General Soil Knowledge

1. How to Determine if the Soil is Sand, Silt, Clay, Rock, Marsh, Topsoil
2. What is Texture, Grain Size, Liquid Limit, Plastic Limit
3. Importance of Density and Moisture Control

Identification of Soil

What Type of Soil Am I Dealing With?

Describing Soil

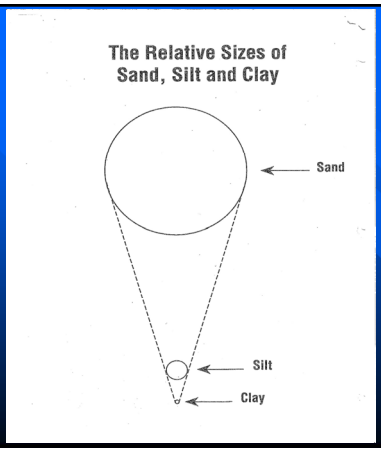
- Color
- Predominant Soil Type
- Grain Size
- Depositional Features
- Degree of Saturation/Relative Moisture
- Density (Granular Soils) or Consistency (Cohesive Soils)

Visual Classification System

Types of Soils:

1. Granular
2. Silt
3. Clay
4. Organic Soils (Top Soils)
5. Rock and Boulders

Often Soils Are a Combination of Soil Types



Identification of Soils

Material	Definition	Fractions	Sieve Limit Upper	Sieve Limit Lower	Comments
Boulders	Material too large to pass an opening 12 in. square				
Cobbles	Material passing through a 12 in. sieve and retained on 3 in. sieve				
Gravel	Material passing through a 3 in. sieve and retained on No. 4 sieve	Coarse	3 in.	3/4 in.	Classification Based on Size
		Fine	3/4 in.	No. 4	
Sand	Material passing through a No. 4 sieve and retained on the No. 200 Sieve	Coarse	No. 4	No. 10	
		Medium	No. 10	No. 40	
		Fine	No. 40	No. 200	
Silt	Material passing the No. 200 sieve which is also non-plastic in character and exhibits little to no strength when dry		No. 200		Classification Based on Plasticity
Clay	Material passing the No. 200 sieve which can also be made to exhibit plasticity within a certain range of moisture contents and which exhibits considerable strength when dry		No. 200		

Soil Classification	
Primary Soil Component:	Upper case letters
Secondary:	Adjective used if ~20 - 50% of total (e.g., Silty SAND)
Other Components:	Mostly - 50 - 100% Some - 30 - 45% Little - 15 - 25% Few - 5 to 10% Trace - < 5%

Granular Soils

- Good Construction Soil
- Sands and Gravels
- Size of Gravel and Sand

Granular Soils

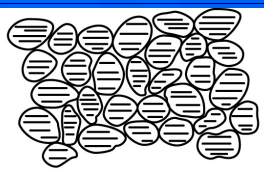
- Sand and Gravel
- Excellent Foundation, Embankment and Backfill Material
- High Permeability
- Not Susceptible to Frost
- Settle Rapidly When Loaded
- Develop Strength Through Particle Contact/Friction

Size Range of Granular Soils

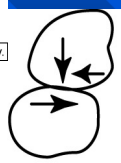
PARTICLE SIZE CLASSIFICATION (ASTM D 2487)

Sieve Size		Particle Diameter (in.)		
Passes	Retained On	in.	mm	Soil Classification
	12 in.	>12	>350	Boulder
12 in.	3 in.	3 - 12	75 - 350	Cobble
3 in.	3/4 in.	0.75 - 3	19 - 75	Coarse Gravel
3/4 in.	#4	0.19 - 0.75	4.75 - 19	Fine Gravel
#4	#10	0.079 - 0.19	2 - 4.75	Coarse Sand
#10	#40	0.016 - 0.079	0.425 - 2	Medium Sand
#40	#200	0.0029 - 0.016	0.075 - 0.425	Fine Sand
#200		<0.0029	<0.075	Fines (silt & clay)

Granular Soils – Structure
Strength Development



The two loads on a particle resist the sliding face to attain stability.



What soil looks like at a near microscopic level

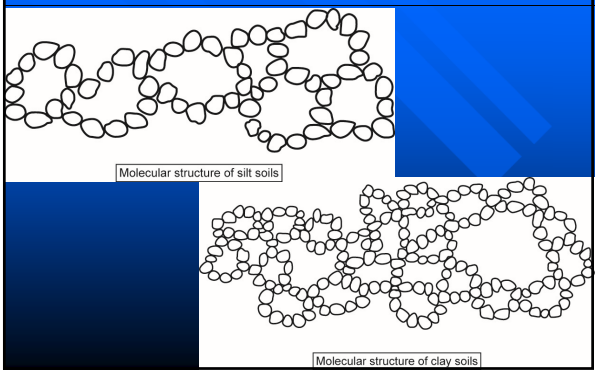
Fine-Grained Soils

- Passing No. 200 Sieve (<0.075 mm)
- Silts – Non-plastic
- Clays - Plastic

Plastic

Soil is Capable of Being Shaped or Formed

Molecular Structure Silts & Clays



Silts

- Non-plastic
- Unstable in Water
- Change Volume When Shape Changes
- Pulverized By Finger When Dry

