Universal Engineering & Science College

Affiliated to Pokhara University

Chakupat, Lalitpur

Department of Civil Engineering

A Compiled Lab Report
on
Soil Mechanics

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Department of Civil Engineering

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Sieve Analysis

Objective

To determine the grain size distribution of a soil by sieve analysis.

Theory

The grain size analysis is also known as mechanical analysis. In this analysis the percentage of individual grain sizes present is determined by sieving a known weight of soil through successive smaller sieves. Based on grain size the soil is divided into four parts as:

Gravel: Greater than 4.75mm

Sand: 0.075mm to 4.75mm

Silt: 0.002mm to 0.0075mm

Clay: Smaller than 0.002mm

The uniformity of a soil is expressed qualitatively by a term known as uniformity coefficient, C_u. The larger the numerical value of C_u, the more is the range of particles. Soils with the value of C_u less than 2 are uniform soils. Sands with a value of C_u of 6 or more, are well-graded. Gravels with a value of C_u of 4 or more are well-graded.

$C_u = D_{60}/D_{10}$.

Where, D_{60} = particle size such that 60% of the soil is finer than this size.

D_{10} = particle size such that 10% of the soil is finer than this size.

The general shape of the particle size distribution curve is described by another coefficient known as the coefficient of curvature C_c or the coefficient of gradation C_g. For a well-graded soil, the value of the coefficient of curvature lies between 1 and 3. It may be noted that the gap grading of the soil cannot be detected by C_u only. The value of C_c is also required to detect it.

$(D_{30})^2/(D_{60}*D_{10})$

Where, D_{30} = particle size such than 30% of the soil is finer than this size.

Applications

The results of grain size distribution are widely used for soil classification, design of filters, construction of earth dams, highway embankments, for construction of building, hydraulic structures and road construction, etc.

Apparatus

- For coarse sieve analysis: IS Sieves 100, 63, 20, 10 and 4.75mm
- For fine sieve analysis: IS Sieves 2, 1, 0.6, 0.425, 0.212, 0.150 and 0.075mm
- Oven
- Weighing machine

- Sieve Shaker
- Trays
- Pan

Procedure

a) Coarse Sieve Analysis

1. Take suitable quantity of oven-dry soil.
2. Arrange set of sieves such that 100mm sieve is at the top and 4.75mm sieve is at the bottom.
3. Put cover on top sieve and pan at bottom of 4.75mm sieve and put the soil on top sieve before covering it.
4. Put the sieves in the sieve shaker and clamp it tightly.
5. Shake the sieves for 10 minutes.
6. Find the weight of soil retained on each sieve.
7. Find the weight of soil on pan.

b) Fine Sieve Analysis

1. Arrange set of sieves such that 2mm sieve is at the top and 0.075 mm sieve is at the bottom.
2. Put pan at the bottom of 0.075mm sieve.
3. Put the soil passing 4.75mm sieve on top sieve and then cover it.
4. Put the set of sieves with pan and cover in the sieve shaker.
5. Shake the sieves for 10 minutes.
6. Find the weight of soil retained on each sieve.

For both coarse-grained analysis and fine-grained analysis find the percentage of soil retained on each sieve; cumulative percentage retained and percentage finer. Particle size distribution curve is obtained by plotting particle size on x-axis on log scale and percentage finer on y-axis.

Observations and Calculations

S.No.	Sieve Size	Mass of soil retained (gm)	Percentage mass retained	Cumulative percentage retained	Percentage finer (N)
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					
11.					

1. Plot curve between percentage finer and grain size on semi-log graph.
2. Find particle size for 10% finer, D_{10}; particle size for 30% finer, D_{30}; particle size for 60% finer, D_{60}.
3. Find uniformity coefficient as $C_u = D_{60}/D_{10}$.
4. Find coefficient of curvature as $C_c = (D_{30})^2/(D_{60}*D_{10})$

Result

C_u =

C_c =

Conclusion

Liquid Limit and Plastic Limit Test

Objective

To determine the liquid limit and plastic limit of soil specimen.

Theory

The liquid limit is the water content at which soil changes from liquid state to the plastic state. At liquid limit, the soil possesses a small value of shear strength. Liquid limit is the water content at which a part of soil, cut by a groove of standard dimensions, will flow together for a distance of 13mm under an impact of 25 blows in Cassagrande's liquid limit apparatus.

Plastic limit is the water content below which the soil stops behaving as a plastic material. At this water content the soil loses its plasticity and passes into semi-solid state. It is the minimum water content at which a soil will just begin to crumble (crack) when rolled into a thread approximately 3mm in diameter.

