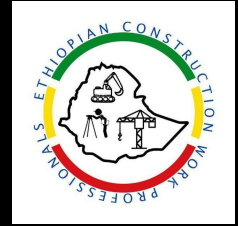




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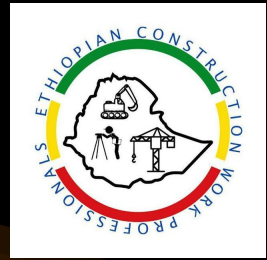
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Laboratory Soil Compaction Test

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Overview

- Definition
- Objectives
- How it can apply in field?
- Types (In detail)
- Apparatus
- Test Procedure
- Significance
- Factors affecting compaction
- Conclusion

What Is Compaction?



- Compaction is the process of increasing the **bulk density** of a soil or aggregate by driving out air only.
- For any soil, at a given compactive effort, the density obtained depends on the moisture content.
- For any soil, an “optimum water content” exists at which it will achieve it’s maximum density.

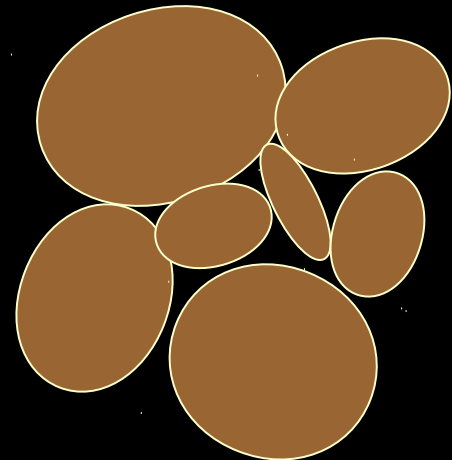
What is compaction?

The most commonly used ground improvement technique, where the soil is densified through external compactive effort/mechanical means by reducing volume of air.

