BACKGROUND

SOIL TEXTURE & ENGINEERING PROPERTIES

Most General Classification is by Grain Size

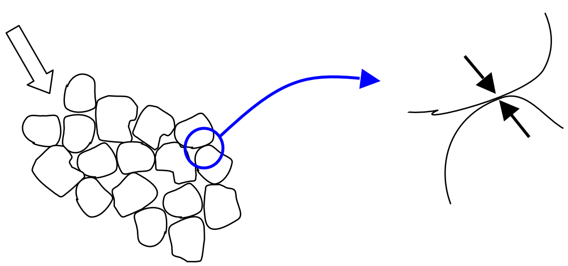
Coarse Grained Soil
Sand & Gravel — Can see by eye

d = 0.075 mm #200

Fine Grained Soil
Silt & Clay — Can't see by eye

Coarse Grained Soil (D>0.075mm)

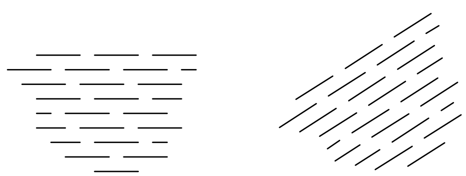
Mechanical interparticle forces control the engineering properties. These, depend on: grain size distribution, shape, strength and density of particles.



- As a result → no cohesion therefore called Cohesionless Soils.
- Allow easy flow of water → quick drainage

Fine Grained Soil (D<0.075mm)

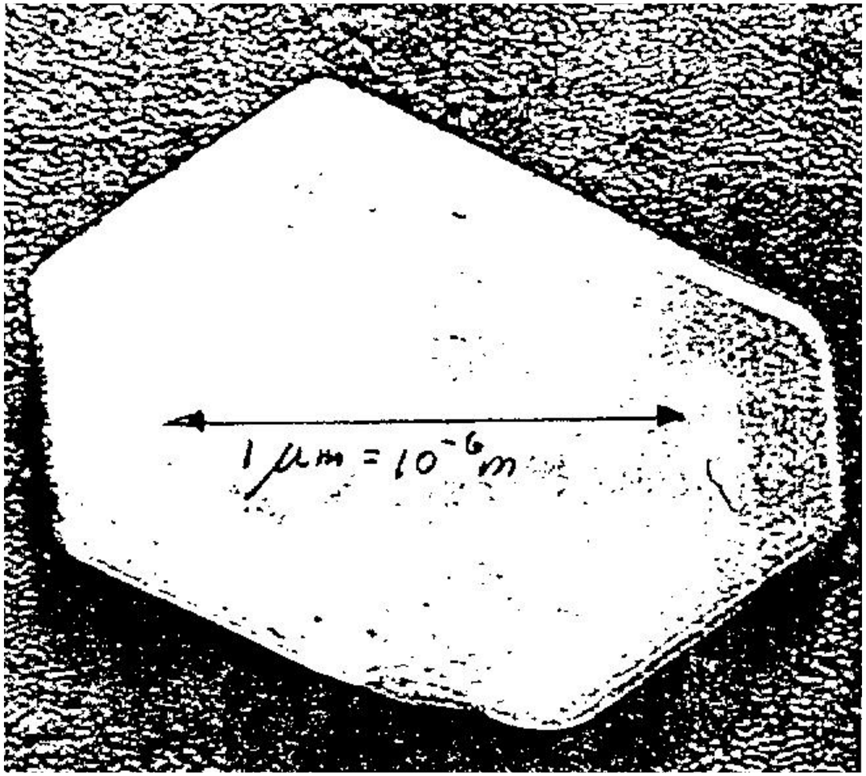
Electro chemical forces control the engineering properties. These, depend on: mineralogy, surface area and water content.



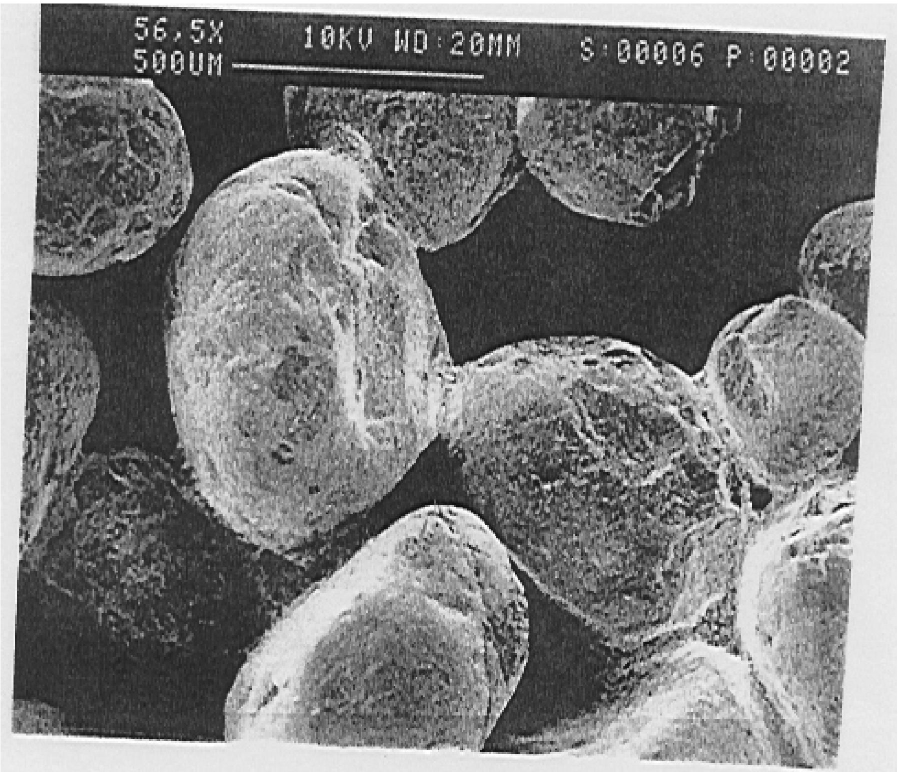
- As a result → Internal (interparticle) attraction creates cohesion, which is independent of external forces, therefore called Cohesive Soils.
- Difficult water flow → slow drainage or impervious

BACKGROUND

IMAGES OF SOIL PARTICLES



Kaolinite (Clay)
Lambe (1951)
from Lambe & Whitman.



