Construction Technology L 6

(Compaction)

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Soil Compaction:

Soil compaction:

- ✓ it is defined as the method of mechanically increasing the density of soil.
- ✓ In construction, this is a significant part of the building process. If performed improperly, settlement of the soil could occur and result in unnecessary maintenance costs or structure failure.
- ✓ Almost all types of building sites and construction projects utilize mechanical compaction techniques.

Factors Affecting Compaction technique

- Soil Type.
- Soil moisture content:
- Compaction effort required.

Soil Compaction:

❖ ***Engineering properties of soils can be improved by compaction. Therefore the purpose of Compaction is:***

1. Increases load-bearing capacity.
2. Reduce or Prevents soil settlement.
3. Provides stability to the Supporting Soil.
4. Reduces water seepage, swelling and contraction.
5. Reduce settlement of soil
6. Reduce Permeability
7. Control Volume change

Because there is a correlation between the above soil parameters and the soil dry density, construction documents usually call for achieving a specified dry density.

Soil Compaction:

- The benefits of proper compaction are enormous which exceeding their cost. Typically a uniform layer of soils from 10 to 30 cm is compacted by means of several passes of heavy compaction equipment.
- In terms of strength of an overlooked fact is that the denser the soil is compacted the better will it performs in service.
- Better compaction leads to higher bearing capacity which in turn save footing dimensions to and thereby reduce the cost of concrete foundation which is the most expensive item in construction.
- Of course, compaction costs money and the owner is interested in achieving the most economical construction that will perform as intended .
- The contractor is concerned with meeting the specifications. This can be done through the following.

Specifications Governing Compaction:

- Methods Only (often termed recipe):
- End Result Only (often termed performance):
- Method and End result:

- **Method only specifications, if the specifications for a project direct the contractor to place the soil in lifts with a specified depth, with the soil having a specified moisture content, with the provision that a specified type of roller having a specified weight to be used to compact the soil by making a specified number of passes over each lift.**
- **In this case the contractor will have no choice except to comply with the requirements of the specifications. If the owner prescribes this type of specifications, he assumes responsibility for the results while the contractor will bear no responsibility as far as the specified method is strictly followed.**

Specifications Governing Compaction:

- **Method only specifications,**
- **A specified type of soil.**
- **A specified depth of soil and layer thickness**
- **A specified moisture content in soil.**
- **Specified type of compacting roller with a specified weight.**
- **A specified number of passes over each lift.**

- **The Contractor has no choice but to follow the specifications but he is not responsible for the results.**

Specifications Governing Compaction:

- **End Result Only specifications:**
- **End Result only specifications, if the specifications dictate that the soil shall be compacted to 95% relative density based on the modified proctor test.**
- **Such specification would be "end result". Several states and agencies are moving towards a policy of using this type of specifications. The argument for the use of this policy is that the Owner is interested primarily and solely in the end results.**
- **Unless there are justified reasons for prescribing the method to be used, the contractor is permitted to select his own method which may be substantially less expensive compared with other prescribed methods.**

Methods and End Results Spesification:

- For most projects, this is not a satisfactory specifications.
- Unless extensive predesign tests are performed on soil samples to ensure that the soil will not behave differently than expected.
- In case of methods only, the compaction operations may be discontinued before adequate density is achieved. However since the method and the end result are prevailing, the contractor will bear the responsibility if the specified density is not achieved.
- The above method may prevent the contractor from using the method which he was found to be economical as he is obliged to follow the specified method.
- This type of specification is usually has a higher cost compared with the other methods.