Compactive
Effort

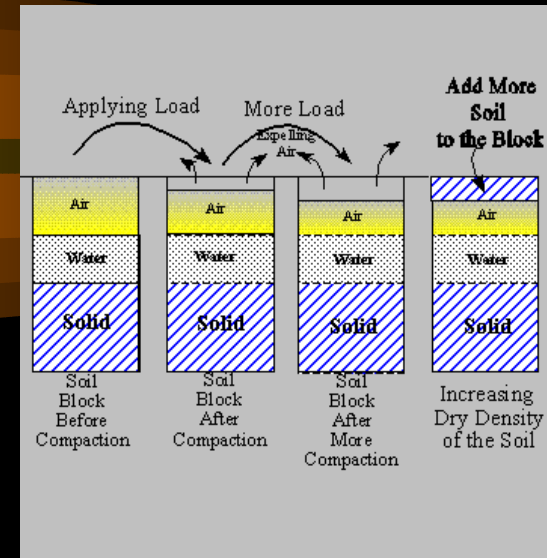


+ air voids =

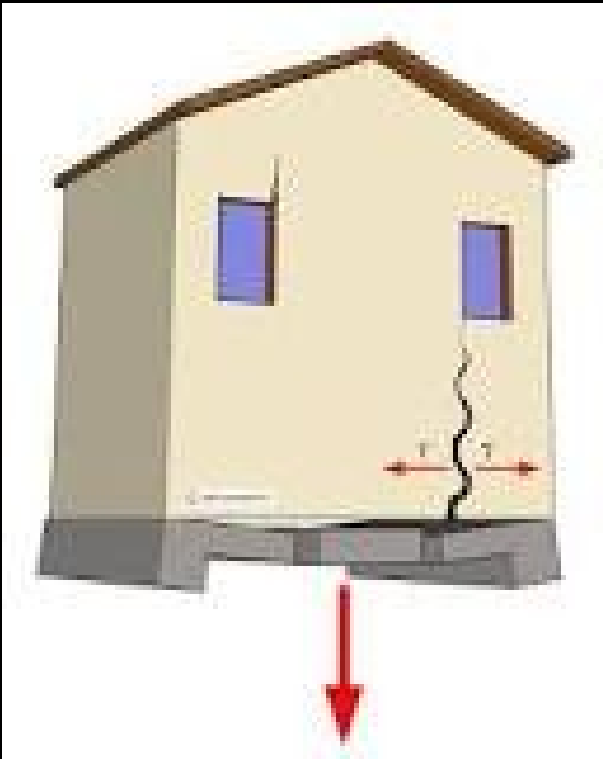


Moisture Content and Compaction

- The degree of compaction of soil is measured by its unit weight, γ_{dry} and optimum moisture content, w_c .
- By reducing the air voids, more soil can be added to the block. When moisture is added to the block, the soil particles will slip more on each other causing more reduction in the total volume, which will result in adding more soil and hence, the dry density increases accordingly.
- Increasing w_c will increase γ_{dry} to certain limit called Optimum moisture Content, (OMC)
- After this limit Increasing w_c will decrease dry density.

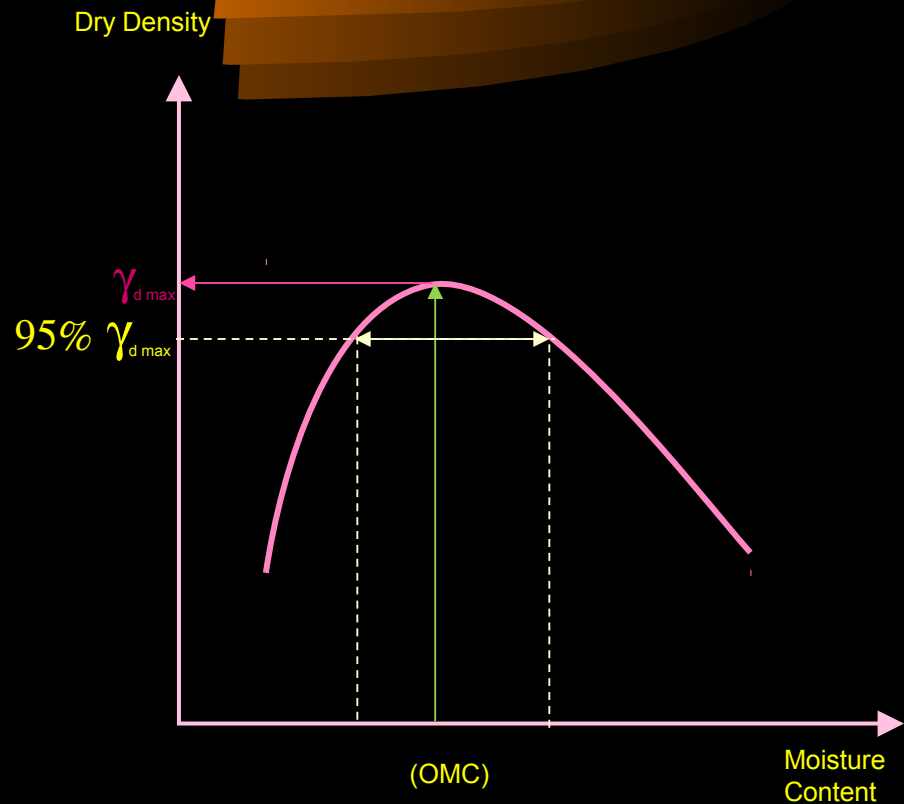


Why it is important !!



How it relates to field compaction?

Because of the differences between lab and field compaction methods, the maximum dry density in the field may reach 90% to 95%.



Main Objectives of Compaction

1. To increase strength and stability
2. To decrease permeability.
3. To enhance resistance to erosion.
4. Decrease compressibility under load and minimize settlement.

Basic Terminology

- The peak dry unit weight is called the "maximum dry density".
- The Optimum Water Content, w_{opt} , is the water content at the soil's maximum dry density. .
- Zero air voids curve: The curve represents the fully saturated condition ($S = 100\%$). (*It cannot be reached by compaction*)
- Line of optimum: A line drawn through the peak points of several compaction curves.

