Grain Size Analysis of Soils

Definition

Grain size analysis is the determination of the size grain of particles present in a soil. It is expressed as a percentage of the **total dry weight**. Two methods are generally used to find particle size distribution of soil: Sieve analysis and Hydrometer analysis.

Introduction

The sieve analysis is generally applied to the soil fraction larger than 75 μm (retaining on the No. 200 Sieve). Grains smaller than 75 μm (0.075 mm) are sorted by using sedimentation process (hydrometer analysis).

The basic principles for sieve analysis and hydrometer analysis are described in the following two sections.

Section One / Sieve Analysis

Definition

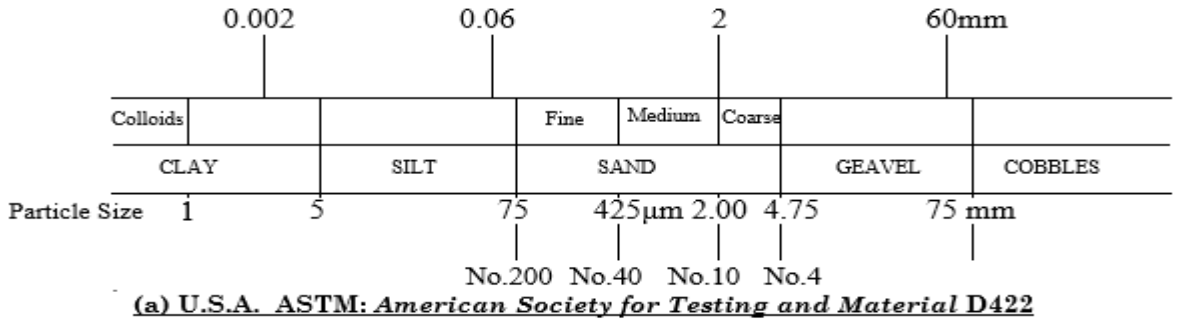
Sieve analysis consists of shaking the soil sample through a set of sieves that have progressively smaller openings.

Introduction

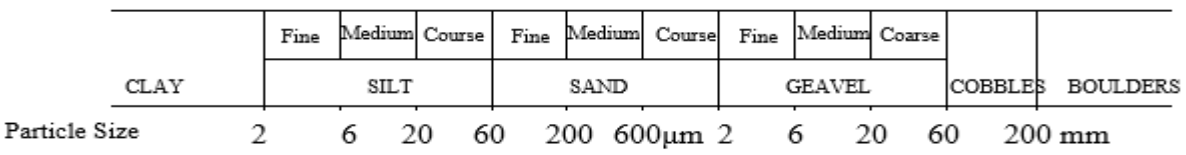
- Fortunately, not all soils contain the full range of particle sizes so the test can be simplified. Soils that are non-cohesive may only require dry sieving. It is usually considered that the sedimentation procedure is not necessary if the soil contains less than 10% fines.

- Soils may be divided on the basis of their dominating particle size six arbitrary categories which are called boulders, cobbles, gravel, sand, silt and clay.

Sieve Designation



(a) U.S.A. ASTM: *American Society for Testing and Material* D422



(b) BS 1377:1975 *British Standard*

Particle Size Distribution Curve

- The particle size distribution curve, also known as a gradation curve, represents the distribution of particles of different sizes in the soil mass. A coarse soil is described as:

Well graded:

If there is no absence of particles in any size range and if no intermediate sizes are lacking. The smooth concave upward grading curve is typical of well-graded soil, which is shown by curve (1) in Fig (a).

Poorly graded if:

a. A high proportion of the particles have sizes with narrow limits (a uniform soil or narrowly graded soil) as shown by curve (2).
b. Particles of both large and small sizes are present but with relatively low proportion of the particles of intermediate sizes (a gap-graded or step-graded soil) as shown by curve (3).

- Soil particles have sizes ranging from greater than 200 mm down to less than 0.002 mm (2 μm).