Soil Compaction:

- **Types of Compaction Effort**
  There are four types of compaction effort on soil or asphalt:
- Vibration
- Impact
- Kneading
- Pressure
- **These different types of effort are found in the two principle types of compaction force: static and vibratory.**

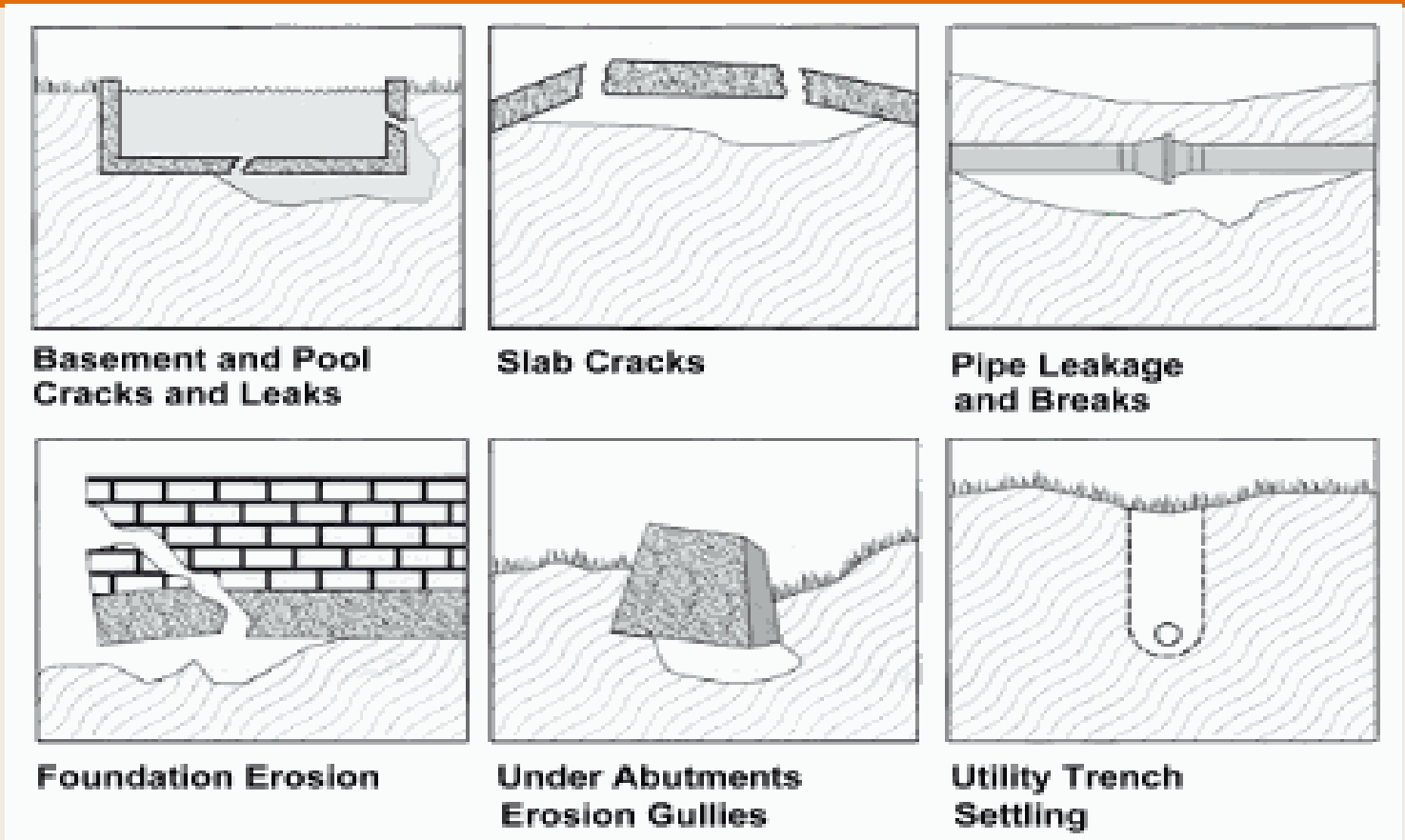
- ***Static force***
- It is simply the deadweight of the machine, applying downward force on the soil surface, compressing the soil particles. The only way to change the effective compaction force is by adding or subtracting the weight of the machine. Static compaction is confined to upper soil layers and is limited to any appreciable depth. Kneading and pressure are two examples of static compaction.