Applications

Fine grained cohesive soils are classified by knowing liquid limit and plastic limit. From liquid limit and plastic limit, we can find flow index, toughness index and plasticity index. These gives an idea about plasticity, cohesiveness, compressibility, shear strength and permeability of cohesive soils.

Liquid Limit Test

Objective

To determine liquid limit of soil specimen using Casagrande's apparatus.

Apparatus

1. Casagrande's liquid limit apparatus
2. Grooving tool
3. Spatula
4. Mixing dish or bowl
5. Containers for water content
6. Balance, sensitive to 0.01g
7. Oven
8. Sieve 0.425mm

Procedure

1. About 120gm of the dried soil sample passing through 425 micro sieve is taken. It is mixed thoroughly with distilled water.
2. A portion of the soil paste is kept in cup and levelled by means of spatula.
3. Using standard grooving tool, a groove is cut in the soil from back to front dividing the paste in the bowl into two equal halves. Consider Cassagrande's tool for a normal fine-grained soil.

4. Turn the handle of Cassagrande's device at a steady rate of two revolutions per second. Continue turning until two halves of soil pat come in contact at the bottom of the groove along a distance of 13mm.
5. Note the number of blows.
6. The water content of the soil is altered and process is repeated.
7. Adjusting the water in such a way that the number of blows to close the groove may fall within the range of 5 to 40 blows carries out at least four tests.
8. The water content values are plotted as ordinate on natural scale against number of blows to obtain a best fitting straight line which is referred as flow curve.
9. From this plot, the liquid limit is obtained as water content corresponding to 25 blows.

Observations and Calculations

No. of blows				
Container No.				
Wt. of Container (gm)				
Wt. of container + Wet Soil (gm)				
Wt. of container + Dry Soil (gm)				
Wt. of Water (gm)				
Wt. of Dry Soil (gm)				
Water Content (%)				

Plot log N on X-axis and Water Content, w on Y-axis. From plot find the water content for 25 number of blows. This gives the value of liquid limit.

Result

Conclusion

Plastic Limit Test

Objective

To determine the plastic limit of a soil specimen.

Apparatus

- Glass or plastic plate
- Metal rod of 3mm diameter
- Spatula
- Containers (Small Size)
- Weighing Machine
- Oven

Procedure

1) Take about 20gm of soil for plastic limit test. The soil should pass through 0.425mm IS sieve.
2) Mix the soil with distilled water thoroughly to get soil paste.
3) Make the soil paste into a ball of diameter 10 to 20mm.
4) Convert the ball of soil into a thread by rolling on a glass plate with the hand until it formed in form of thread of 3mm diameter.
5) If the thread crumbles when rolled into diameter of 3mm, collect such threads for water content determination. The crumbled thread is tested for water content when its weight is found out before drying say w1 and after drying say w2 (in oven), then $W_p = W_w/W_s = (W_1\text{-}W_2)/W_2$. If the thread does not crumble, knead the sample and again make the thread. Repeat this process until the thread crumbles at 3mm diameter.
6) Repeat steps 1 to 5 with three more fresh samples.

Observations and Calculations

Container No.				
Wt. of Container (gm)				
Wt. of container + Wet Soil (gm)				
Wt. of container + Dry Soil (gm)				
Wt. of Water (gm)				
Wt. of Dry Soil (gm)				
Water Content (%)				

Average Plastic Limit, W_P =

Plasticity Index, $I_P = W_L - W_P$ =

Result

Conclusion

Determination of In-situ Density of Soil by Sand Replacement Method

Objective: To determine the in-situ density of soil.

Apparatus Required

- Tray
- Sand cone fitted with valve
- Sand bucket (Sand Pouring Cylinder)
- Mould (Calibrating Cylinder)
- Standard Sand (Dry)
- Metal tray with central hole and impression
- Knife

Theory

Density of soil is defined as the mass per unit volume of the soil. The density calculated in the field is insitu density of soil. This is done with the instant fresh sample of soil without actually disturbing it's any other properties.

Sand replacement method to determine insitu density of soil finds its application in case the soil is cohesionless or coarse grained since core-cutter method cannot be used because of inability of core-cutter to penetrate through coarse grained particles like minor rock chunk.

In this method, at first the density of the standard sand is figured out and by using the standard sand, the volume of part from which soil is excavated is calculated. Then by measuring the respective mass, we find density of soil.