Types of soil compaction test in laboratory



- Standard Proctor test
- Modified Proctor test
- Gyratory compaction test

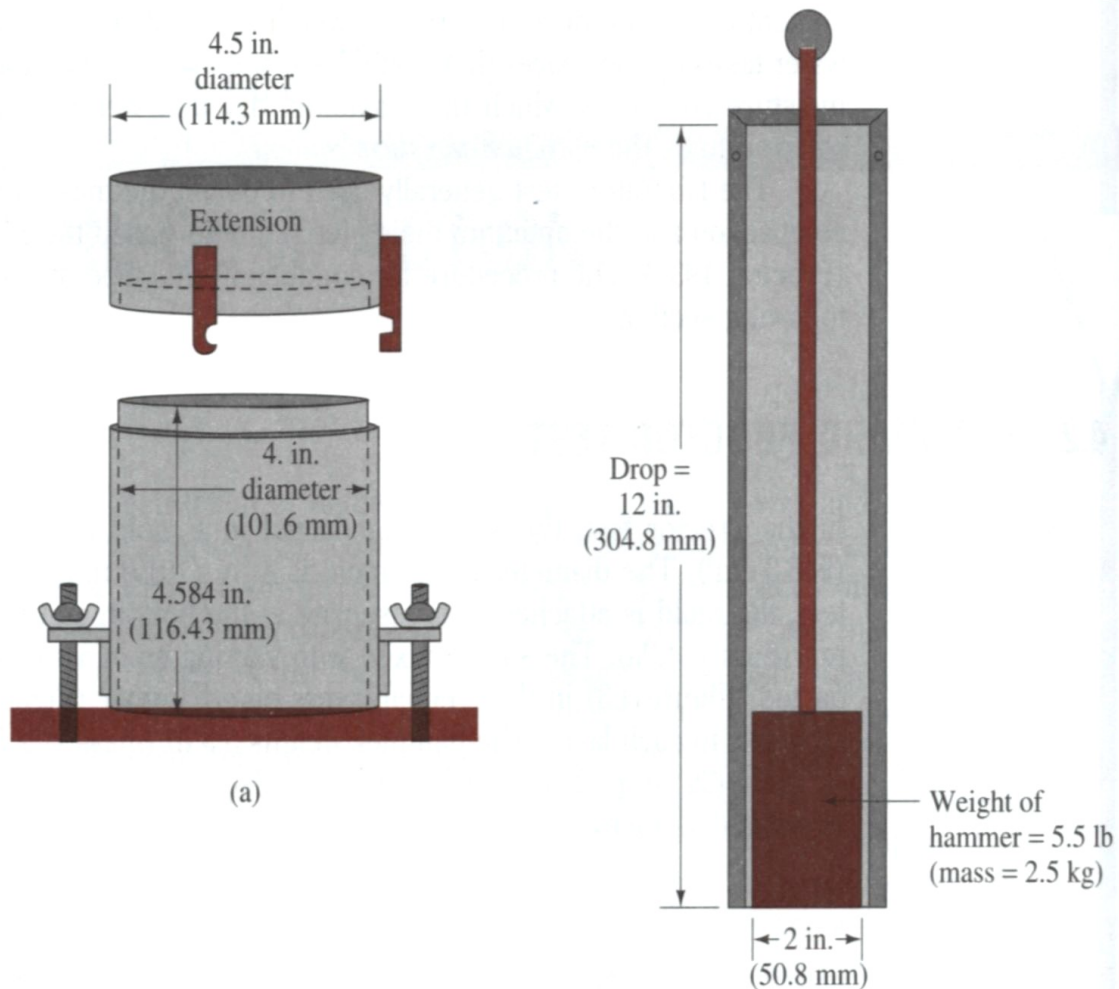
Apparatus and its setup



Standard Proctor test

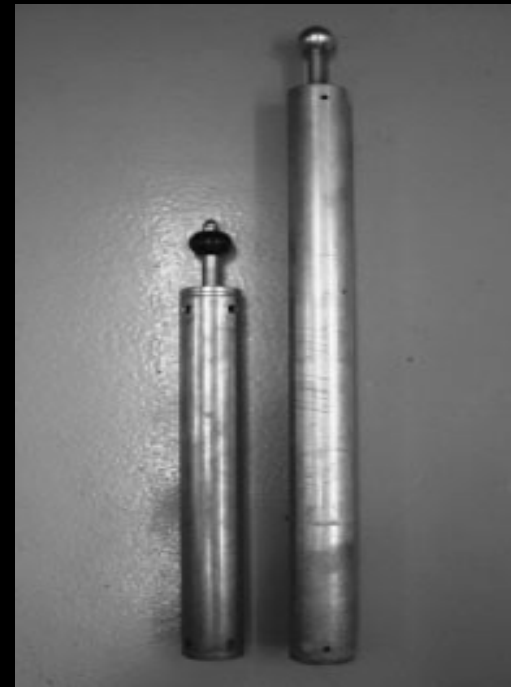
In the Proctor test, the soil is compacted in a mold that has a volume of 944 cm³. The diameter of the mold is 101.6 mm. During the laboratory test, the mold is attached to a baseplate at the bottom and to an extension at the top. The soil is mixed with varying amounts of water and then compacted in three equal layers by a hammer that delivers 25 blows to each layer. The hammer has a mass of 2.5 kg and has a drop of 30.5 mm. Total compactive energy required for SPT = 600 KJ

Standard proctor test



Modified proctor test

- Same mold 944 cubic cm, 101.6 mm diameter, hammer mass 4.54 kg and drop height 45.7 cm.
- Mold is connected with Base plate at bottom and extension at top.
- No. of layers is 5
- No. of blows to each layer is 25.
- Compaction energy = 2700 KN-m/m^2



Comparison between standard Proctor hammer (left) and modified Proctor hammer (right)

Gyratory compaction Test