Ottawa Sand
(0.18-0.83mm, D_{50} = 0.50mm)
Paikowsky et al. (1995)

BACKGROUND

SOIL GRAIN SIZES

Soil Type	USCS Symbol	Grain Size Range (mm)			
		USCS	AASHTO	USDA	MIT
Gravel	G	76.2 to 4.75	76.2 to 2	>2	>2
Sand	S	4.75 to 0.075	2 to 0.075	2 to 0.05	2 to 0.06
Silt	M	Fines < 0.075	0.075 to 0.002	0.05 to 0.002	0.06 to 0.002
Clay	C		< 0.002	< 0.002	< 0.002

Determined by Mechanical Analysis (i.e. Sieve) and Hydrometer Analysis

(ASTM D422-63 (2007) *Standard Test Method for Particle-Size Analysis of Soils*)

BACKGROUND

MECHANICAL SIEVE ANALYSIS (D422, D1140, T88)

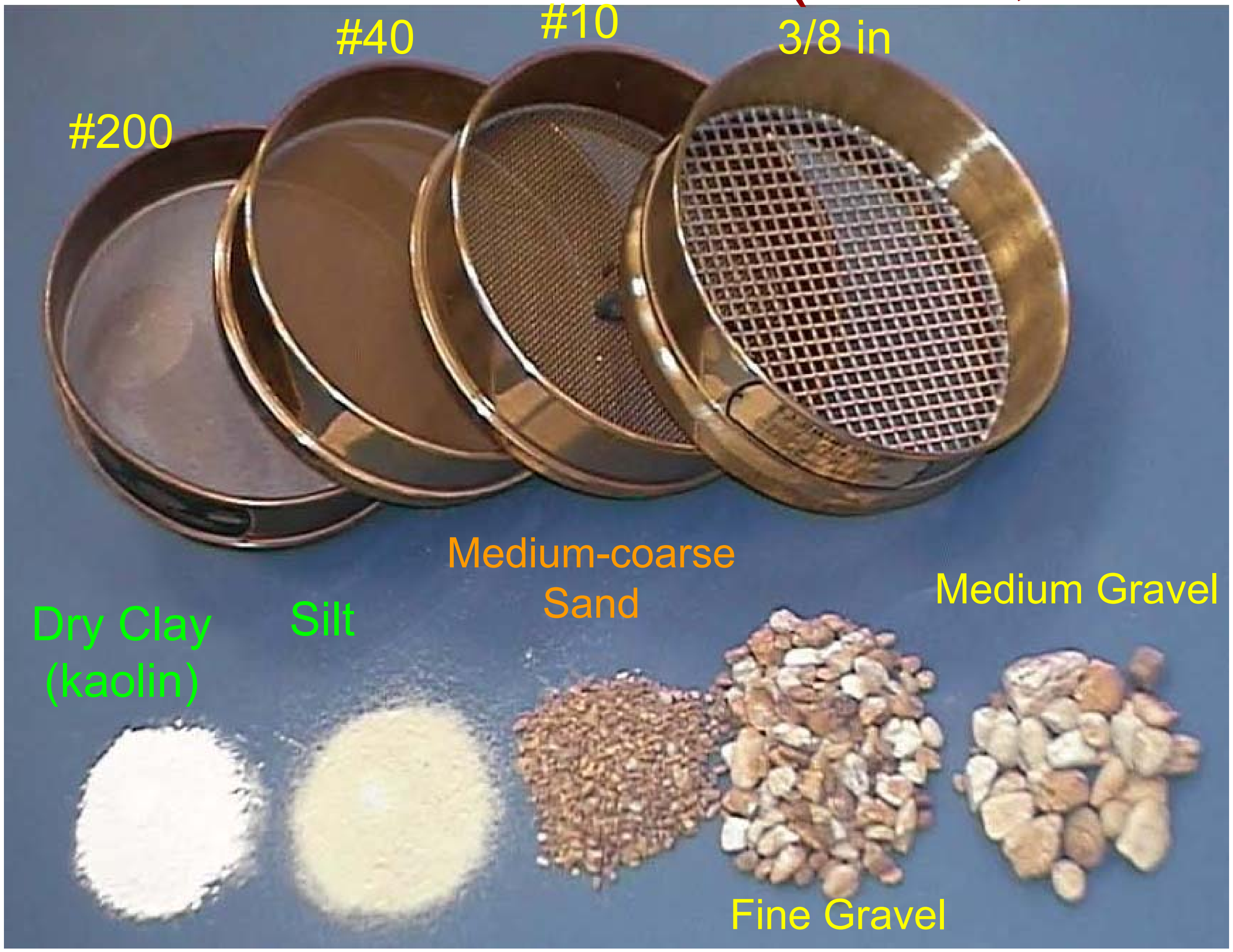


Figure 7.1. from FHWA NHI-01-031.

BACKGROUND

HYDROMETER ANALYSIS (D442, D1140, T88)

Based on the principle of sedimentation of soil grains in water

Stokes Law: $$v = \frac{\rho_s - \rho_w}{18\eta} D^2$$

Where:

- v = Velocity
- ρ_s = soil particle density
- ρ_w = water density
- η = water viscosity
- D = Diameter of soil particles