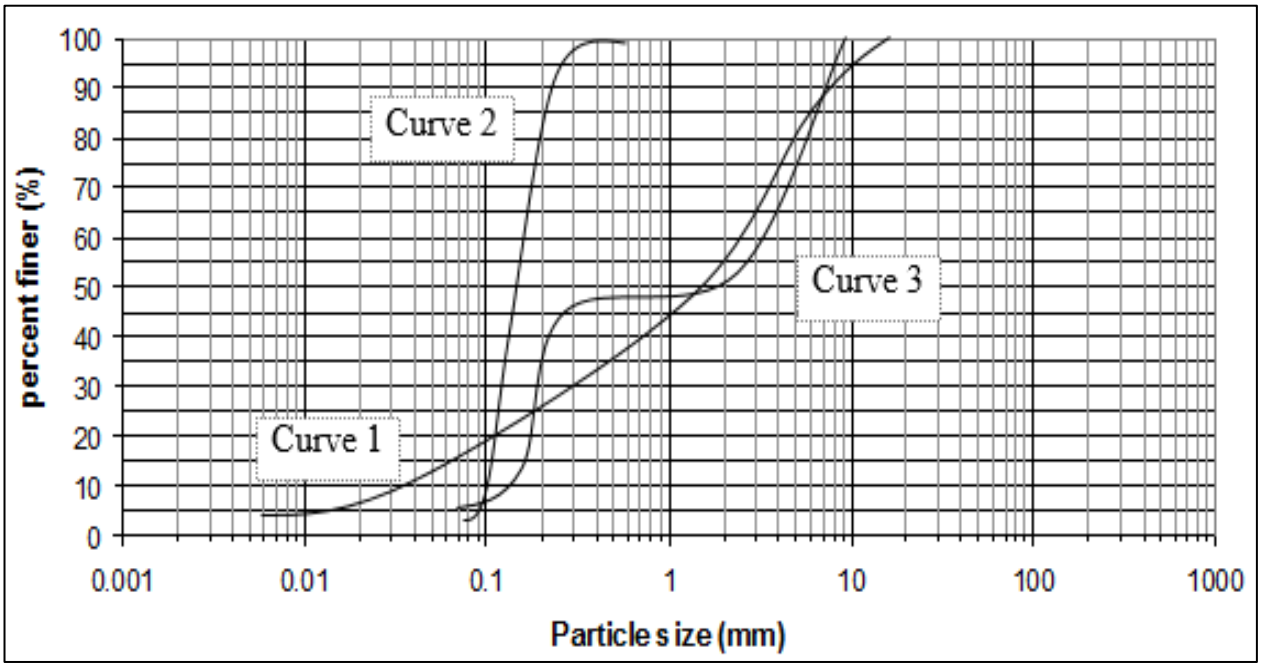


Figure (a) Grain Size Distribution Curves of Soil.

Purposes

To determine the grain size distribution curve of a soil sample by which soil can be classified and their engineering properties assessed.

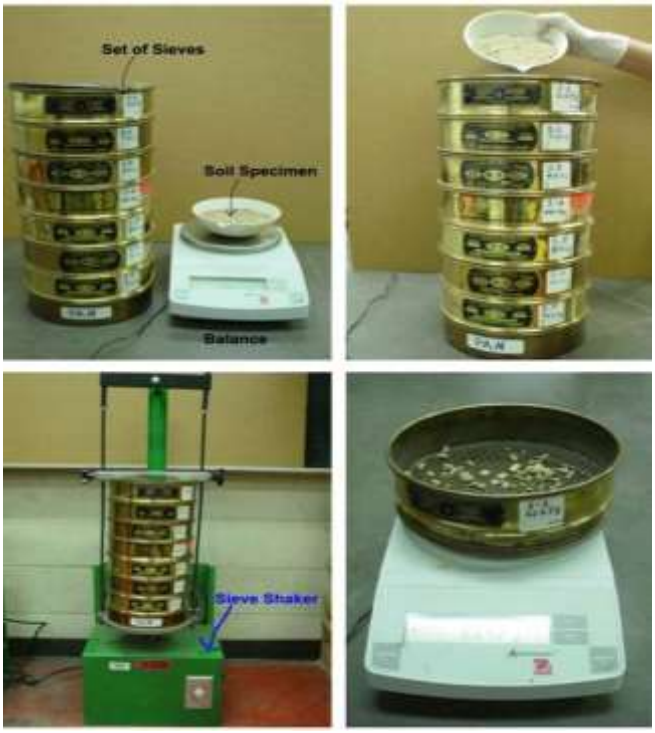
Apparatus

The equipment used in sieve analysis includes:

1. A series of standard sieves of square mesh, including cover plate and bottom pan. Two recommended sieve stacks (having successively smaller mesh sizes) are as shown in table (1):

Table (1): A series of standard sieves.

