June 2002

Gravel:
Gradation of Granular Materials

Cornell Local Roads Program
Tech Tips

The term gradation, as applied to gravel mixtures, refers to the relative amounts of gravel, sand, and fines (silt and clay). A well-graded mixture has a minimum of air spaces to trap and hold water, and when compacted, achieves a high density and provides good load support. In Figure 1, the contents of the two tubes are identical. In the left tube the materials are not mixed but separated by grain size. In the right tube, the well-graded gravel is mixed. Note the lesser volume in this right tube (increased density) resulting from the voids between the gravel particles being filled with sand and the voids between sand particles being partially filled with silt and clay.

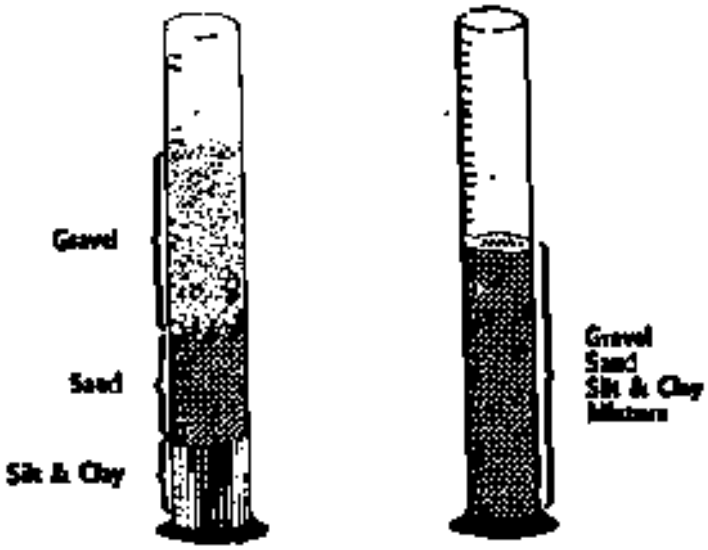


Figure 1: A mixture of gravel, sand, silt and clay has a greater density than its components

MAXIMUM GRAVEL SIZES EXPECTED

When building gravel bases, it is desirable that the maximum size of gravel be no larger than one-half the thickness of a compacted lift. If we compact our bases in 6-inch lifts, the maximum size of gravel is about 3 inches.

For gravel surfaces, smooth rideability and maintenance dictate that the top size be limited to about 1 inch.

CORNELL LOCAL ROADS PROGRAM
416 RILEY-ROBB HALL, ITHACA, NY 14853
PHONE: (607) 255-8033
FAX: (607) 255-4080
E-MAIL: *clrp@cornell.edu*
INTERNET: *www.clrp.cornell.edu*

Tech Tips are published by the Cornell Local Roads Program with support from the Federal Highway Administration, the New York State Department of Transportation, and Cornell University. The content is the responsibility of the Local Roads Program.

DESIRABLE SPECIFICATIONS

Soils are classified by their size into four general categories. Soil analysis is the process of classifying soils by the percentage of each size material they contain. We need to know the amount of each class of materials in an aggregate to determine if it is suitable for building a road.

Table: Soil classes and sizes

Soil types	Size (mm)	Sieve sizes
Boulders & cobbles	>75 mm	Retained on the 75 mm (3 “) sieve
Gravel	2.0 to 75 mm	Retained on the #10 sieve
Sand	0.075 to 2.0 mm	Retained on the #200 sieve
Fines (silt & clay)	<0.075 mm	Passes the #200 sieve

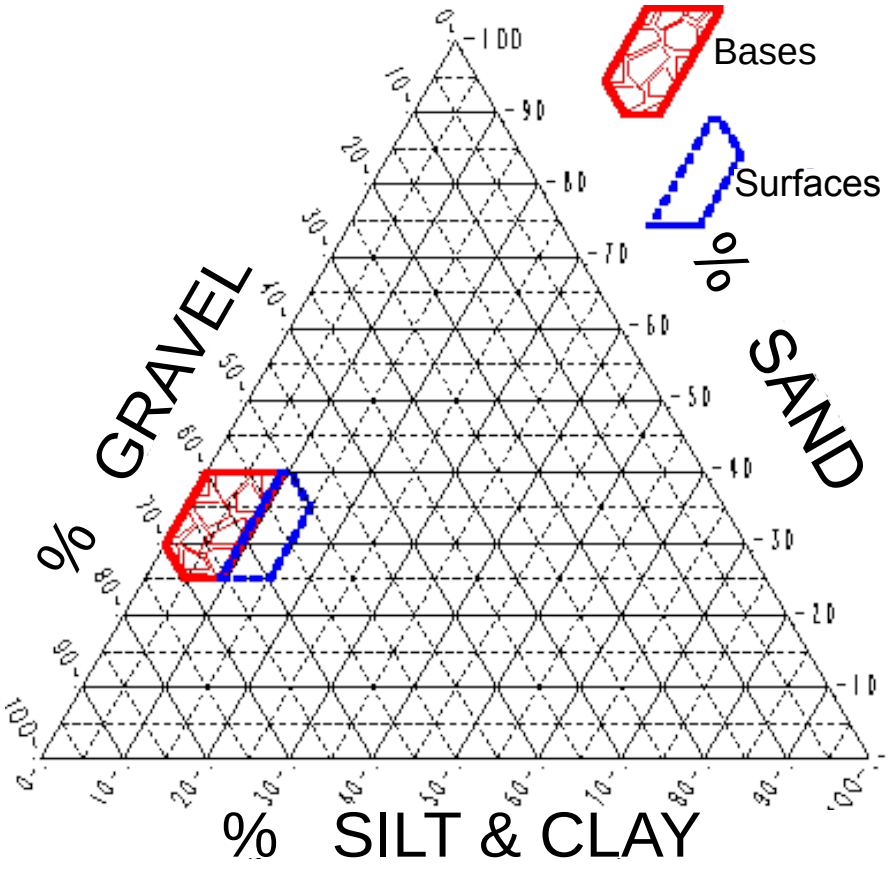
- **Boulders and cobbles** are very large and should not be used in the base and surface of roads. They are very useful for erosion control, scour protection and filling gabions.
- **Gravel** particles are large and have high strength. Due to their importance in providing strength, we refer to the mixture of particles used to build roads as gravel.
- **Sands** drain very well and are relatively stable. They fill the voids between gravel particles.
- **Fines (silts and clays)** have the smallest size particles. Clay soils are hard when dry, but very soft when wet. Clays feel greasy when wet. Silts are slightly larger and erode very easily. Fines provide no strength. Their primary purpose in gravels is to help bind together surface materials exposed to traffic.

Assuming good gradation through the gravel and sand ranges, a suitable gravel mixture for use in roads should contain:

Table 2: Gradations of gravels for roads

Particle size	Surface	Base	Subbase
Gravel	50-70%	50-70%	50-70%
Sand	25-40%	25-40%	25-40%
Silt and clay	8-15%	0-5%	0-8%

A detailed specification for gravel is available in this series. (see *Tech Tips: Gravel: Local Road Gravel Specification*)



Surface, Base, Subbase and Subgrade

- Surface
The wearing surface of a road. May be almost any construction material including: gravel, asphalt, concrete, and brick

- Base
The layer immediately below the surface layer. Should be of very high quality, especially if the surface is thin.

- Subbase
A layer below the base that helps continue spreading the vehicle loads over the subgrade. Sometimes used for drainage.

- Subgrade
The native material underlying the roadway.