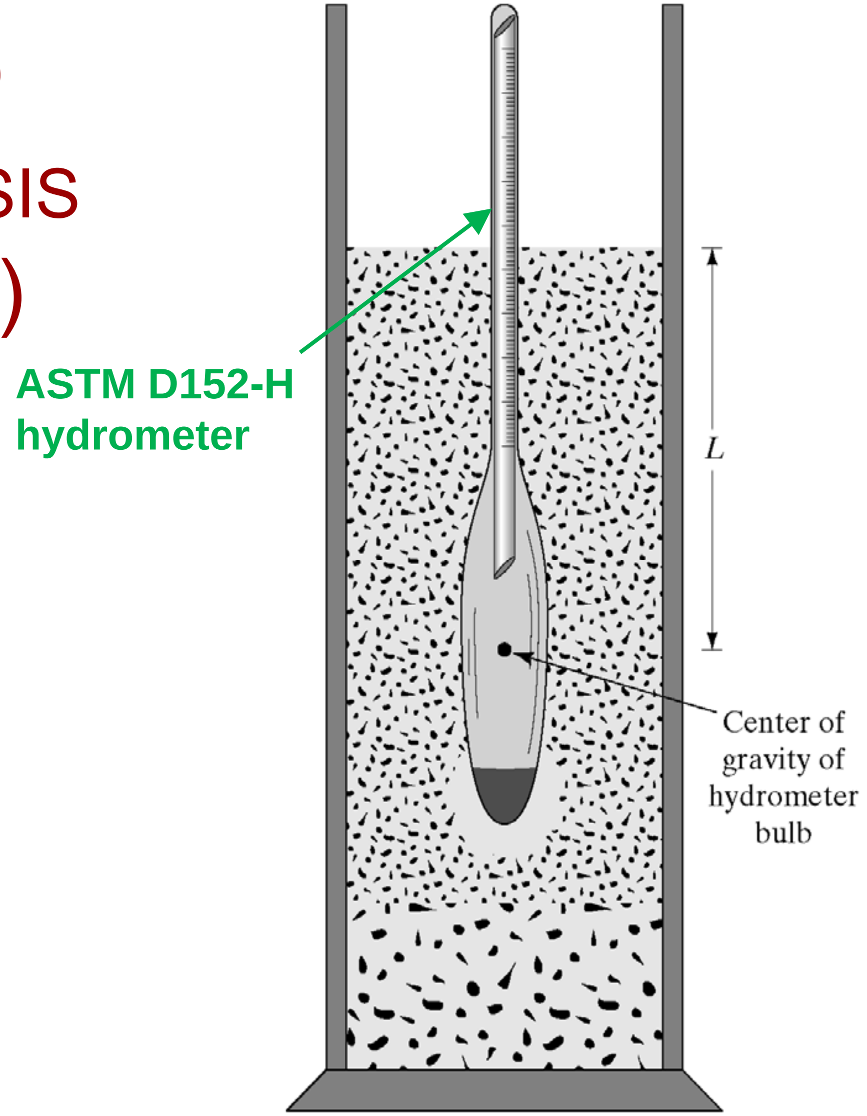
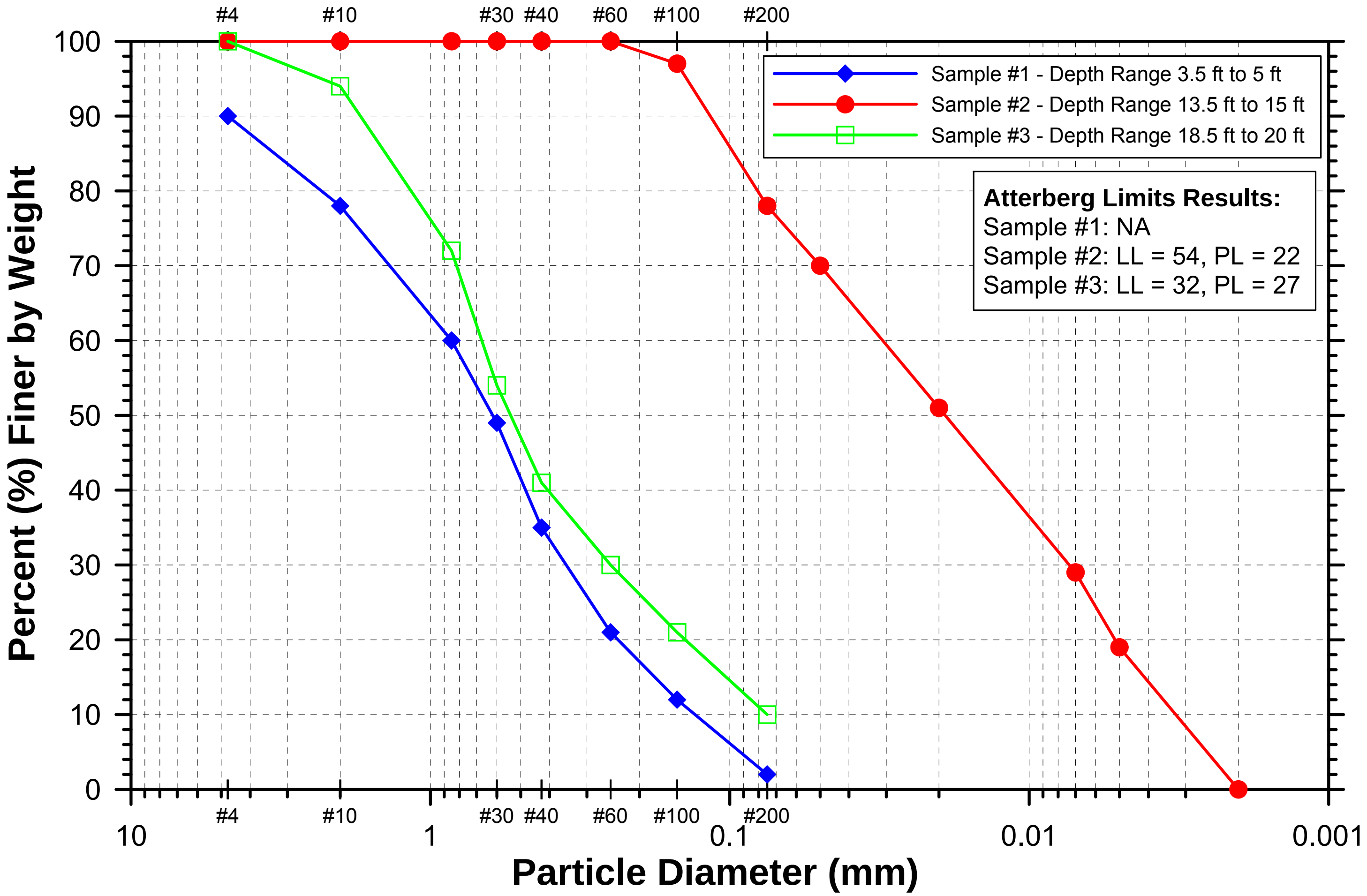


Figure 2.5. Das FGE (2005).

