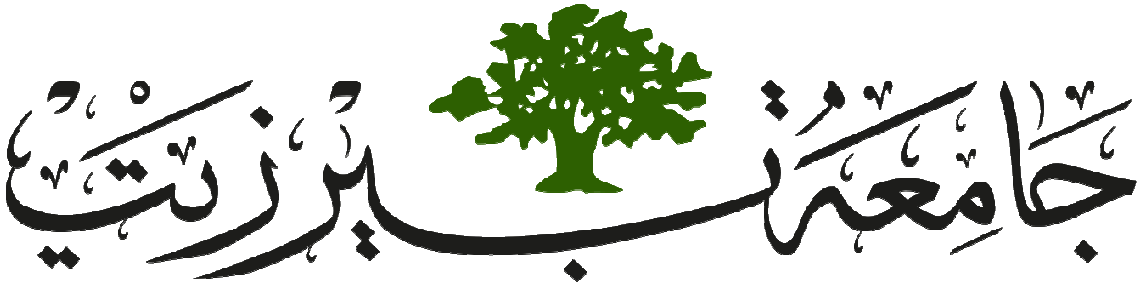

Faulty of Engineering and Technology

Civil Engineering Department

Soil Lab

ENCE311

Experiment #3 :

" Hydrometer Analysis "

Instructors :

Dr. Saheem Murshid

Eng. Maha Jarrar

Done by Group A :

Mohammad Al-Swaity	" 1181136 "
Wajih Sammour	" 1180956 "
Samer Maali	" 1180360 "
Thaljea Shaabna	" 1182216 "

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Contents :

Introduction :

Soil is an inconsistent aggregate of minerals and organic matter with liquid and gas in the spaces between its solid particles. These particles differ in shapes and sizes. Therefore, in order to deal with the soil in the best and most beneficial way possible, it is imperative to understand and classify the soil with knowledge of all its properties and variables .

Hydrometer analysis is used to determine the particle size distribution of a fraction of soil more precisely than the sieve size # 200 . This method is based on the Stokes formula for the final velocity of the hit ball. The Stokes equation has been developed to obtain perfect spheres while most of the silt and clay particles are in the shape of platy. In addition, the clay particles contain a tightly bound layer of adsorbed water that remains on the particle as it falls through the water column, resulting in a greater resistance surface than the surface of the clay particle alone. Ignoring these factors which are sources of error, the hydrometer method is accepted as being (of value for estimating the diameter and ratio of the smallest soil particles).

According to this law, the speed at which the grains settle outside the suspension, with all other factors being equal, depends on the shape, weight and size of the grains, so after it has been assumed that the soil particles are spherical and have the same gravitational quality. It can be said that coarse particles will settle more quickly than fine particles and will give the final velocity;

$$\mathbf{V = \frac{g\,(Gs - Gw)}{18\eta * D2}}$$

Where;

V = final velocity of soil particles (cm / s)

D = diameter of soil particles (cm)

Gs = specific gravity of soil particles ,,

Gw = specific gravity of water

η = viscosity of water (g / cm2)

A hydrometer is an instrument made of glass and consists mainly of two parts: a cylindrical stem with graduation marks and a mercury-weighted lamp at the bottom.

To present reasonably accurate results, the soil sample must be completely divided into individual soil grains prior to testing. This is achieved by thorough wetting and mixing the soil in a dispersing agent. A concentrated solution of water and sodium hexametaphosphate (40 g / L) was used for this purpose. Then the hydrometer is inserted at different time intervals and the depth at which it sinks is recorded. This data is used to calculate the settling velocity (final velocity) according to the formula below;

$$\mathbf{V = \frac{L}{t}}$$

Where;

V = stabilization velocity (cm / s ,, t = time interval

L = effective length or distance particles fall at time t (hydrometer reading) (cm)

$L = 203.93 - 4 * R_m$

Where;

Rm = value of reading after meniscus correction as mentioned here

And so on;

$$D = A \sqrt{\frac{L}{t}}$$

The value A is a function of temperature and particle density as shown below;

$$A = 0.005531 * \sqrt{\frac{\eta}{(Gs+1)\, g\, Gw}}$$

Corrections for hydrometer readings:

Meniscus Correction (Fm):

Hydrometer scales are designed to be read in the lower part of the meniscus. Since this is not possible with soil suspensions, the top of the meniscus should be read and the correction agent applied.