The basic formulae employed are:

Volume of hole dug in field = Wt. of sand replaced (weighed) / Density of sand (Determined)

Insitu density of soil = Wt. of soil / Volume of hole dug

Experimental Procedure

i) Determination of density of sand

1. The internal diameter, height and weight of empty mould were measured.
2. Sand (Standard and dry) was filled in the mould and its weight was measured.
3. Using mass of sand in mould and volume of mould, density of sand was calculated.

ii) Determination of mass of sand in cone

1. The mass of cone fitted sand jar with enough sand was measured.
2. The sand jar was inverted over a tray until the sand kept falling such that the conical portion of sand was removed.
3. The mass of sand jar was taken again.
4. The difference in mass of sand jar gave mass of sand in conical portion.

iii) Determination of in-situ density of soil

1. The top soil in field was removed in order to throw away soil-less garbage and then the ground was levelled.
2. A pit of about 4-5cm depth was excavated with the help of knife by placing the metal tray with central hole above the ground. This ensured the diameter of the pit excavated to be the same as the diameter of the tray and cone.
3. The mass of soil was collected in a tray and was weighed.
4. The sand jar with cone was inverted and sand was poured in the hole.
5. The difference in weight of sand jar gave mass of sand used in filling excavation from which volume of hole and thus, density of soil was obtained.

Observations and Calculations

i) Diameter of mould (d) =
ii) Weight of mould (W_a) =
iii) Height of mould (h) =
iv) Volume of mould (V) =

Determination of Density of Sand

i) Wt. of mould + sand (W_b) =
ii) Density of sand (ρ_{sand}) = $(W_b - W_a) / V$

=

Determination of Field Density of Soil

i) Wt. of the soil in the hole (W1) =
ii) Wt. of pouring cylinder + Sand before pouring (W2) =
iii) Wt. of pouring cylinder + Sand after pouring (W3) =
iv) Wt. of sand filling the conical end (W4) =
v) Wt. of sand filling the hole (Wt. of sand replaced) = W2 – W3 – W4

=

vi) Volume of Hole (V_{hole}) = Wt. of sand replaced / Density of sand

= $(W2-W3-W4) / \rho_{sand}$

=

vii) Density of soil (ρ_{soil}) = (Wt. of Soil / Volume of Hole)

= $(W1 / V_{hole})$

=

Result

Conclusion

Determination of Dry Density of Soil by Core Cutter Method

Objective: To determine the dry density of soil.

Apparatus Required

i) Cylindrical core cutter, 100 mm internal diameter and 130 mm long.
ii) Steel rammer, mass 9 kg.
iii) Steel dolley, 25 mm high and 100 mm internal diameter.
iv) Weighing balance.
v) Knife, etc.

Theory

Density of soil is defined as the mass per unit volume of the soil. The density calculated in the field is insitu density of soil. This is done with the instant fresh sample of soil without actually disturbing it's any other properties. Core cutter method is quite suitable for soft, fine grained soils. It cannot be used for stony, gravelly soils.

For determination of the dry density of the soil cutter is pressed into the soil mass so that it is filled with the soil. The cutter filled with the soil is lifted up. The mass of the soil in the cutter is determined. The dry density is obtained as.

$$\rho_d = \frac{M/V}{1+w}$$

Where, M = Mass of the wet soil in the cutter.

V = Internal Volume of the cutter.

w = Water Content.

Procedure

1. Determine the internal diameter and height of the core cutter.
2. Determine the mass of the cutter (M_1).
3. Expose a small area of the soil mass to be tested. Level the surface.
4. Place the dolley over the top of the core cutter and press the core cutter into the soil mass using the rammer.
5. Stop the process of pressing when about 15 mm of the dolley protrudes above the soil surface.
6. Remove the soil surrounding the core cutter, and take out the core cutter.
7. Remove the dolley. Trim the top and bottom surface of the core cutter carefully.
8. Weigh the core cutter filled with the soil (M_2).
9. Remove the core of the soil from the cutter. Take a representative sample for the water content determination.
10. Determine the water content.

Observations and Calculations

i)	Diameter of the core cutter (d)	=
ii)	Height of the core cutter (h)	=
iii)	Mass of cutter (M_1)	=
iv)	Mass of cutter and soil (M_2)	=
v)	Mass of soil (M)	= $M_2 – M_1$ =
vi)	Volume of the soil (V)	= Volume of the core cutter = $\frac{\pi d^2}{4} * h$ =
vii)	Bulk Density (ρ)	= M / V =
viii)	Weight of sample before drying	= W_1 =
ix)	Weight of sample after drying	= W_2 =
x)	Water Content (w)	= $(W_1 - W_2) / W_2$ =
xi)	Dry Density (ρ_d)	= $\frac{\rho}{1+w}$ =

Result

Conclusion