

From Chapter 4 Soil Formation and Characteristics

U.S. Army (1997) Military Soils Engineering. Field Manual 5-410.

On-line at <http://www.adtdl.army.mil/cgi-bin/atdl.dll/fm/5-410/toc.htm>

Grain or Particle Size

In a natural soil, the soil particles or solids form a discontinuous mass with spaces or voids between the particles. These spaces are normally filled with water and/or air. Organic material may be present in greater or lesser amounts. The following [paragraphs](#) are concerned with the soil particles themselves. The terms "particle" and "grain" are used interchangeably.

Determination. Soils may be grouped on the basis of particle size. Particles are defined according to their sizes by the use of sieves, which are screens attached to metal frames. [Figure 4-3](#) shows sieves used for the Unified Soil Classification System (USCS). If a particle will not pass through the screen with a particular size opening, it is said to be "retained on" that sieve. By passing a soil mixture through several different size sieves, it can be broken into its various particle sizes and defined according to the sieves used. Many different grain-size scales have been proposed and used. Coarse gravel particles are comparable in size to a lemon, an egg, or a walnut, while fine gravel is about the size of a pea. Sand particles range in size from that of rock salt, through table salt or granulated sugar, to powdered sugar. Below a Number 200 sieve, the particles (fines) are designated as silts or clays, depending on their plasticity characteristics.

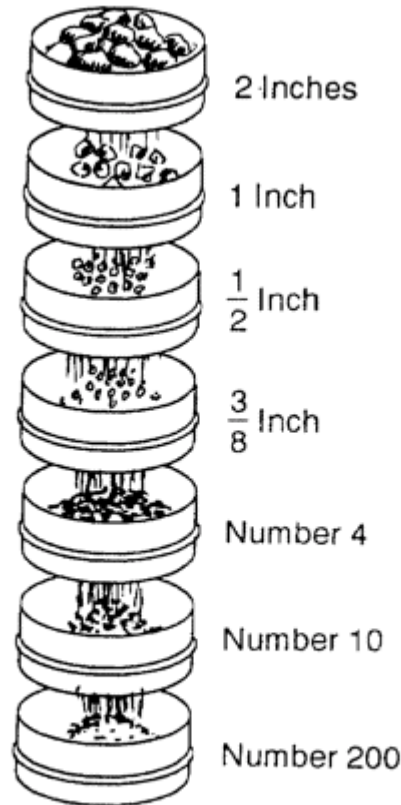


Figure 4-3. Dry sieve analysis.

Other grain-size scales apply other limits of size to silts and clays. For example, some civil engineers define silt as material less than 0.05 mm in diameter and larger than 0.005 mm. Particles below 0.005 mm are clay sizes. A particle 0.07 mm in diameter is about as small as can be detected by the unaided eye. It must be emphasized that below the Number 200 sieve (0.074-mm openings), particle size is relatively unimportant in most cases compared to other properties. Particles below 0.002 mm (0.001 mm in some grain-size scales) are frequently designated as soil colloids. The organic materials that may be present in a soil mass have no size boundaries.

Several methods may be used to determine the size of soil particles contained in a soil mass and the distribution of particle sizes. Dry sieve analysis has sieves stacked according to size, the smallest being on the bottom. Numbered sieves designate the number of openings per lineal inch. Dimensioned sieves indicate the actual size of the opening. For example, the Number 4 standard sieve has four openings per lineal inch (or 16 openings per square inch), whereas the 1/4-inch sieve has a sieve opening of 1/4 inch.

The practical lower limit for the use of sieves is the Number 200 sieve, with 0.074-millimeter-square openings. In some instances, determining the distribution of particle sizes below the Number 200 sieve is desirable, particularly for frost susceptibility determination. This may be done by a process known as wet mechanical analysis, which

employs the principle of sedimentation. Grains of different sizes fall through a liquid at different velocities. The wet mechanical analysis is not a normal field laboratory test. It is not particularly important in military construction, except that the percentage of particles finer than 0.02 mm has a direct bearing on the susceptibility of soil to frost action. A field method for performing a wet mechanical analysis for the determination of the percentage of material finer than 0.02 mm is given in [Technical Manual \(TM\) 5-530](#). The procedure is called decantation.

The [procedures](#) that have been described above are frequently combined to give a more complete picture of grain-size distribution. The procedure is then designated as a combined mechanical analysis.

Other methods based on sedimentation are frequently used in soils laboratories, particularly to determine particle distribution below the Number 200 sieve. One such method is the hydrometer analysis. A complete picture of grain-size distribution is frequently obtained by a combined sieve and hydrometer analysis. This method is described in [TM 5-530 \(Section V\)](#).

Reports. Test results may be recorded in one of the following forms:

- Tabular (see [Figure 4-4](#)).
- Graphic (see [Figure 4-5](#)).

SIEVE ANALYSIS DATA					1. DATE STARTED 22 FEB 91	
2. PROJECT BRAVO AIRFIELD			3. EXCAVATION 1+00		4. DATE COMPLETED 28 FEB 91	
5. SAMPLE DESCRIPTION LIGHT BROWN SANDY SOIL					6. SAMPLE NUMBER 1A	
					7. PREWASHED (r one)	
XX		YES		NO		
8. ORIGINAL SAMPLE WEIGHT 2459			9. + #200 SAMPLE WEIGHT 2359		10. -#200 SAMPLE WEIGHT 100	
11. SIEVE SIZE	12. WEIGHT OF SIEVE	13. WEIGHT OF SIEVE + SAMPLE	14. WEIGHT RETAINED	15. CUMULATIVE WEIGHT RETAINED	16. PERCENT RETAINED	17. PERCENT PASSING
1½	202					
1	231					
½	210	210	0	0	0	100.0
¼	230	624	394	394	16.0	84.0
#4	205	332	127	521	5.2	78.8
#8	225	691	466	987	19.0	59.8
#20	215	612	397	1384	16.2	43.6
#60	235	581	346	1730	14.1	29.5
#100	250	612	362	2092	14.7	14.8
#200	260	515	255	2347	10.4	4.4
18. TOTAL WEIGHT RETAINED IN SIEVES (Sum Column 14)				2347	19. ERROR (18 - 22)	
20. WEIGHT SIEVED THROUGH #200 (Weight in pan) 270-260				10	2459-2457 = 2	
21. WASHING LOSS (18 - 19 + 20) 2459 - (2359+100)				0		
22. TOTAL WEIGHT PASSING #200 (20 + 10) 10+100				110		
23. TOTAL WEIGHT OF FRACTIONS (18 + 22)				2457		
24. REMARKS					25. ERROR (Percent)	
USCS <u>SP</u> PERCENT - G <u>21.2</u> PERCENT - S <u>74.4</u> PERCENT - F <u>4.4</u>					$\frac{\text{ERROR (19)}}{\text{ORIGINAL WT (8)}} \times 100 =$ $\frac{2}{2459} \times 100 = .08$	
26. TECHNICIAN <i>Joe Blob PV2</i>			27. COMPUTED BY (Signature) <i>Joe Blob PV2</i>		28. CHECKED BY (Signature) <i>Fred Jones SSG</i>	

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Figure 4-4. Data sheet, example of dry sieve analysis.

The tabular form is used most often on soil consisting predominantly of coarse particles. This method is frequently used when the soil gradation is being checked for compliance with a standard specification, such as for a gravel base or a wearing course.

The graphic form permits the plotting of a grain-size distribution curve. This curve affords ready visualization of the distribution and range of particle sizes. It is also particularly helpful in determining the soil classification and the soil's use as a foundation or construction material.