Clays

- Plastic
- Compressible
- When Wet:
  - Low Resistance to Deformation
- Hard Cohesive Mass When Dry
- Low Permeability

Silt Soils

- Difficult Construction Soil (moisture sensitive)
- Non-Plastic
- Combination of Sand & Clay
- Generally Attracts and Absorbs Water, and Holds It

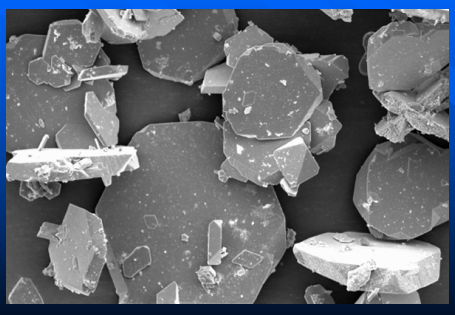
Silt Soils

- May Require Drying or (In Some Rare Cases) Additional Moisture to Achieve Density
- Under Repeated Loading, Can Pump/Attract Water From Below
- Can Form a Thin Dry Layer/Crust on Top, But Will Become Unstable Under Repeated Loadings Such as Spreading Base

Clay Soils

- Pretty Good Construction Soil
- Sheds Rain Water if Properly Compacted, Sealed, and Sloped
- Isn't Affected Rapidly by Water Content
- Often Requires Drying to Aid Compaction When Used as Fill

Clay Particle Structure



What is Plasticity?

- Ability to Roll Soil Into a Ribbon
- Moist Soil Can Be Rolled Into a Ball

Descriptive Term	Degree of Plasticity
Sandy SILT or SILT	None
SILT, trace clay, or organic SILT	Slight
Clayey SILT or organic clayey SILT	Low
Silty CLAY or organic silty CLAY	Medium
Clay or organic CLAY	High to Very High

Atterberg Limits (Albert)

- Used for Classification, Comparisons, Identification
- Represent Moisture Contents
- Include:
  - Liquid Limit (LL)
  - Plastic Limit (PL)
  - Shrinkage Limit (SL)

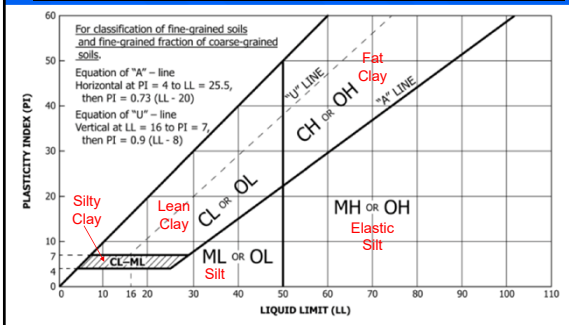
Liquid Limit & Plastic Limit

- Liquid Limit is the moisture content at which soil will begin to exhibit the properties of a liquid rather than a slurry. It will move under load, not on its own.
- Plastic Limit is the moisture content at which the soil changes from a plastic state to semi-solid. The soil will no longer flow or compress under load.

Plasticity Index (PI)

- The Difference Between the Liquid Limit and the Plastic Limit is the Plasticity Index or PI

Liquid Limit & Plastic Limit



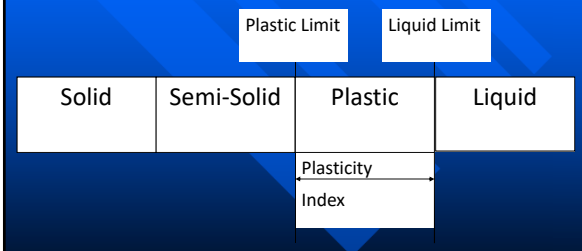
Plasticity Index

Some Examples:

- Liquid Limit 20, Plastic Limit 10; PI is 10
- Liquid Limit 32, Plastic Limit 12; PI is 20

Soil With a PI of 20 Can Be Effectively Compacted Within a Wider Range of Moisture Than a Soil With a PI of 10

Plastic Soil States



Organic Soils

- Contain Different % of Organic Matter
- Organics Adversely Affects the Engineering Properties of Soil
- Examples – Topsoil, Peat, Marsh and Organic Silt

Organic Soils

- Mineral Topsoil
  Not Too Bad, Generally ≤10% Organic
- Organic Topsoil
  Feels Like Mulch, 50% Organic, Use Outside 1:1?
- Marsh and Peat
  Requires a Separate Bid Item, Remove From Project?