Rt = R + Fm

Where;

Rt = true hydrometer reading

R = hydrometer correction

Fm = meniscus correction

Temperature Correction (Feet):

The test temperature should be 20 ° C but the actual temperature may vary and this affects the density of the solution and thus the hydrometer reading.

Ft = 0.25T-4.85

Fz Correction:

Since the solution of sodium hexametaphosphate has a greater specific gravity than pure distilled water, the hydrometer gives a higher reading than it gives in distilled water. The difference between the two readings is called the dispersion factor correction or zero correction that is applied to all hydrometer readings subsequent to the soil water suspension.

$$Rd = R + Ft - Fz$$

Where;

Rd = hydrometer reading

Pass percentage = a $\frac{Rd}{m}$

Where;

M = mass of sample.

A = $\frac{Gs}{(Gs-1)} * 100$

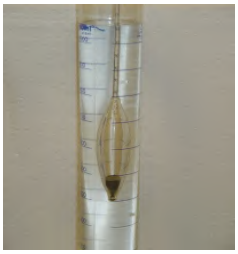
A graph of the diameter (D) can be plotted against the more accurate percentage of the particle size distribution curve development.

Purpose:

The hydrometer method is used to determine the grain size distribution of soil fine particles passing through the # 200 sieve and cannot be determined mechanically by the sieve analysis method.

Materials and Equipment's :

Look at the **" Table 1 "** that show the equipment we used in this experiment :

Equipment	The name of it :	Equipment	The name of it :
 Figure 1	**Hydrometer device**	 Figure 2	**Cans fill with different solutions**
 Figure 3	**Stop Watch**		

" Table 1 "

Procedure :

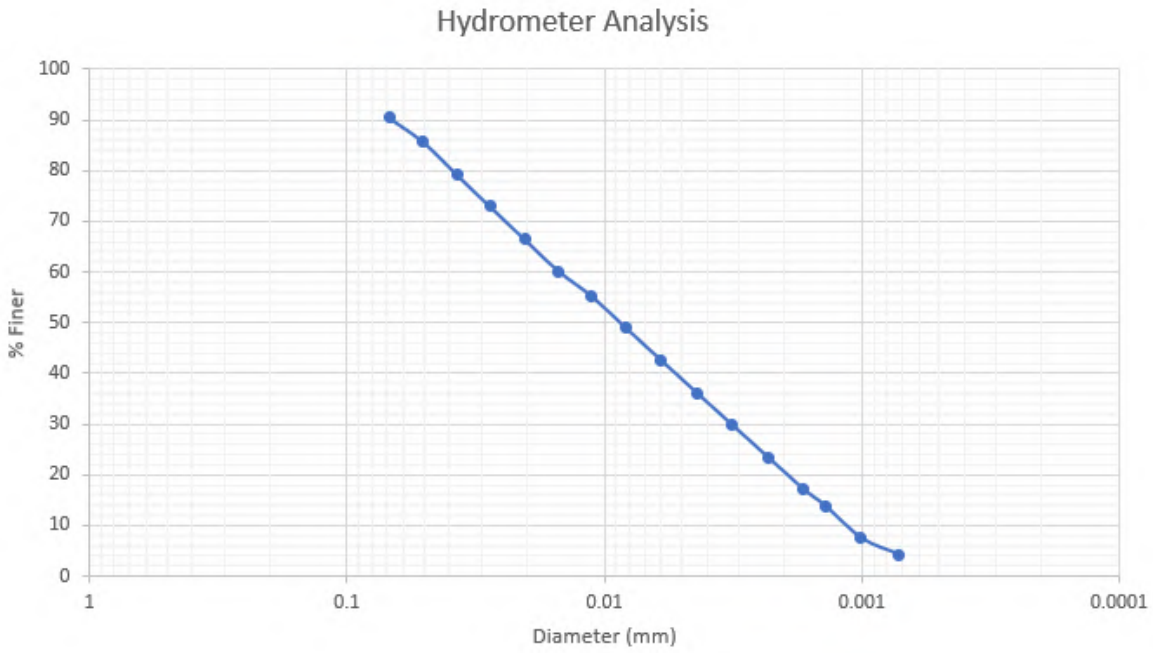
- A sample of soil was sieved on sieve #200 and a 50 gm of passed soil was taken.
- The sample was put in a cylinder with water and 4% hexametaphosphate for at least 8hrs.
- After that, the sample was put in another cylinder with 1 litter water.
- The cylinder was put in water path .
- Another 2 cylinders were put in the same path, first one was filled with water and the other one was filled with water and salt.
- The cylinder with sample was taken and an end-to-end shaking was done for it, then it was put in the water path again.
- The hydrometer was taken and it was put in the cylinder water and then it was put in the cylinder of salt and water ,then the readings were taken, and it was used for zero correction.
- The hydrometer was put in the cylinder of sample.
- Many readings were taken at a different times (starting at 5s to 30mins).
- At 14 minute, the hydrometer was removed from the cylinder of sample and it was put in the water to be cleaned .

