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Determination of Particle Size Distribution of Fine-Grained Soils by the Hydrometer

# Purpose of the Test

* Hydrometer analysis is a widely used method of obtaining an estimate of the distribution of soil particle sizes from the No. 200 (0.075 mm) sieve to around 0.01 mm.
* To determine the grain size distribution of the fine fraction ( smaller than 0.074 mm) of a soil sample
* Material which is obtained from sieve analysis should be used so that the entire grain size distribution (GSD) of the soil can be acquired.
* In an actual test, sieve analysis and hydrometer tests should be done one after another. That is, sieve analysis must firstly be done in order to obtain particles those diameters are smaller than 0.074 mm, and after obtaining fine particles hydrometer test should be done. However, in this lab session, the fine particles are given to the students as if they did sieve analysis.

# Equipment

List of the equipment is taken from the CE363-Soil Mechanics course website.

* high-speed stirrer
* scale
* hydrometer
* thermometer
* ruler
* two 1L-volume cylinders
* distilled water
* squirt bottle
* temperature bath (or another water container deep enough to take the hydrometer)
* dispersing agent: sodium hexametaphosphate (NaPO3)6
* large evaporating dish

# Genral Rules

* Diameter of all materials inside the soil sample should be smaller than 0.074 mm, and soil sample should not consist of soluble materials such as salt because it will affect the test results.
* Meniscus level should be taken into account, and all hydrometer readings should be read on the top of the meniscus.
* Before starting the test, a few practice readings should be done
* When obtaining the hydrometer reading;
* the device should be submerged slowly and carefully
* release the device so that it can come to equilibrium position.
* When trasfering soil one container to another, solid particles should not be left behind. Moreover, with the aid of minimal amount of water, wash the container into the new container. Minimal amount of water is prominent to avoid achieving impractical volumes before the test.

# Specimen Preparation

* Weight 49.97 gr soil (dry weight)
* 5 g sodium hexametaphospahate is added to the soil
* In order to obtain a slurry, one tea-glass of distilled water is poured
* In this lab session, (NaPO3)6 should be dissolved.
* In an actual test, letting the slurry temper overnight in a closed container, but skip this part in this lab session due to time limitaions
* Use a stirrer to mix the mixture for 5-10 minutes.

# Calibration

## Meniscus Reading

* It is a property of climbing up of the water to the hydrometer stem due to interfacial properties.
* Follow the instructions below in order to obtain meniscus correction;
* Put the hydrometer into clear water
* Have a look at the top of the meniscus, and jot down the numerical value
* Obtain another numerical value at the level of the flat water surface which is the true measurement
* Meniscus correction is the difference between the readings, and shoul be added all reading while taking datas during the experiment

## Height of Fall

* The heigth of fall, changing linearly with density, is from the surface of the water to the hyrometer centroid

## Water Elongation

* When hydrometer is inserted, it displaces and stretches the suspension, increasing the height of fall. So the real height of fall is less than what you calculate in 4.2.
* Determine average volume of submerged portion of the hydrometer. You can do this by weighing the hydrometer and dividing its mass by the density measurement. You can take a constant number (such as the average of your density measurements, or the mean of the measurement range of the hydrometer), as the volume of the stem is negligible; or you can tie this calculation to each density measurement during the test.
* Determine cross section area of the cylinder by dividing volume of 1000 cm3 by height of the 1 lt mark from the base of the cylinder.
* Elongation is equal to Vhyd / 2Acyl

## Density Changes Due to Temperature and Solute Concentration

In an actual experiment, there is a pool in order to keep the temperature constant, and temperature is measured in each step. However, because of the time constraints and absence of a pool, temperature is taken constant in this lab session which is 23O C.

