soil (M4) = 20.69 g

Mass of box (M5) = 19.35 g

Moisture content ( m= 100\*(M3 - M4) / (M4 - M5) ) = 17.16 %

Dry density (ρd = 100ρ / (100+m) ) = 1.82 g/ml

Specific gravity of soil particles (Gs) = 2.7

Mass of dry soil (MD = 100\*Ms / (100+m) ) = 256.49 g

Volume of solids (VD = MD / Gs) = 95.00 ml

Volume of voids (Vv = Vs – VD) = 45.89 ml

Void ratio (e = 100\*Vv / VD) = 48.31 %

Porosity (n = 100\*Vv / Vs) = 32.57 %

Degree of saturation (Sr = m\*Gs / e) = 95.91 %

**Reporting of Results:**

1. Dry density of the soil : 1.82 g/ml
2. Moisture content of the soil : 17.16 %
3. Void ratio : 48.31 %

Porosity : 32.57 %

Degree of saturation : 95.91 %

**Discussion of Results:**

As we can see from the results, our soil sample is almost fully saturated, since the degree of saturated is found as 95.91% which is very close to 1. We assumed that water is distributed equally through the whole soil and made our calculations based on this assumption. This assumption and human factors such as paraffin wax usage may affect the accuracy of this test. To improve accuracy, we need to minimize factors increasing error. This can be provided by carrying out this experiment a few times more and taking samples from different parts of the soil.

**Conclusion:**

We found bulk density, moisture content, dry density, void ratio, porosity and the degree of saturation values of soil sample tested as 2.13 g/ml, 17.16 %, 1.82 g/ml, 48.31 %, 32.57 % and 0.96 respectively by water displacement method.

**References**

Mirata T. (1980) , Laboratory Instructions for Soil Mechanics Students, METU Press, Ankara (reprinted in 2009)

http://www.epa.gov/athens/learn2model/part-two/onsite/mc.html