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| **Course Code :** 5620363 | **Date of Testing:** 15.10.2010 |
| **No and Title of Test:** 7(a) Determination of Particle Size Distribution of Fine-Grained Soils by the Hydrometer | |
| **Section:** 4 | **Lab. Group:** 3 |
| **SURNAME, Other names of student:** | |

**7(a) Determination of Particle Size Distribution of Fine-Grained Soils by the Hydrometer**

**Object of the Experiment:** To determine quantitatively the particle size distribution in a soi1 from the coarse sand size down. The test is not applicable if 1ess than 10 % of the material passes the 63 micron sieve as measured by wet or dry sieving.

**Apparatus:**

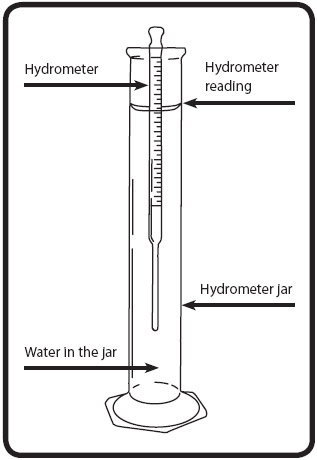


Figure 1 – Hydrometer

**Theory:**

Hydrometer analysis is the test used to determine the grain size distribution of the soils passing from No. 200 sieve. Hydrometer analysis is based on Stokes’ law, which relates the terminal velocity of a free-falling sphere in a liquid to its diameter.

It is assumed that Stokes’ law can be applied to a mass of dispersed soil particles of various shapes and sizes. Larger particles settle more rapidly than the smaller ones. The hydrometer analysis is an application of Stokes’ law that permits the calculation of the grain size distribution in silts and clays, where the soil particles are given the sizes of equivalent spherical particles.

**Method of Test:**

1. Of the air-dried soil, obtain by riffling two sub samples weighing 50-100g approximately. The actual amount of soil required will vary according to the type of soil, e.g. 50g with a clay soil and 100g with a sandy soil. Determine the moisture content (ma) of one sample. Weigh the other accurately to the nearest 0.01g (ma), and place in an evaporating dish.

2. To the soil in the evaporating dish add 100ml of sodium hexametaphodphate solution, and warm the mixture gently for about 10 minutes.

3. Transfer the mixture to the dispersing cup of the mixer, by means of a jet of distilled water from a wash-bottle. Do not use more than 150ml of water for this operation. Then stir the soil suspension for 15 minutes by means of the mechanical mixer.

4. Transfer the suspension immediately to the 63 micron test sieve placed on the receiver, and washes the soil on the sieve using a jet of distilled water from the wash-bottle. Take particular care to wash of all traces of suspension adhering to the dispersion cup and buffle wires. Do not use more than 500ml of water for this operation. Transfer the suspension that has passed through the sieve to the 1000ml measuring cylinder and make up to exactly 1000ml with distilled water.

5. Transfer the material retained on the 63 micron sieve to an evaporating dish, and dry in the oven at 105-110˚C. After drying, sieve this material on the 2.5mm, 630µm, 200µm, 63µm test sieves. Weigh the material retained on each sieve and recorded the masses (Mg, Mc, Mm, Mf respectively).

6. Insert a rubber bung in the mouth of the measuring cylinder, shake this vigorously until a uniform suspension is formed, and finally invert it end over end. Immediately the shaking has ceased, allow the measuring cylinder to stand, and start the stop watch. Immerse the hydrometer to a depth slightly below its floating position, and then allow it to float freely. Take the hydrometer readings after periods of ½, 1, 2 and 4 minutes. Then remove the hydrometer slowly, rinse it in distilled water, and keep it in a cylinder of distilled water at the same temperature as the soil suspension.

7. Re-insert the hydrometer in the suspension and take readings after periods of 8, 15 and 30 minutes, 1, 2 and 4 hours after shaking. Remove the hydrometer. Rinse it and place it in distilled water after each reading. In taking all readings, insert and withdraw the hydrometer carefully to avoid disturbing the suspension unnecessarily, allowing about 10 seconds for each operation. After 4 hours’ sedimentation, take readings once or twice daily, noting the exact period of sedimentation.