Soil compaction:

- ***Vibratory force:***
- It is usually use a mechanism of engine-driven, to create a downward force in addition to the machine's static weight. The vibrating mechanism is usually a rotating eccentric weight or piston/spring combination (in rammers).

- The compactors deliver a rapid sequence of blows (impacts) to the surface, thereby affecting the top layers as well as the deeper layers. Vibration moves through the material, setting particles in motion and moving them closer together for the highest density possible. Based on the materials being compacted, a certain amount of force must be used to overcome the cohesive nature of particular particles.

Results of Poor Compaction



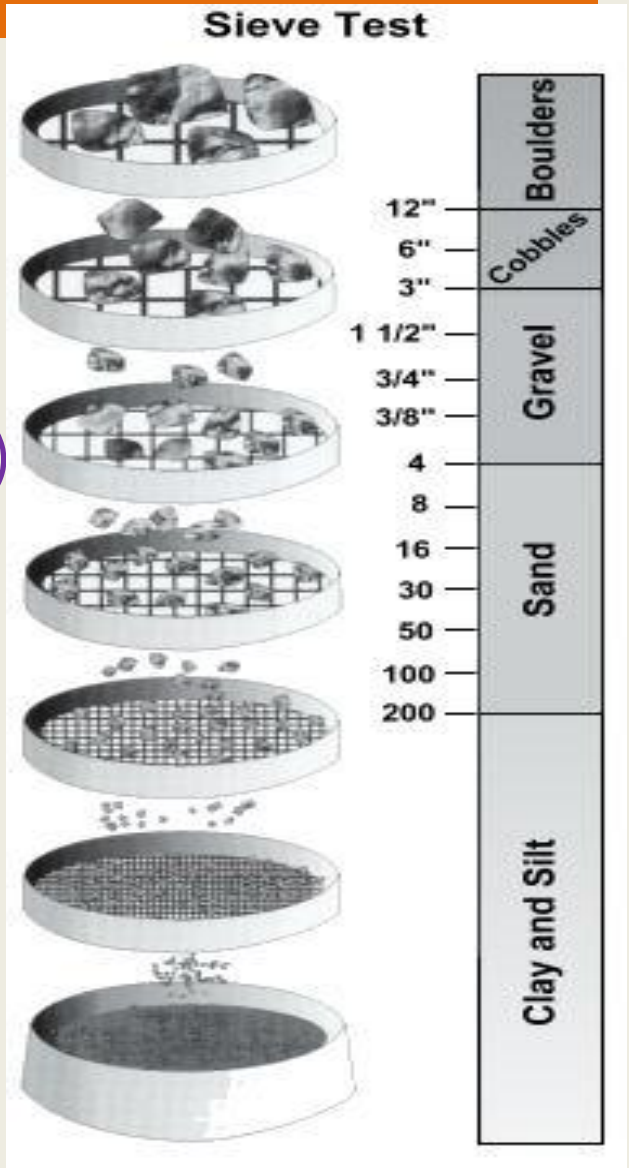
- **Both illustrations above show the result of improper compaction and how proper compaction can ensure a longer structural life.**

Soil Types and Conditions

- Every soil type behaves differently with respect to maximum density and optimum moisture. Therefore, each soil type has its own unique requirements and controls both in the field and for testing purposes.
- Soil types are commonly classified by grain size, determined by passing the soil through a series of sieves to screen or separate the different grain sizes.
- Soil classification is categorized into 15 groups, a system set up by AASHTO (American Association of State Highway and Transportation Officials). Soils found in nature are almost a combination of soil types.
- A *well-graded* soil consists of a wide range of particle sizes with the smaller particles filling voids between larger particles. The result is a dense structure that lends itself well to compaction. A soil's makeup determines the best compaction method to use.