Typical Sieve Stack		Alternative Sieve Stack	
Sieve No.	Opening (mm)	Sieve No.	Opening (mm)
Lid		Lid	
4	4.75	4	4.75
10	2	10	2
20	0.85	30	0.6
40	0.425	50	0.3
60	0.25	100	0.15
140	0.106	200	0.075
200	0.075	Pan	
Pan			



2. Sieve shaker.
3. Balance sensitive to 0.1g.
4. Mortar and pestle (pulverizer for breaking up aggregations of soil particles).
5. Brush (for cleaning sieve).
6. Oven.

Preparation of Soil Sample

The aggregations or lumps of soil tested are thoroughly broken up with the mortar and pestle or (pulverizer).The specimen to be tested should be large enough to be representative of the soil in the field. It should also be small enough not to overload sieves. The size of representative specimen depends on the maximum particle size. Table (2) gives some guidelines for selecting the maximum sample weight.

Table (2): Size of representative specimen depends on maximum particle size.

Maximum Particle Size	Minimum Weight of Sample (g)
7.5 cm	6000
5 cm	4000
2.5 cm	2000
1 cm	1000
Finer than No. 4 sieve	200
Finer than No. 10 sieve	100

Procedure

1. Oven dry the sample, allow it to cool. Then take 500 g (depending on maximum particle size) of oven dried soil.
2. Select a stack of sieves suitable to the soil being tested. Weigh each sieve and a pan to be used W_o (make sure each sieve is clean before weighing it, by using a brush to remove grains stuck in mesh openings).
3. Arrange the stack of sieves so that the largest mesh opening is at the top and the smallest is at the bottom and attach the pan at the bottom of the sieve stack.
4. Put dry sample on top sieves. Add a cover plate (to avoid dust and lost particles while shaking).
5. Place the stack of sieves in the mechanical shaker and shake for **10 min**.
6. Remove the stack of sieves from the shaker, and measure the weight of each sieve and the pan with the soil retained on them W_f.
7. Subtract the weights obtained in step (2) from those of step (6) to give the weight of soil retained on each sieve. Their sum is compared to the initial sample weight; both weights should be within about 1%. If the difference is greater than 1%, too much material was lost, and weighing and/or sieving should be repeated / $W_f - W_o$ / > 1%.

Calculation

- % Retained on each sieve = $\frac{\text{Weight of soil retained}}{\sum} * 100$
- % finer (passing) than any sieve size = 100 – Cumulative % Retained.
- The gain-size distribution curve can be used to determine some of the basic soil parameters such as the: Uniformity coefficient (C_u); is a measure of the slope of the curve. $C_u = \frac{D_{60}}{D_{10}}$

  Coefficient of gradation or concavity (C_c); is defined as. $C_c = \frac{(D_{30})^2}{D_{60} * D_{10}}$

Where: D_{10} = (Effective size) is the diameter in grain size distribution curve corresponding to 10% finer, D_{30} = diameter through which 30% of the total soil mass is passing and D_{60} = diameter corresponding to 60% finer.

- Find gravel, sand and (silt and clay) percentage according ASTM.
- Find coarse, medium and fine sand according ASTM.

Discussion

1. How can you quickly verify the result of dry sieve?
2. Under what conditions should you use wet sieving instead of dry sieving?

Sieve Analysis Data Sheet

Student Name: ..... Signature: .....
Group name: ..... Test date / /

Total sample mass = ...

(1) ASTM Sieve number	**(2)** Sieve opening (mm)	**(3)** Weight of sieve (g)	**(4)** Weight of sieve + soil retained (g)	**(5)** Weight of soil retained (g)	**(6)** **%**Retained on each sieve (g)	**(7)** Cumulative of %Retained	**(8)** %Passing or (% finer)
4	4.750						
10	2.000						
20	0.850						
30	0.600						
40	0.425						
100	0.150						
200	0.075						
Pan							
				∑