# Test Procedure

* Prepare the control jar by adding 125 ml of 4% sodium metaphosphate (NaPO3) solution and sufficient distilled water to produce 1000 ml. (This solution can be made by mixing 40g of dry chemical with enough water to make 1000 ml).
* All slurry should be trasfered into the 1-liter test cylinder.
* Distilled water should be poured the cylinder up to 1 L mark.
* Mix slurry and water by inverting the suspension
* Wait 1 hour for the temperature equilibration, but in this lab session skip this part
* For the advantages of the students, they should practice how to submerge the hydrometer into the suspension
* Measure the temperature of the suspension (Skip this part in this lab session, and take the temperature 23o C.
* Start the clock, and take data 15 sec(if possible), 30 sec, 1 min, but it is taken in this lab session when the hydrometer level is changed.
* Clean the hydrometer in each step for the accuracy of the test ( in our test, it is done only once)
* Waiting for a long time permits the students to see changing the level of the hydrometer.

# Calculation

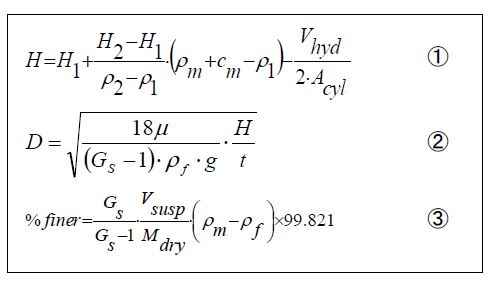


Figure 1: Formulas for calculations

**According to 1st formula;**

H=19.9+(7.7-19.9)\*(1.024+0.0005-1)/(1.05-1)-75/(2\*28.2743)= 12.59504 cm **(for the first line)**

**According to 2nd formula;**

D=sqrt(18\*0.938\*12.59504/(2.7-1)\*1.002\*981\*24)= 0.072818 cm **(for the first line)**

**According to 3rd formula;**

%finer=2.7\*75\*(1.024-1.002)\*99.821/((2.7-1)\*49.97)= 69.7991 cm **(for the first line)**

* Calculations that are shown above were done only first row of the table given below.

Table 1: Data Sheet for the Hydrometer Test

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| DATA TO BE RECORDED | | | | DATA TO BE CALCULATED | | | |
| Time (s) | Temp.(°C) | Density of Fluid (ρf) | Density of Suspension (ρm) (g/cm^3) | Heigth of Fall (H) (cm) | Equivalent Diameter (D) (cm) | Percantage Finer Than D (%) | Adjusted Percantage Finer Than D (%) |
| **24** | **23** | **1.002** | **1.0240** | **12.59504** | **0.07282** | **96.96589** | **69.79914** |
| 71 | 23 | 1.002 | 1.0235 | 12.71704 | 0.04254 | 94.76212 | 68.21280 |
| 103 | 23 | 1.002 | 1.0230 | 12.83904 | 0.03549 | 92.55835 | 66.62645 |
| 170 | 23 | 1.002 | 1.0225 | 12.96104 | 0.02775 | 90.35458 | 65.04011 |
| 313 | 23 | 1.002 | 1.0220 | 13.08304 | 0.02055 | 88.15081 | 63.45377 |
| 635 | 23 | 1.002 | 1.0210 | 13.32704 | 0.01456 | 83.74327 | 60.28108 |
| 86400 | 23 | 1.002 | 1.0160 | 14.54704 | 0.00130 | 61.70557 | 44.41764 |

# Discussion of Results

In this informative experiment, how to determine particle size distribution by Hydrometer experiment was learned with the guidance of Makbule Ilgaç. In the light of data obtained from hydrometer, particle size of the materials those are smaller than 0.074 mm were determined. However, because of the time constraints, some of the experiment steps were skipped, and it, of course, affected the accuracy of the experiment. For example, in the real hydrometer experiment, there is a pool which enables the tester to keep the temperature of the hydrometer and environment constant. Moreover, the temperature of the hydrometer should have been measured in each step, but it was not taken into account because of the time limitation, as stated before. Another important point is that surface of the hydrometer should have been cleaned so that the materials accumulated around the hydrometer could not influence the results, yet it was only done once. This experiment was made to measure the particle size distribution of the materials those are below the sieve of number of 200 (0.074 mm). Owing to the reasons mentioned above, the results may not be accurate, but the purpose of this experiment was comprehended. Graph of adjusted percentage finer than D is given below **Table-2**.

Table 2: Graph of Adjusted Percantage Finer Than D