Gyratory Compactor is designed to compact asphalt specimens. It also handles soils, emulsions, and concrete. It is a customer favourite because it is user-friendly, reliable, durable, and well supported. The G2 compacts material at a constant consolidation pressure, a constant angle of gyration, and a fixed speed of gyration using an electro-mechanical system.



Proctor Compaction Procedure

- Soil is air dried, pulverized & passed through 4.75micron sieve.
- The water content of each sample is adjust by adding water.
- Using the proctor mold, soil is place 1/3 rd in height & compact soil in 3 layers for standard and 5 layers for modified.



Proctor Compaction Procedure

- We provide 25 nos blows for each layer.
- After the last layer, with the help of straight edge the excess soil is trim to the top of the mold.
- The weight of the mold with the compacted moist soil is measured.
- Extrude from mould and collect a sample for water content determination.
- Repeating for each sample over a range of moisture contents.



Proctor Compaction Procedure

- After collecting all weights, the dry density is calculate and graph is plotting between dry density vs. water content.

$$\gamma_{\text{total}} = \gamma_d (1 + w/100)$$

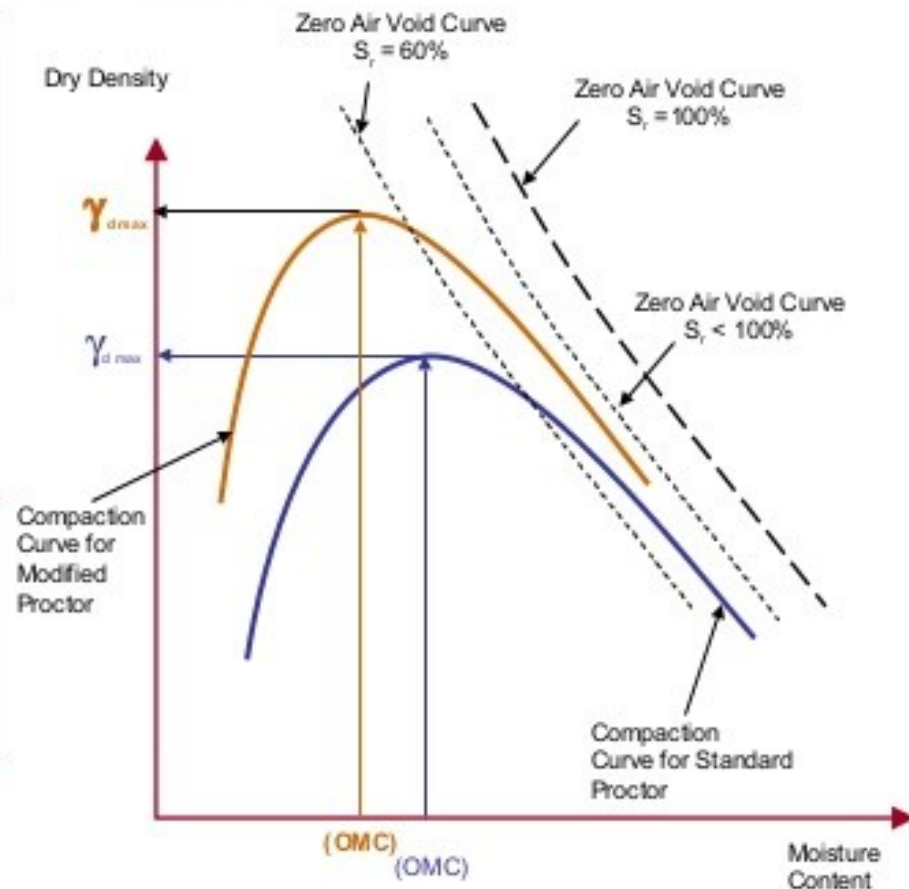
Soil Compaction in the Lab:

1- Standard Proctor Test
ASTM D-698 or AASHTO T-99

Energy = 12,375 foot-pounds per cubic foot

2- Modified Proctor Test
ASTM D-1557 or AASHTO T-180

Energy = 56,520 foot-pounds per cubic foot

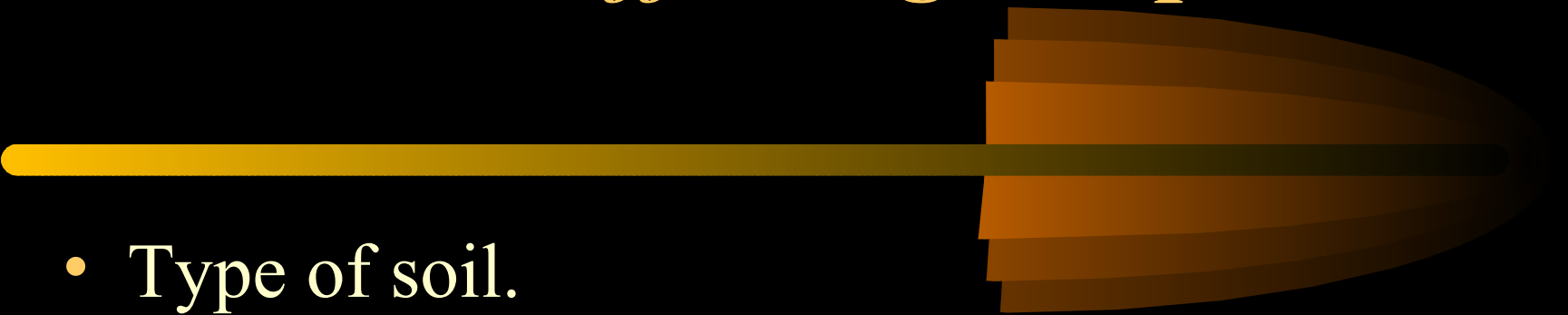


$$\text{Energy} = \frac{\text{Number of blows per layer} \times \text{Number of layers} \times \text{Weight of hammer} \times \text{Height of drop hammer}}{\text{Volume of mold}}$$

Percent Compaction

- Then, comparing the maximum dry density to the actual density being achieved we can calculate % compaction as:
- % Compaction = $\rho_{\text{dry field}} / \rho_{\text{dry max}}$

Factors affecting compaction.



- Type of soil.
- Compactive Effort / Compactive Energy.
- Layer Thickness / Thickness of Lift.
- Number of Roller Passes.
- Moisture Content.
- Contact Pressure.
- Speed of Rolling

Significance

- ❖ Mechanical compaction is one of the most common and effective means of stabilizing soils.
- ❖ Most engineering properties like strength, stiffness, resistance to shrinkage, and impervious of the soil is increase by increasing the soil density.
- ❖ Compacting soil at optimum moisture content results into maximum dry density.
- ❖ Compacting soil at water content higher than the optimum water content results in a relatively disperse state.
- ❖ And flocculated structures at water content lower than the optimum.