Rock & Boulders

- Requires a Separate Bid Item 205.0200
  - Expands When Blasted or Ripped
- Boulders
  - Specification 205.2.3 States: If Larger Then 1 Cubic Yard, Pay as Rock Excavation
- Watch Where Placed
  - Specification States: Not Within xx Feet of Finished Grade, Beam Guard Posts, Piling, or Signs

Density and Moisture

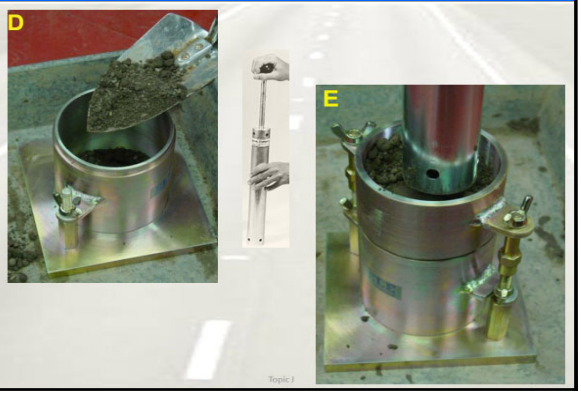
Proctor Test (Ralph)

- A Laboratory Test Used to Determine the Maximum Dry Density and Accompanying Optimum Moisture Content, Under a Given Compactive Effort
- Can be Standard (AASHTO T99) or Modified (T180) Effort

Proctor Test

- Mix Soil Sample With Water
- Compact Specimen - 1/30 Cubic Foot
- Remove Extension Collar and Trim Soil
- Weigh and Subtract Mold Weight
- Break Up Soil and Get Dry Weight
- Plot Dry Unit Weight vs. Moisture %
- Add Water and Repeat – 5 Times/Points

Proctor Mold



Determine Moisture-Density Relationship

ATTACHMENT 13 SAMPLE NO. #1A

DETERMINATION OF MOISTURE-DENSITY RELATION OF SOIL SHEET 1 OF 2

Determination of Maximum Density and Optimum Moisture Content Based on Oven Dry (110°C) Weights.

Project: Operator:

Location: Date:

Method of Test: Method: Mold #:

Standard (AASHTO T99): A ☐ ☒ B ☐ D ☐ Scale #: (lb.) Scale # (gm)

Type of Hammer: Manual Electric Field ☒

Tare of Mold: 10.27 lbs. Volume of old: 1/30 cu. ft.

% R4 Determination: 1.038 R4 lb. + 1.583 P4 lb. = 2.621 Total R4 & P4

1.038 R4 lb. + 2.621 Total R4 & P4 x 100 = 39.6 % R4

TYPE OF SOIL			1	2	3	4	5
TRIAL NUMBER							
Weight of Wet Specimen and Mold (lbs.)			14.81	15.13	15.31	15.21	15.14
Tare of Mold (lbs.)			10.27	10.27	10.27	10.27	10.27
Wet Weight of Specimen (lbs.)			4.54	4.86	5.04	4.94	4.87
Wet Weight of Specimen (lbs.) x 30 Wet Weight (lbs./cu. ft.)		(W)	136.2	145.8	151.2	148.2	146.1
MOISTURE SAMPLE	Moisture Can No.		68	10	14	9	17
	Wet Sample & Can (gms.)	(A)	880.50	934.10	845.80	919.40	904.38
	Dry Sample & Can (gms.)	(B)	852.30	893.12	804.30	866.40	844.96
	Weight of Can (gms.)	(C)	337.80	332.82	326.20	332.30	289.65
	Moisture Loss (gms.)		28.20	40.98	41.50	53.00	59.42
	Dry Weight of Sample (gms.)		514.40	560.32	478.10	536.10	555.31
	Moisture (%)	(w)	5.50	7.31	8.68	9.92	10.70
DRY DENSITY (lbs./cu. ft.)		(W)	129.10	135.86	139.12	134.82	131.98

Calculations:

Moisture Content:

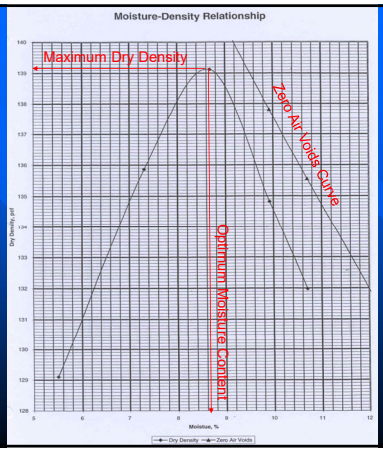
$$w = \frac{A - B}{B - C} \times 100$$

w = Percentage of moisture in the specimen, based on oven-dry weight of soil;
A = Weight of container and wet soil;
B = Weight of container and dry soil
C = Weight of Can
W = Dry weight in lbs./cu. ft. of compacted soil, and
W_t = Wet weight in lbs./cu. ft. of compacted soil.

Dry Density (lbs./cu. ft.):

$$W = \frac{W_t}{w + 100} \times 100$$

Moisture-Density Graph



General Soil Knowledge - Review

- Sand Particles Are Larger Than Both Silt and Clay Particles?
- Both Clay and Silt Soils Can be Plastic?
- Organic Soils Can Contain as Little as 5%, to More Than 50%, Organics?
- Proctor Test Determines the Optimum Amount of Water Required to Achieve Maximum Density of All Soil Types?