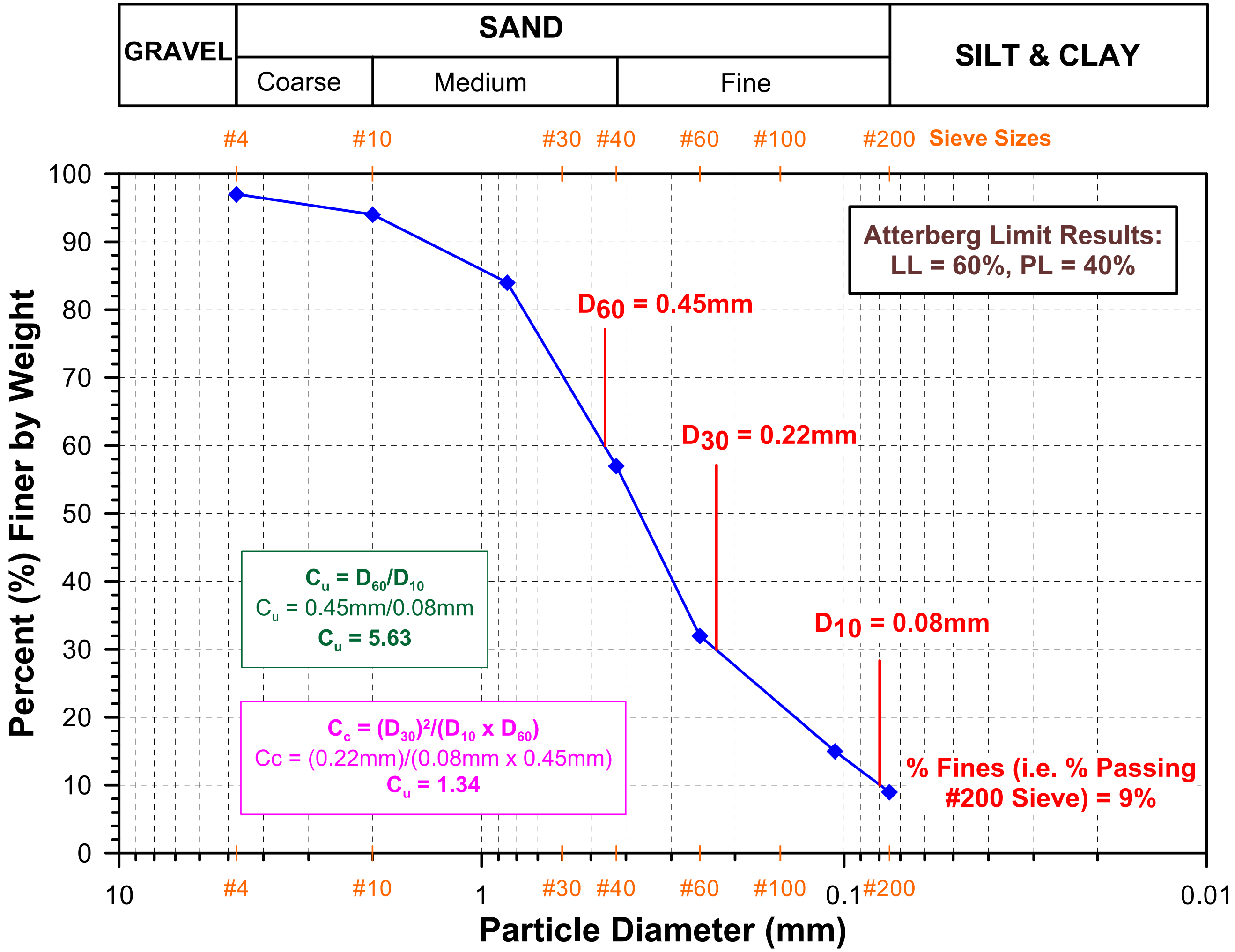
BACKGROUND

GRAIN SIZE DISTRIBUTION



BACKGROUND

GRAIN SIZE DISTRIBUTION: COARSE GRAIN SOILS



BACKGROUND

GRAIN SIZE DISTRIBUTION: COARSE GRAIN SOILS

Key Particle Sizes (D = Diameter)

D_{60} = Diameter corresponding to 60% finer in the grain size distribution.

D_{30} = Diameter corresponding to 30% finer in the grain size distribution.

D_{10} = Diameter corresponding to 10% finer in the grain size distribution. Also known as *Effective Size.*

BACKGROUND

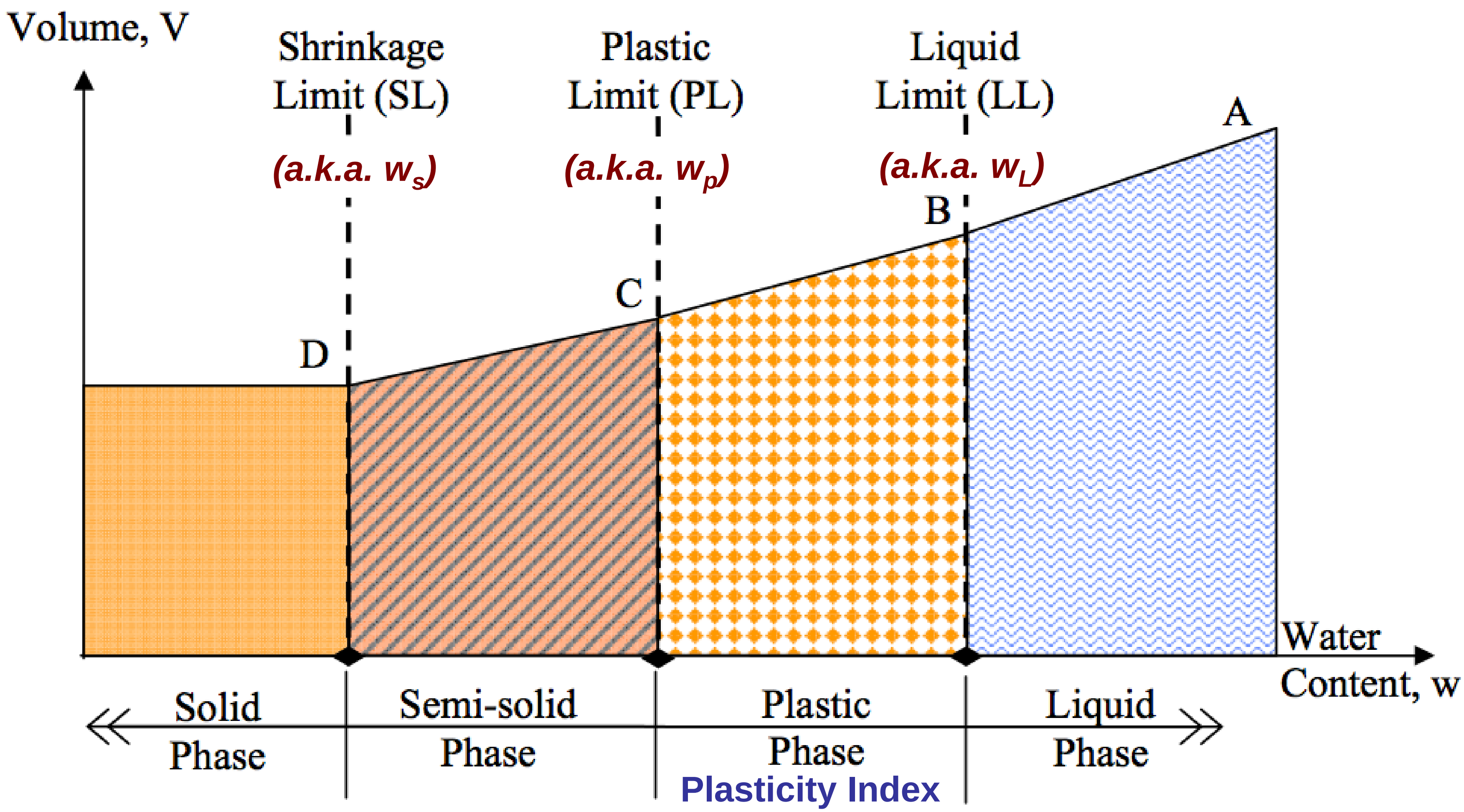
GRAIN SIZE DISTRIBUTION: COARSE GRAIN SOILS

Key Coefficients (C):

C_u = Coefficient of Uniformity (ASTM D2487)
$= D_{60}/D_{10}$

C_c = Coefficient of Gradation
= Coefficient of Curvature (ASTM D2487)
$= (D_{30})^2/(D_{60} x D_{10})$