Specifications Governing Compaction:

- **The are three basic soil groups:**
- **Cohesive**
- **Granular (Cohesion-less)**
- **Organic** (this soil is not suitable for compaction and will not be discussed here)



Types Of Soils

- **Cohesive soils**
- Cohesive soils have the smallest particles. Clay has a particle size range of .00004" to .002". Silt ranges from .0002" to .003". Clay is used in embankment fills and retaining pond beds.
- **Characteristics**

Cohesive soils are dense and tightly bound together by molecular attraction. They are plastic when wet and can be molded, but become very hard when dry. Proper water content, evenly distributed, is critical for proper compaction. Cohesive soils usually require a force such as impact or pressure. Silt has a noticeably lower cohesion than clay. However, silt is still heavily reliant on water content.

Types Of Soils

- **Granular Soil**
- Granular soils range in particle size from .003" to .08" (sand) and .08" to 1.0" (fine to medium gravel). Granular soils are known for their water-draining properties.
- **Characteristics**
- Sand and gravel obtain maximum density in either a fully dry or saturated state. The water Content is not vital however, the desired dry density can be obtained with less effort if the water content is around the optimum moisture Content. For higher or lower water contents, the desired dry density can be achieved with greater effort.

Fill Material

Fill Materials					
	Permeability	Foundation Support	Pavement Sub grade	Expansive	Compaction Difficulty
Gravel	Very High	Excellent	Excellent	No	Very Easy
Sand	Medium	Good	Good	No	Easy
Silt	Medium Low	Poor	Poor	Some	Some
Clay	None+	Moderate	Poor	Difficult	Very Difficult
Organic	Low	Very Poor	Not Acceptable	Some	Very Difficult

Soil Compaction:

Materials				
	Lift Thickness (Inch)	Impact	Pressure (with kneading)	Vibration
Gravel	12+	Poor	No	Good
Sand	10+/-	Poor	No	Excellent
Silt	6+/-	Good	Good	Poor
Clay	6+/-	Excellent	Very Good	No

Soil Compaction: Effect of Moisture Content:

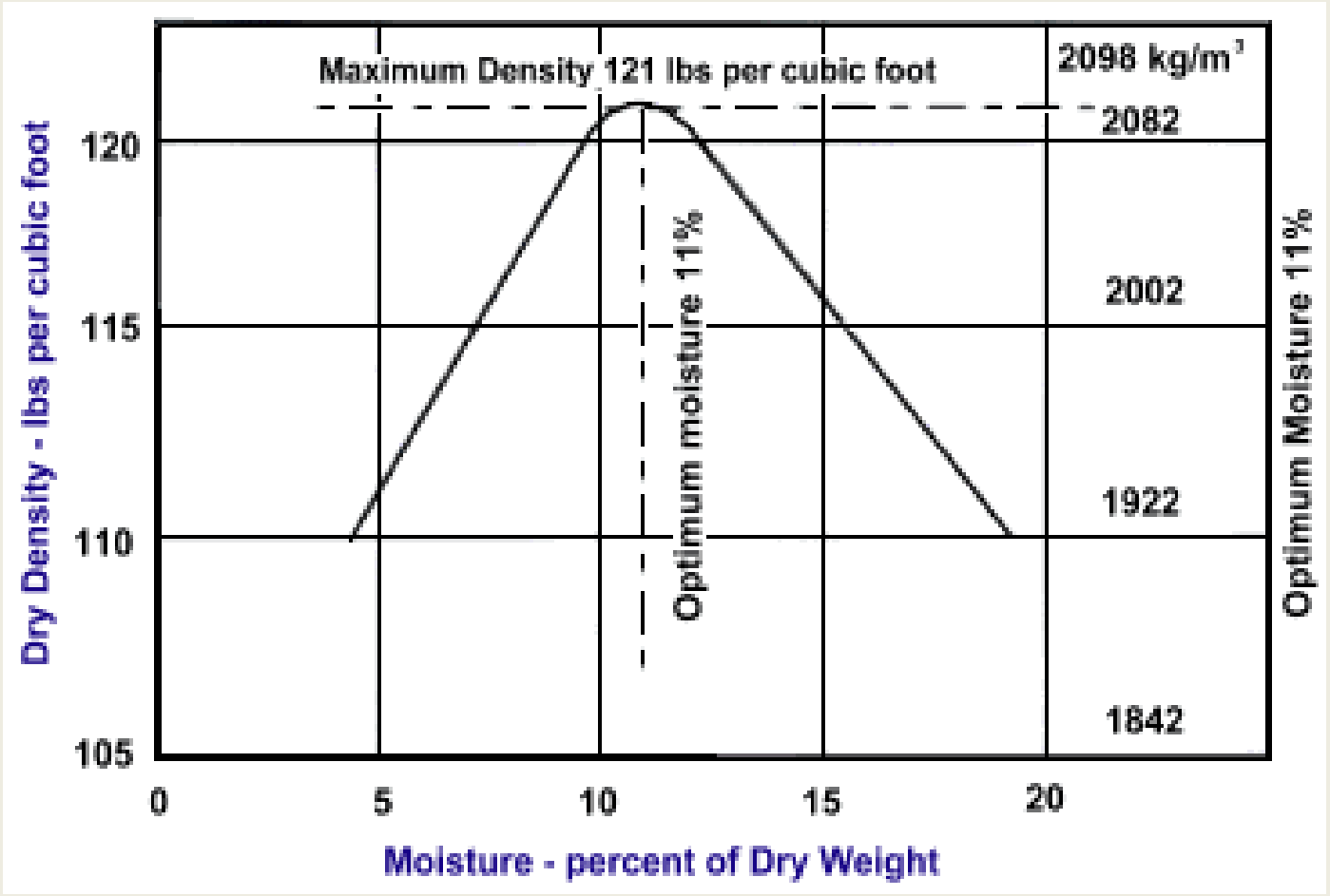
Moisture vs. Soil Density:

- Moisture content of the soil is vital to proper compaction. Moisture acts as a lubricant within soil, sliding the particles together.

- Too little moisture means inadequate compaction - the particles cannot move against each other to achieve density.

- Too much moisture leaves water-filled voids and subsequently weakens the load-bearing ability. The highest density for most soils is at a certain water content for a given compaction effort. The drier the soil, the more resistant it is to compaction. In a water-saturated state the voids between particles are partially filled with water, creating an apparent cohesion that binds them together.

Soil Compaction: Effect of Moisture Content:



Soil Compaction: Dry Density Tests:

- **Soil Density Tests:**
  To determine if proper soil compaction is achieved for any specific construction application, several methods were developed. The most prominent by far is soil density.
- **Why Test?**
  Soil testing accomplishes the following:
- Measures density of soil for comparing the degree of compaction vs. specification.
- Measures the effect of moisture on soil density vs. specs
- Provides a moisture density curve identifying optimum moisture

Soil Compaction: Laboratory Tests:

- **Proctor Test (ASTM D1557-91) :**
- The Proctor, or Modified Proctor Test, determines the maximum density of a soil needed for a specific job site. The test first determines the maximum density achievable for the materials and uses this figure as a reference.
- Secondly, it tests the effects of moisture on soil density. The soil reference value is expressed as a percentage of density. These values are determined before any compaction takes place to develop the compaction specifications.
- Modified Proctor values are higher because they take into account higher densities needed for certain types of construction projects. Test methods are similar for both tests.