Effect of compaction

The following properties of soil are affected on compaction—

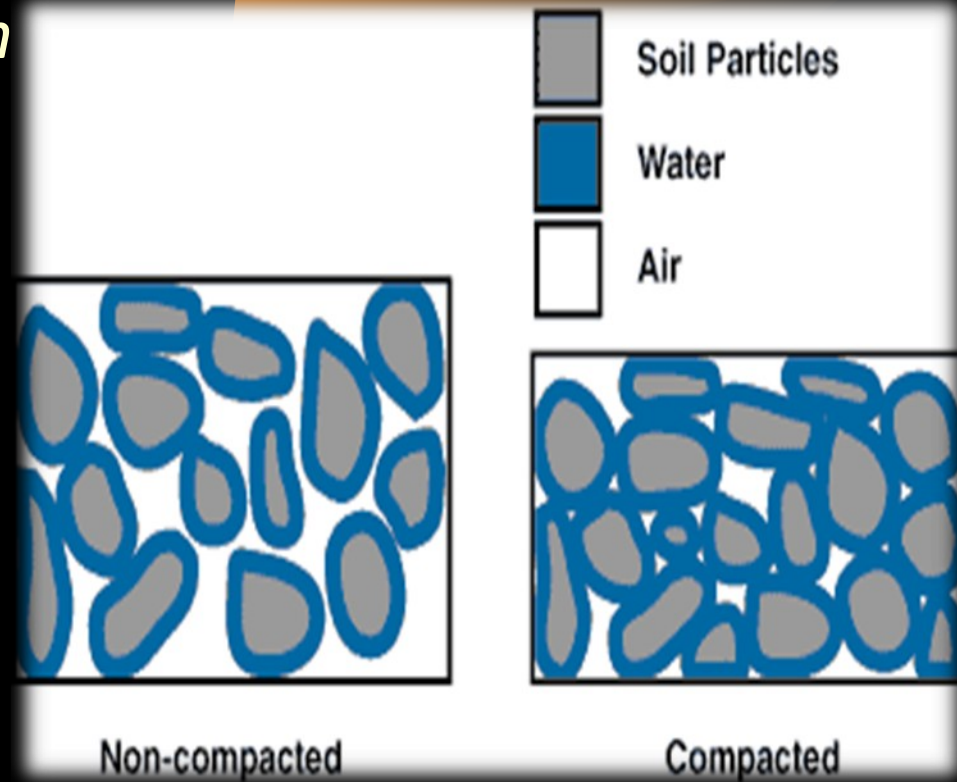
- ❖ Soil Structure
- ❖ Permeability
- ❖ Pore water pressure
- ❖ Swelling
- ❖ Compressibility

Effect on Soil structure

❖ *The water content at which the soil is compacted plays an important role in soil structure.*

❖ *Soils compacted at water content less than optimum water content have flocculated structure.*

❖ *Soils compacted at water content more than optimum water content have dispersed structure.*