BACKGROUND: ATTERBERG LIMITS

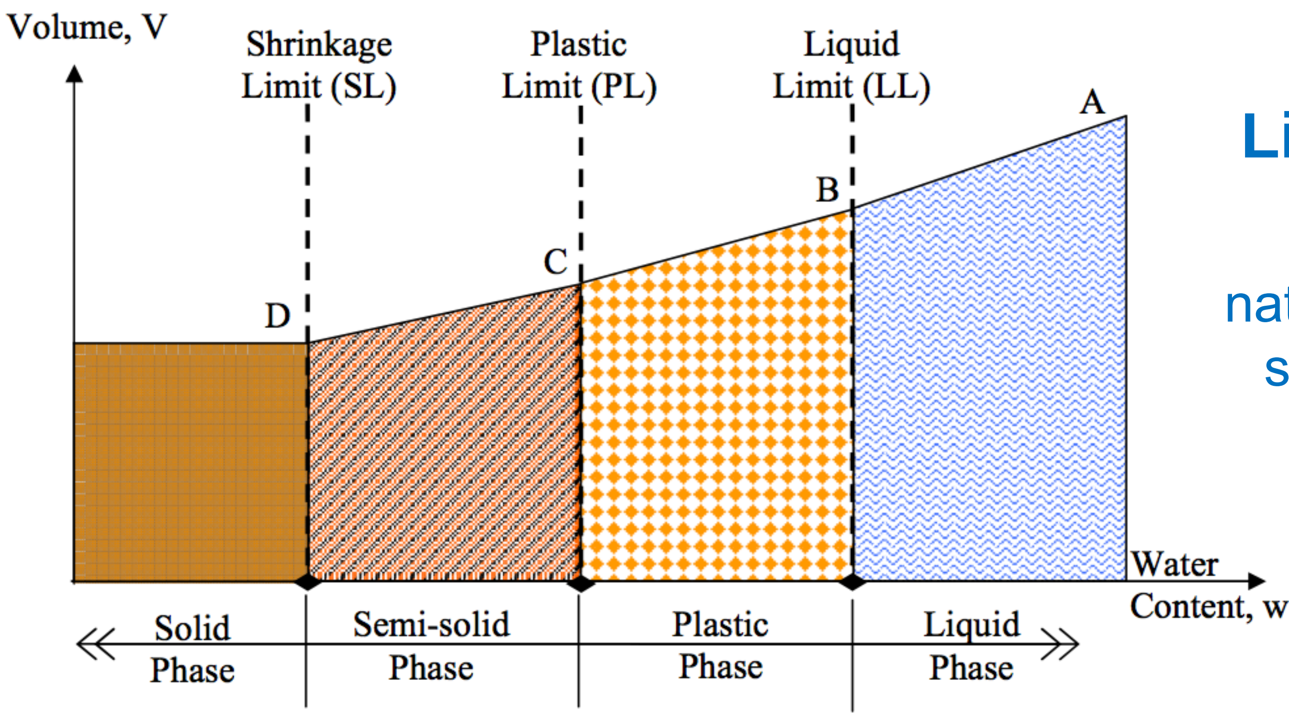


Plasticity Index (PI) PI = LL - PL

Range of water content over which soil remains plastic.

Figure 2-5. FHWA NHI-06-088.

BACKGROUND: ATTERBERG LIMITS

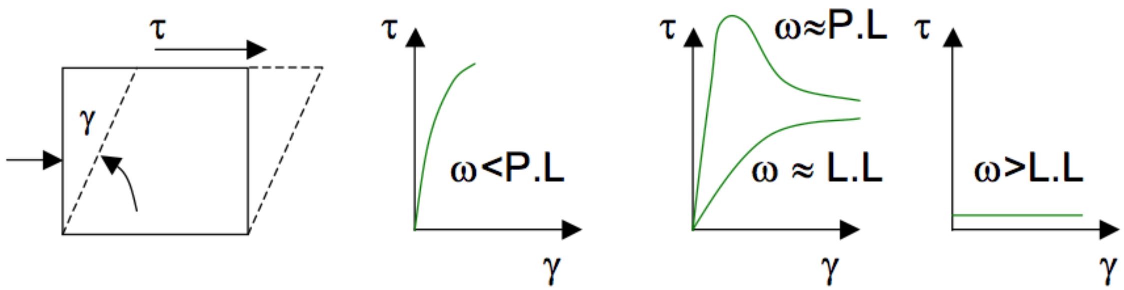


Liquidity Index (LI)

Used for scaling the natural water content of a soil sample to the A.L.

$$LI = \frac{w - PL}{PI}$$

LI = 1 ⇨ Liquid



Shear Stress-Strain Behavior @ Different A.L.

CASAGRANDE PLASTICITY CHART

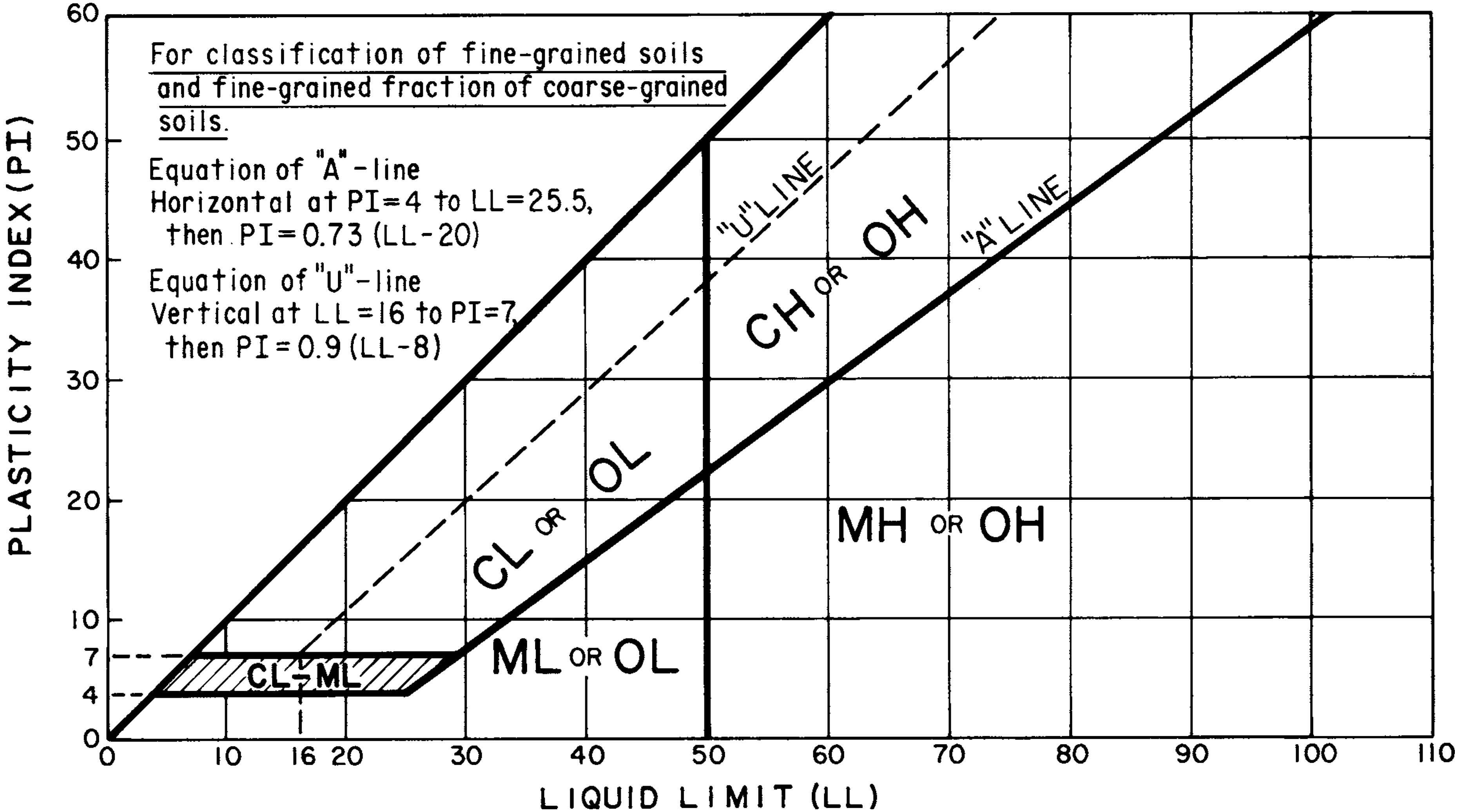


Figure 4. (ASTM D2487-11).