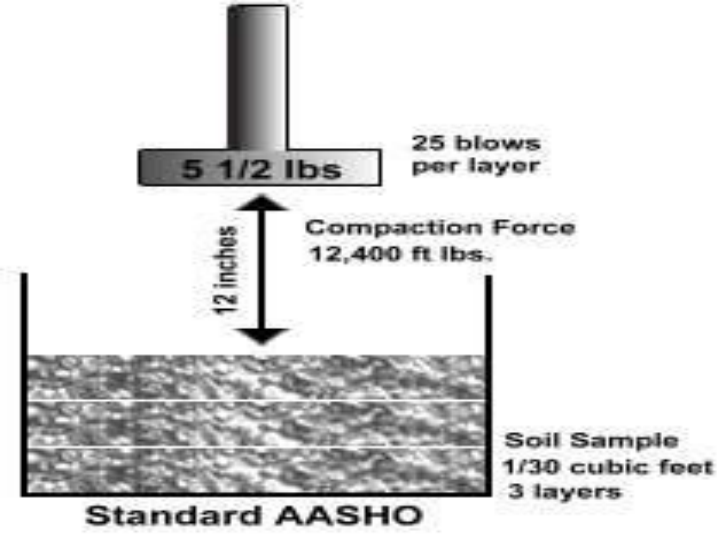
Soil Compaction: Laboratory Tests:

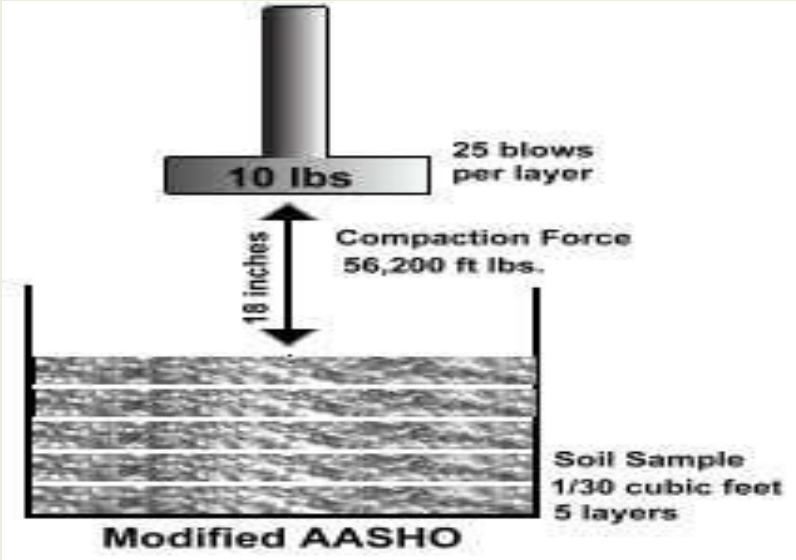
Proctor Test:

A small soil sample is taken from the jobsite. A standard weight is dropped several times on the soil. The material weighed and then oven dried for 24 hours in order to evaluate water content

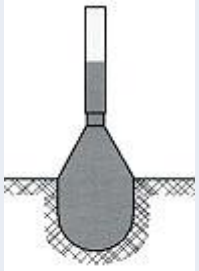
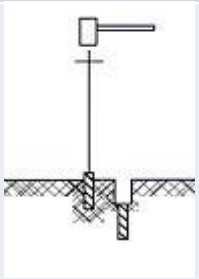
Modified Proctor Test

This is similar to the Proctor Test except a hammer is used to compact material for greater impact, The test is normally preferred in testing materials for higher shearing strength.





Field Density Testing Method

	Sand Cone	Balloon Dens meter	Shelby Tube	Nuclear Gauge
				
Advantages	* Large sample * Accurate	• Large sample • Direct reading obtained • Open graded material	* Fast * Deep sample * Under pipe haunches	* Fast * Easy to redo * More tests (statistical reliability)
Disadvantages	* Many steps * Large area required * Slow * Halt Equipment	* Slow * Balloon breakage * Awkward	* Small Sample * No gravel * Sample not always retained	* No sample * Radiation * Moisture suspect * Encourages amateurs
Errors	* Void under plate * Sand bulking * Sand compacted * Soil pumping	* Surface not level * Soil pumping * Void under plate	* Overdrive * Rocks in path * Plastic soil	* Mis-calibrated * Rocks in path * Surface prep required * Backscatter
Cost	* Low	* Moderate	* Low	* High

Next lecture is ready mixed Concrete

THANK YOU!