8. Read and record the temperature of the suspension once during the first 15 minutes and then after every subsequent reading, with an accuracy of at least ± 0.5˚C.

9. Place exactly 50ml of the dispersing agent solution in a weighed beaker, and place this in the oven at 105-110˚C until the water evaporates. Hence calculate the mass (Md) of dispersing agent. Calculate the dispersing agent correction (x) from the formula:

X = 2Md

**Calculations:**

Mb = 50 g

Weight of materials retained on each sieve:

|  |  |
| --- | --- |
| Sieve Number | Weight(g) |
| 20 | 16.12 |
| 30 | 4.02 |
| 50 | 2.11 |
| 100 | 1.36 |
| 200 | 8.63 |

We need to find the percentages of materials retained on each sieve to plot the cumulative percentages of the particles passing each sieve vs particle size.

% = (weight of retained / total weight) \*100

|  |  |
| --- | --- |
| Sieve Number | % |
| 30 | 24.93 |
| 50 | 13.09 |
| 100 | 8.43 |
| 200 | 53.53 |

The corrected hydrometer reading was calculated by adding hydrometer reading (Rh’) to the meniscus correction coefficient (Cm = 0.5) and the temperature correction was calculated by the help of nomographic chart (Mt = +0.58).

Rh=Rh’+Cm

Rh =17+0.5=17.5 ( t=1/2 min)

Rh = 16.5+0.5= 17 ( t=1 min)

Rh =16+0.5=16.5 (t=2 min)

Rh =15+0.5=16 (t=4 min)

Rh =14.8+0.5=15.5 (t= 8min)

Rh =10.8+0.5=11.3(t= 24 hours)

The relation between Rh and HR is given by the chart below;

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **0.5 min** | **1 min** | **2 min** | **4 min** |
| **Rh** | 40 | 30 | 20 | 10 |
| **Hr (cm)** | 8.95 | 11.4 | 13.88 | 16.36 |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **0.5 min** | **1 min** | **2min** | **4 min** | **8 min** | **15 min** | **24 hr** |
| Rh’ | 21.0 | 20.0 | 18.8 | 18.0 | 17.0 | 16.0 | 8.0 |
| Rh | 21.5 | 20.5 | 19.3 | 18.5 | 17.5 | 16.5 | 8.5 |
| Hr(mm) | 135 | 137 | 140 | 141 | 142 | 145 | 173 |

By drawing straight lines first between hydrometer readings and time , we found velocities of particles. Secondly, with the help of velocity values and temperature we found “B” values. Finally, by drawing straight lines between “B” and velocity values, we found diameters of particles. In this step, we use nomographic chart to find these values.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| T | 23 | 23 | 23 | 23 | 23 | 23 | 23 |
| v | 0.50 | 0.25 | 0.13 | 0.062 | 0.031 | 0.015 |  |
| D | 0.075 | 0.055 | 0.036 | 0.026 | 0.018 | 0.013 | 0.0014 |

Mb = 50 g and dispersing agent correction; x = 4; so we found these values to be able to find K values by the following formula;



|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Rh+Mt-x | 18.080 | 17.080 | 15.880 | 15.080 | 14.080 | 13.080 | 5.08 |
| Mb | 50 | 50 | 50 | 50 | 50 | 50 | 50 |
| K(%) | 57.420 | 54.246 | 50.434 | 47.894 | 44.718 | 41.542 | 26.996 |

**Graph:**

**Discussion of Results:**

We have made the calculations based on Stokes’ Law and certain formulas. We used nonomographic chart to find some unknowns. We concluded that as time passes, we observe a decreasing equivalent particle diameter and hydrometer reading (Rh and Rh’) , thus decreasing percentage finer than D (K).

**Conclusion:**

To determine the particles size distribution of the soil particles for fine-grained soils, sieve analysis does not work so hydrometer test is used for this process. In laboratory conditions, since every step includes error, we deviate from exact results for this test. These errors can emerge from physical steps such as in stirring step, drying step or shaking step. To sum up, we determined particle size distribution and plotted the related graphs, and discussed on our results.

**References**

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

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