

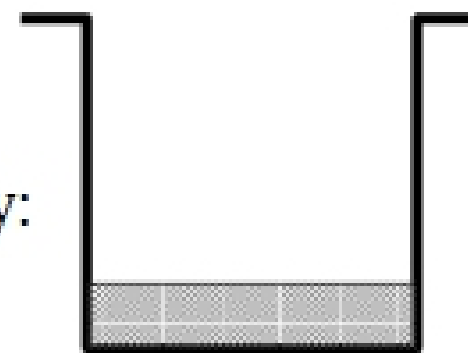
Period #3: Particle Characteristics and Size Effects

A. Motivation:

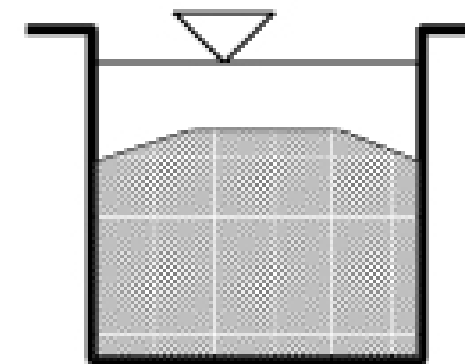
- In the presence of water, some clay soils in pure form can greatly increase in volume (expand, or swell).
- When water is removed from a clay soil (by drying), the volume can be significantly reduced due to shrinkage. This leads to widespread cracking in the soil.
- In *pure* form, the most *active* clay soils can increase or decrease in volume by a factor of over 15! But since pure clays rarely exist naturally, most soils are not nearly that expansive or active.
- Nevertheless, active clay soils can potentially wreak havoc on engineered structures by expanding and shrinking somewhat.

Visualization:

In the laboratory:



dry clay soil



saturated clay soil

Note the expansion of the clay soil with the introduction of water.

In this class period, we will begin to explore why clays expand and shrink.

The expansive and contractive characteristics of clay soils raise some fundamental questions:

- (i) What is the nature of clay particles?
- (ii) Why do clay soils expand when exposed to water?
- (iii) What simple tests can be used to identify the most *active* or *expansive* soils?

B. Grain Size and Specific Surface Area

From previous discussions and readings you know that clay soils are those containing grains with $D \leq 2 \mu\text{m}$.

As soil grain sizes decrease, the specific surface area (SSA) of the soil, which is simply the total surface area of the individual grains per dry mass of the grains, increases exponentially.

This can be demonstrated quite dramatically by considering the following conceptual experiment:

We take a gravel sized single grain of soil and successively breaking it up into smaller and smaller grains of equal size, until we achieve clay-sized grains.

$$i=0, N=1$$

$$r=1 \text{ cm} = 10^4 \text{ } \mu\text{m}$$

$$V=(4/3)\pi \text{ cm}^3$$

$$S = 4\pi \text{ cm}^2$$



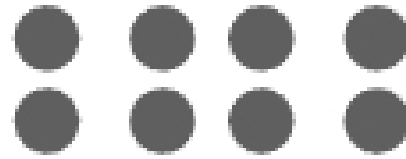
Gravel-sized grains

$$i=1, N=8$$

$$r=1/2 \text{ cm}$$

$$V=(4/3)\pi \text{ cm}^3$$

$$S = 8\pi \text{ cm}^2$$

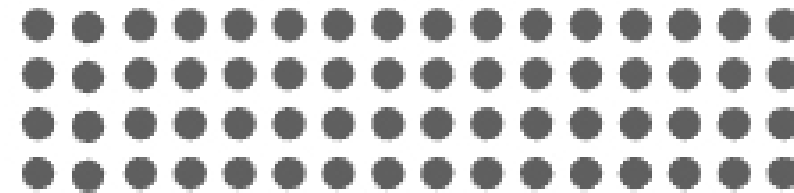


$$i=2, N=64$$

$$r=1/4 \text{ cm}$$

$$V=(4/3)\pi \text{ cm}^3$$

$$S = 16\pi \text{ cm}^2$$

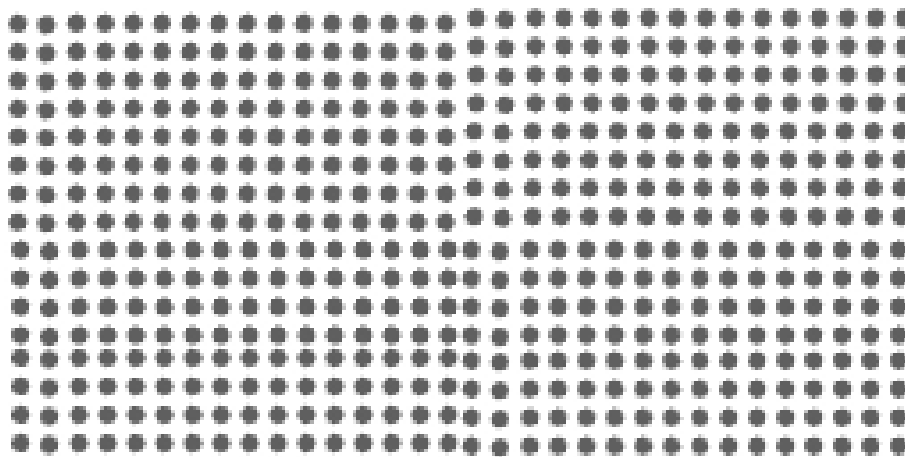


$$i=3, N=512$$

$$r=1/8 \text{ cm}$$

$$V=(4/3)\pi \text{ cm}^3$$

$$S = 32\pi \text{ cm}^2$$



$$i=14, N=4.4 \times 10^{12}$$

$$r=1/(16,384) \text{ cm} = 0.61 \text{ } \mu\text{m}$$

$$V=(4/3)\pi \text{ cm}^3$$

$$S = 65,536\pi \text{ cm}^2$$

Clay-sized grains (Note that SSA increases
by a factor of 2^{14} !)