Data and Calculations :

Data :

Specific Gravity " G_S "	2.68
Temperature of test " T "	24^o C
Dry mass of soil " m "	50 g
Meniscus correction " F_m "	0.5
Zero correction " F_z "	3.5
Dynamic Viscosity " mPas "	0.92
Temperature Correction " F_T "	$F_T = (T * 0.25 - 4.85) = 1.15$
A	$A = 0.005531 * \sqrt{\frac{\square}{(1-Gs)\gamma}} = 0.004093$
a	$a = 100 * \sqrt{\frac{Gs}{Gs-1}} = 159.5238$

Time (min)	Hydrometer Reading " R "	True Reading "R_t"	Effective depth " L "	Modified Reading "R_d"	Particle diameter (mm)	Percent Finer %
0.25	33	33.5	69.93	28.35	0.06845474	90.450
0.5	31.5	32	75.93	26.85	0.05043865	85.664
1	29.5	30	83.93	24.85	0.03749733	79.283
2	27.5	28	91.93	22.85	0.02774951	72.902
4	25.5	26	99.93	20.85	0.02045784	66.521
8	23.5	24	107.93	18.85	0.01503377	60.140
15	22	22.5	113.93	17.35	0.01128016	55.355
30	20	20.5	121.93	15.35	0.00825157	48.974
60	18	18.5	129.93	13.35	0.00602311	42.593
120	16	16.5	137.93	11.35	0.00438814	36.212
240	14	14.5	145.93	9.35	0.0031916	29.831
480	12	12.5	153.93	7.35	0.00231784	23.450
960	10	10.5	161.93	5.35	0.00168101	17.069
1440	9	9.5	165.93	4.35	0.00138939	13.879
2880	7	7.5	173.93	2.35	0.00100585	7.498
5760	6	6.5	177.93	1.35	0.00071937	4.307



Calculations :

$D_{10} = 0.0012$

$D_{30} = 0.0032$

$D_{60} = 0.015$

$C_U = \frac{D60}{D10} = 12.5$

$C_c = \frac{D30 * D30}{D60 * D10} = 0.569$

Results and Conclusion :

Results :

$D_{10} = 0.0012$

$D_{30} = 0.0032$

$D_{60} = 0.015$

$C_U = 12.5$

$C_c = 0.569$

Conclusion :

In this experiment we have a nearly well graded size distribution, since the curve is continuous with no horizontal regions and all the size ranges for the particles are approximately covered, from the chart we can see that in our sample the percent of particles that have the bigger diameters is higher than the particles that have smaller diameters. These information help to get an indication about the properties of the sample, the presence of clay which most of its particles are smaller than 0.001mm' and 0.002 mm is the upper limit contributes to its plasticity.

We can say that the percentage of fine soil is higher so the plasticity of soil is also higher and the ratio of voids in the sample is lower. This means that the soil sample has less permeability.

Sources of errors :

- The stop watch wasn't prepared when the hydrometer was put in the sample cylinder, so the readings were not taken at the exact time.
- The cylinder of sample wasn't shaken correctly, so sum of the sample was stucked at the bottom.

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- http://www.iricen.gov.in/LAB/res/html/Test-02.html