CASAGRANDE PLASTICITY CHART

SIGNIFICANCE OF ATTERBERG LIMITS

I consider it essential that an experienced soils engineer should be able to judge the position of soils, from his territory, on a plasticity chart merely on the basis of his visual and manual examination of the soils. – ***Arthur Casagrande (1959)***

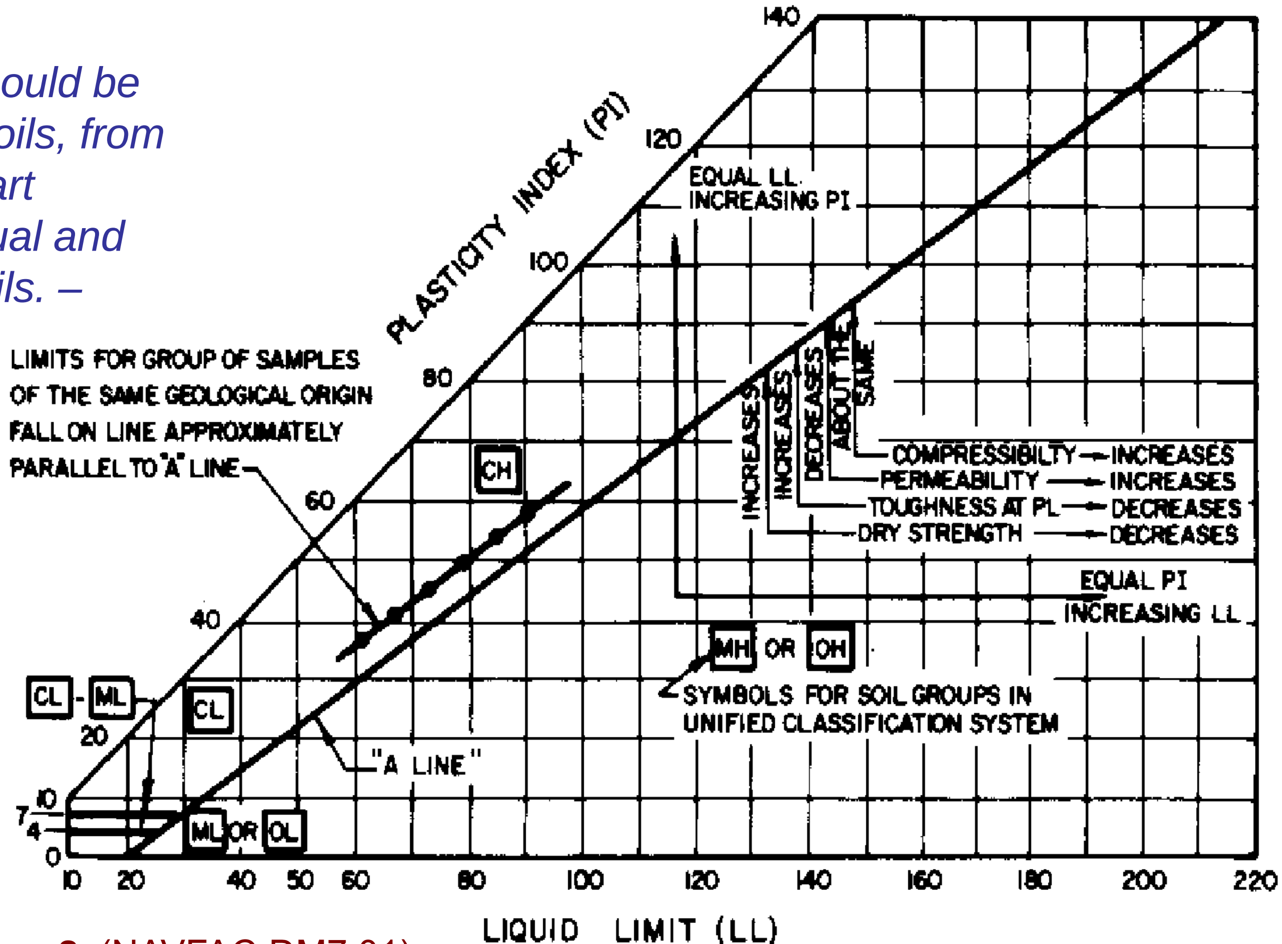


Figure 2. (NAVFAC DM7.01).

UNIFIED SOIL CLASSIFICATION SYSTEM (USCS)

Divided into two broad categories:

- **Coarse Grained Soils**
  Gravels (**G**) and **S**ands (**S**)
  < 50% passing through #200 sieve
  (i.e. >50% retained on #200 sieve)

- **Fine Grained Soils**
  Silts (**M**) and **C**lays (**C**)
  ≥ 50% passing through #200 sieve

USCS – Coarse Grained Soils

(>50% Retained on #200 Sieve)

