SAND AND GRAVEL*

By A. Ledoux
Ontario Bureau of Mines

SAND and gravel belong to the category of unconsolidated clastic rocks. The component fragments vary widely in size, some passing the 200-mesh sieve, others being more than one foot in diameter. Small grains and large fragments may be associated in the same sample. There is no natural limit between sand and gravel; for practical use, we call sand a material made of grains passing the 1¼-in. screen, and gravel a material made of fragments retained on the ¼-in. screen; boulders are fragments larger than 3 ins. in diameter.

Morphological Properties

Size.—The size of the component fragments of a clastic rock affects a certain number of its physical properties, such as specific gravity, absorption and permeability. With regard to size, sands are ordinarily divided into fine, medium and coarse varieties, gravels into fine gravel, pea gravel and coarse gravel.

The classification of a sand or gravel is often made at sight, but more accurately by using sieves. A sieve is defined by the number of holes or meshes per linear inch; for instance, a 100-mesh sieve has 100 holes to the linear inch. A sieve may also be defined by the smallest linear dimension or rating of the hole, a ¼-in. sieve having holes of ¼ in. as their smallest dimension. This last method may be applied to screens with holes larger than one inch. It should be noted that there is a great difference between a 4-mesh sieve and a ¼-in. sieve, depending upon the diameter of the wire. If M represents the number of meshes to the linear inch, D the diameter of the wire in mm., the rating R is expressed in millimeters by the following equation

$$R = (25.4/M) - D.$$

The diameter D is most easily determined by means of a micrometer gauge or by microscopic measurement. The following table gives the number of meshes to the linear inch, the diameter of the wire and the rating, for the series of sieves used in the accompanying metric analyses:—

Sieve Mesh	Diameter of wire Mm.	Rating Inches	Rating Mm.
4	1.651	.185	4.699
8	.813	.093	2.362
10	.889	.065	1.651
20	.437	.0328	.833
28	.318	.0232	.589
48	.234	.0116	.295
80	.1425	.0069	.175
100	.1070	.0058	.147
200	.0530	.0029	.074

In some sands and gravels, the component fragments are of uniform size; in others they vary widely. This can be tested by granular metric analysis. The principle of such an analysis consists in passing a given amount of the material, say 100 to 500 grams, through a series of sieves, and weighing the amount of the sample retained on each of them after sufficient shaking. The results are given in the percentage of the whole *remaining* or *retained* on each sieve. To express the degree of fineness by a single figure, the percentages passing each sieve are added and the total divided by the number of sieves used. The result is called the per cent. of fineness; if the same set of sieves is used this figure may be used for comparing different sands and gravels. The table below gives the results of the granular metric analyses, and shows the difference in the per cent. of fineness between several grades of sand and gravel.

The results of granular metric analysis may be represented by diagrams, taking as abscissae the ratings of the different sieves and as ordinates the percentage of material remaining on each of them. Joining the different points (Fig. 1) we obtain a graphic representation of the granular metric analysis.

On an ordinate $X = a$, the length measured between the curve and the axis of the abscissae indicates the percentage of material remaining on a sieve of a rating equal to A; the length measured between the curve and the line $y = 100$ represents the percentage of material passing through the same sieve. The area comprised between the curve and the line y = 100 is proportional to the fineness of the material; for fine sand this area is large, it is smaller for medium sand, and becomes very small for coarse gravel. This system of geometrical representation (Fig. 2) has been applied to the five granular metric analyses given above. All the curves start from the point 100 on the axis of the ordinates; their general shape is parabolic except near the axis of the ordinate, where there is an inversion on the curves.

Sieve Mesh	A Fine Sand Ret.	A Pass.	B Medium Sand Ret.	B Pass.	C Coarse Sand Ret.	C Pass.	D Fine Gravel Ret.	D Pass	E Coarse Gravel Ret.	E Pass.
4	0.0	100.00	0.30	99.70	32.85	67.15	49.80	50.20	80.00	20.00
8	0.0	100.00	3.10	96.90	39.20	60.80	63.85	36.15	83.40	16.60
10	0.0	100.00	6.40	93.60	42.50	57.50	69.50	35.50	84.65	15.35
20	0.0	100.00	16.80	83.20	54.10	45.90	79.10	20.90	87.00	13.00
28	0.0	100.00	25.70	74.30	69.30	30.70	85.55	14.45	89.45	10.55
48	1.25	98.75	60.00	40.00	93.85	6.15	94.45	5.55	98.65	1.35
80	2.00	98.00	93.25	6.75	97.95	2.05	97.55	2.45	99.80	0.20
100	5.70	94.30	98.40	1.60	98.75	1.25	98.55	1.45	100.00	0.00
200	41.50	58.50	99.15	0.85	99.60	0.40	99.30	0.70	100.00	0.00
Total ..		849.55		496.90		271.90		162.35		77.05
Per cent. of fineness		94.39		55.21		30.21		18.04		8.56

A: Silty sand, very fine, Camp Borden (Simcoe county).
B: Medium sand, Landshore Sand & Gravel Co. (Ontario county).
C: Coarse sand, Markus pit, Pembroke (Renfrew county).
D: Fine gravel, J. Creeper pit, Belleville (Hastings county).
E: Coarse gravel, Bray pit, Port Hope (Durham county).

The maximum difference between the quantities of material remaining on two alternate sieves such as 4 and 10, 8 and 20, 48 and 100, etc., is a measure of the uniformity of the clastic material. This difference is called the *coefficient of uniformity.* The number of the intermediate sieve in our scale of sieves represents the *grade* of the tested material.

Shape.—The shape of the component fragments is also variable in character. In sands the grains are rounded or angular. If the latter shape is quite common to all the grains, they constitute a sharp sand, much appreciated for building purposes. The difference between a sharp and a rounded sand can be tested under the microscope; it can also be easily ascertained by rolling the grains between the tips of the fingers. For gravels a similar distinction may be established: the component pebbles are spherical, elliptical, flat, disc-like or angular: hence such terms as round gravel and sharp gravel.

Physical Properties

The following physical properties are of interest in the study of sand and gravel: Specific gravity, percentage of voids, permeability, absorption, moisture, percentage of silt, cementing value, bonding power.

*From a report to the Ontario Bureau of Mines.