Effect on soil Structure

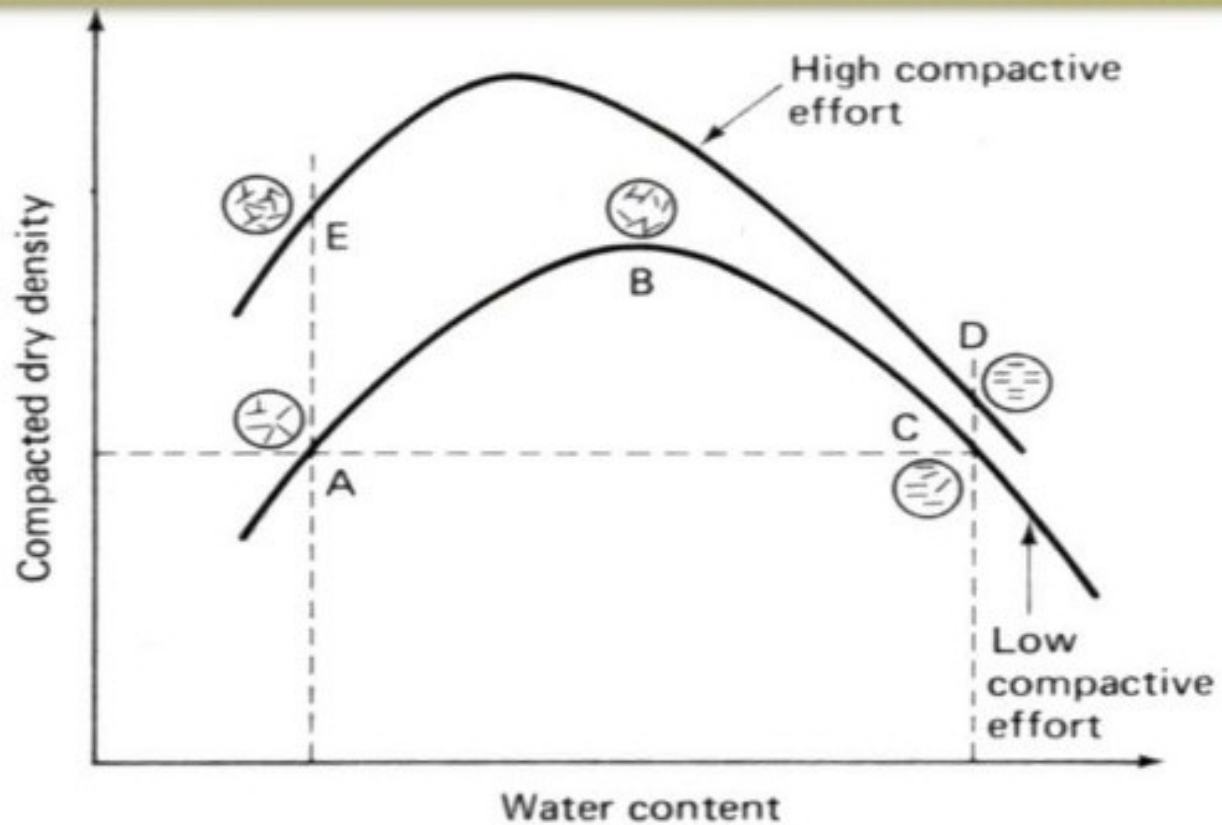


Fig. 5.5 Effect of compaction on soil structure (after Lambe, 1958a).

Effect on Soil structure

- ❖ At Point A, the water content is low and attractive forces are predominant, so results in flocculated structure.
- ❖ As the water content is increased beyond optimum, the repulsive forces increase and particles get oriented into a dispersed structure.

Effect on Permeability

- ◆ Permeability of soil depends on void size.
- ◆ As water content increases, there is an improved orientation of particles resulting in reduction of void size and permeability.
- ◆ Above optimum water content, the permeability slightly increases.
- ◆ If compactive effort is increased, the permeability decreases due to increased dry density.



Effect on Shrinkage



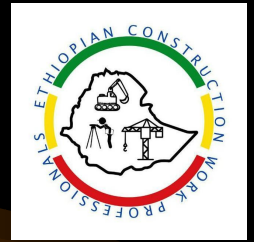
- ❖ Soils compacted dry of optimum shrink less when compared to compacted wet of optimum.
- ❖ The soils compacted wet of optimum shrink more because the soil particles in dispersed structure can pack more efficiently.

Compaction

Maximum Dry Density

- If the soil was below optimum water content it may be necessary to add water by spraying
- The most important factor required for successful compaction is having the correct water content

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CONCLUSION

Ultimately compaction is depending on the void ratio of soil. Compaction is a factor of practical importance is the increase of soil strength and stability. Now adays in urban area land is one of the most common problems. In such cases if soil's engineering properties is not up to the requirement then there is no meaning for that project. So in that case soil compaction can be applied as a one of the most economic ground improvement technique.



THANK YOU