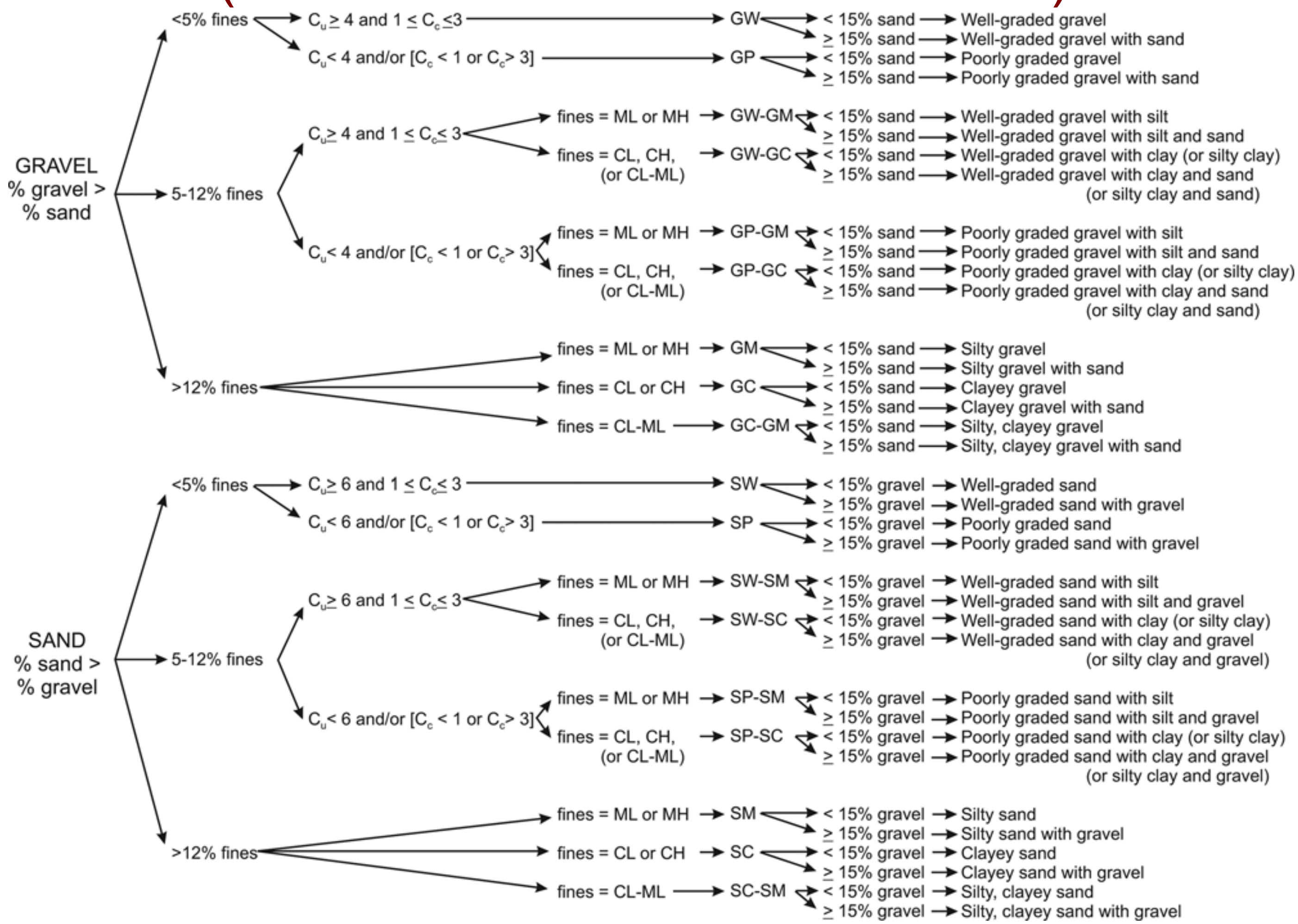


Figure 3. ASTM D2487-11.

USCS – Fine Grained Soils

(≥ 50% Passing #200 Sieve)

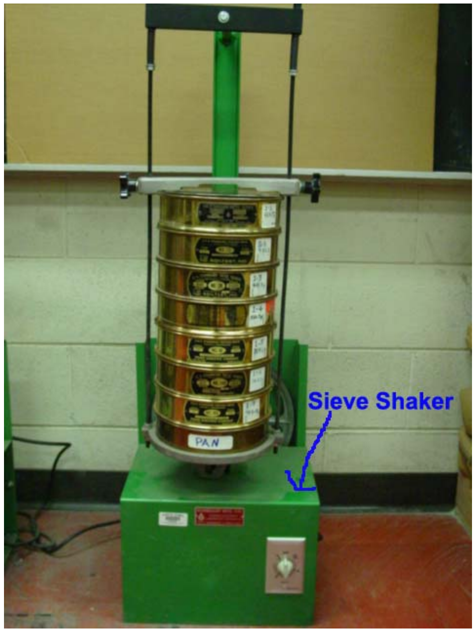
Figure 1. ASTM D2487-11.

EXPERIMENT 1

GRAIN SIZE DISTRIBUTION

ASTM D422-63(2007) Standard Test Method for Particle-Size Analysis of Soils

Mechanical Sieve

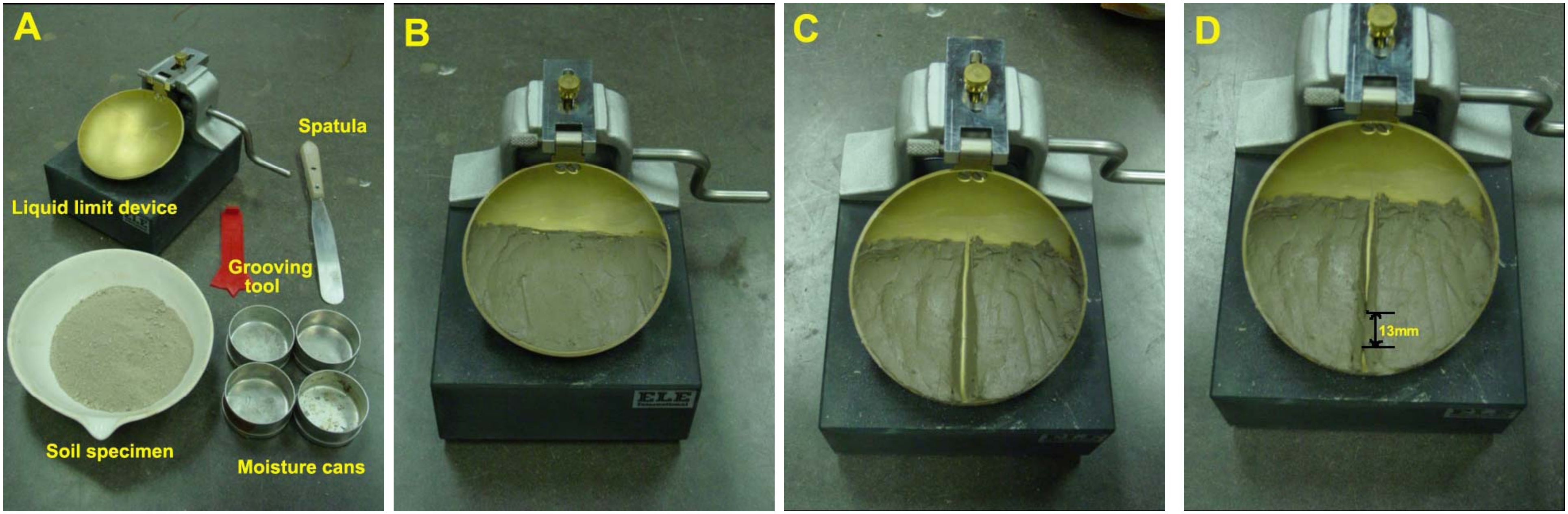


Photographs courtesy of Engineering Properties of Soils Based on Laboratory Testing Manual, Prof. Krishna Reddy, UIC, 2002.

EXPERIMENT 2

ATTERBERG LIMITS (LIQUID & PLASTIC LIMITS)

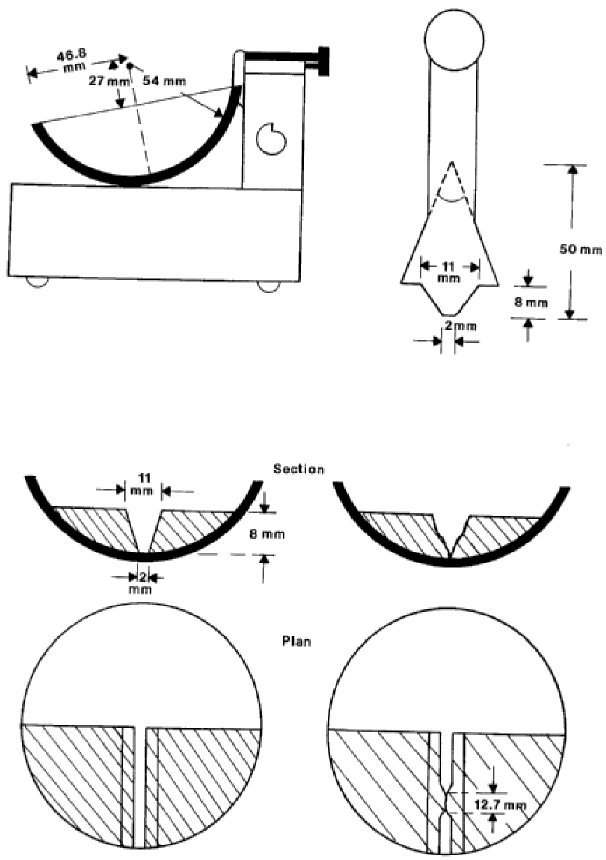
ASTM D4318-10 Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils



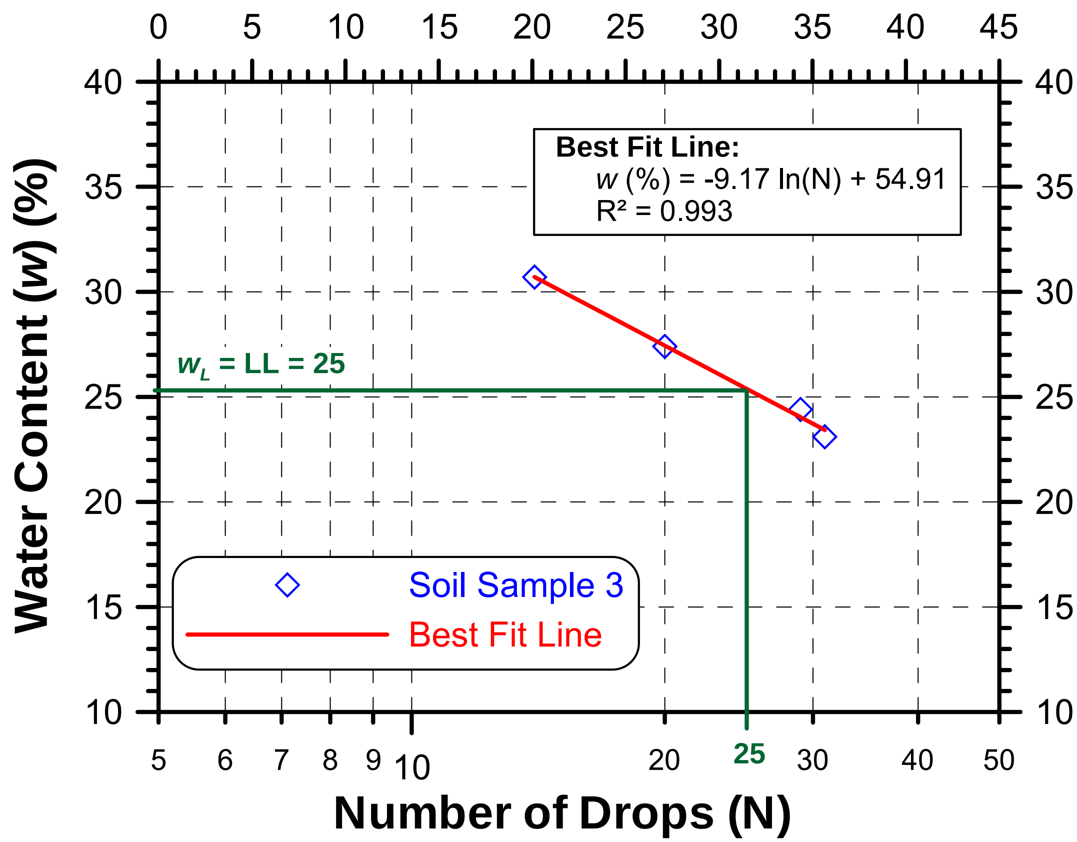
Photographs courtesy of Engineering Properties of Soils Based on Laboratory Testing Manual, Prof. Krishna Reddy, UIC, 2002.

EXPERIMENT 2

ATTERBERG LIMITS (LIQUID LIMIT)



Tools & Groove.

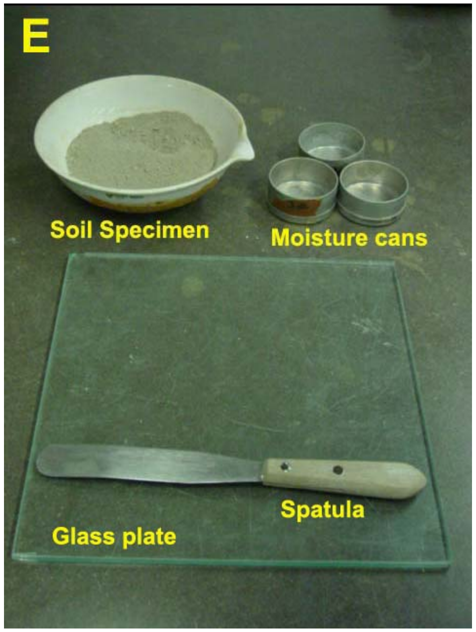


Run 4 Tests – 2 above 25 blows
2 blow below 25 blows.

EXPERIMENT 2

ATTERBERG LIMITS (PLASTIC LIMIT)

ASTM D4318-10 Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils



Photographs courtesy of Engineering Properties of Soils Based on Laboratory Testing Manual, Prof. Krishna Reddy, UIC, 2002.

EXPERIMENT 2

ATTERBERG LIMITS (PLASTIC LIMIT)

ASTM D4318-10 Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

1. **Roll the soil sample on a glass plate using the palm of your hand to a thread that crumbles at approximately 1/8-inch diameter.**
2. **Change the water content of the mixture until you obtain the required results of stage one.**
3. **Determine the water content of the soil at that state.**

REPORT PREPARATION

EXPERIMENT #2: BOSTON BLUE CLAY RESULTS.

Table 1. BBC Results from boring in Newbury, MA.

Depth (ft)	*w* (%)
12	30
22	45
32	45
42	35
52	28

Using your BBC test Results:

1. Calculate the liquidity index (LI) at each depth.
2. Comment about the consistency of the clay at each depth.

Please speculate regarding the reasons for such conditions and its implications for foundations.

LABORATORY MAINTENANCE

PAY ATTENTION!

Clean your equipment thoroughly after you have used it.

Clean your work area thoroughly after you have completed the testing.

See me if you need access to lab after class hours.