

LECTURE 14

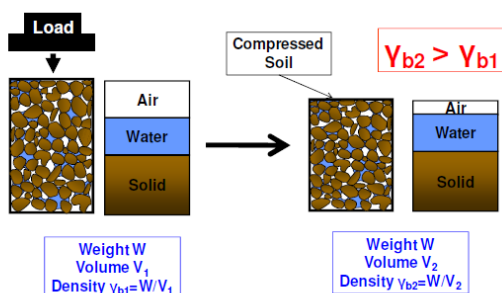
COMPACTION

Introduction:

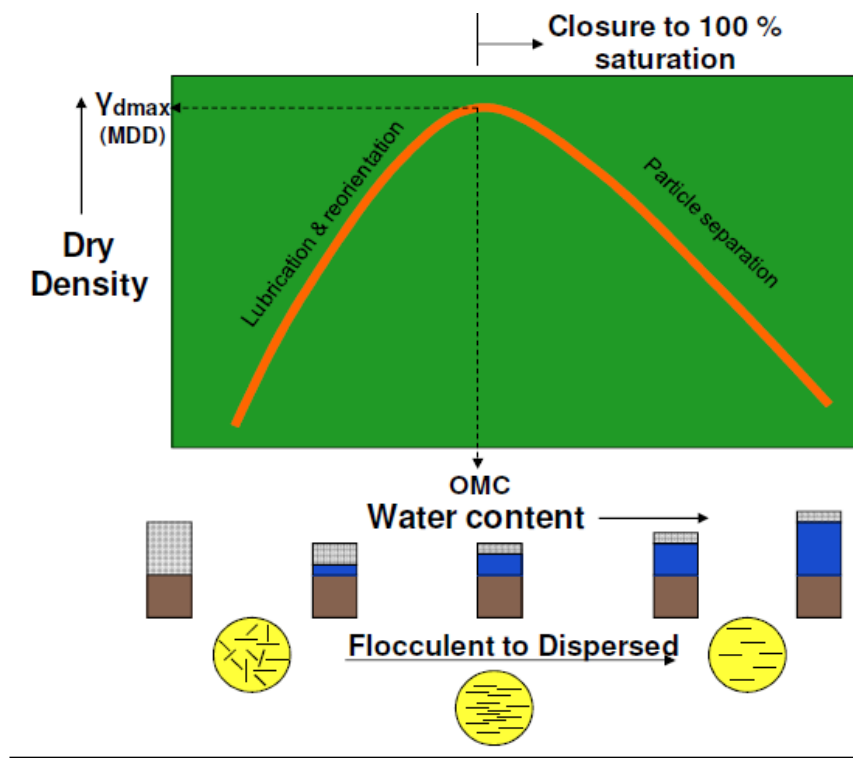
Compaction is the process of increasing the bulk density of a soil or aggregate by driving out air. For any soil, at a given compactive effort, the density obtained depends on the moisture content. An “Optimum Moisture Content” exists at which it will achieve a maximum density. Compaction is the method of mechanically increasing the density of soil. The densification of soil is achieved by reducing air void space. During compaction, air content reduces, but not water content. It is not possible to compact saturated soil. It should be noted that higher the density of soil mass, stronger, stiffer, more durable will be the soil mass.

Hence, Compaction

- 1) Increases density
- 2) Increases strength characteristics
- 3) Increases load-bearing capacity
- 4) Decreases undesirable settlement
- 5) Increases stability of slopes and embankments
- 6) Decreases permeability
- 7) Reduces water seepage
- 8) Reduces Swelling & Shrinkage
- 9) Reduces frost damage
- 10) Reduces erosion damage
- 11) Develops high negative pore pressures (suctions) increasing effective stress



Mechanism of Compaction-

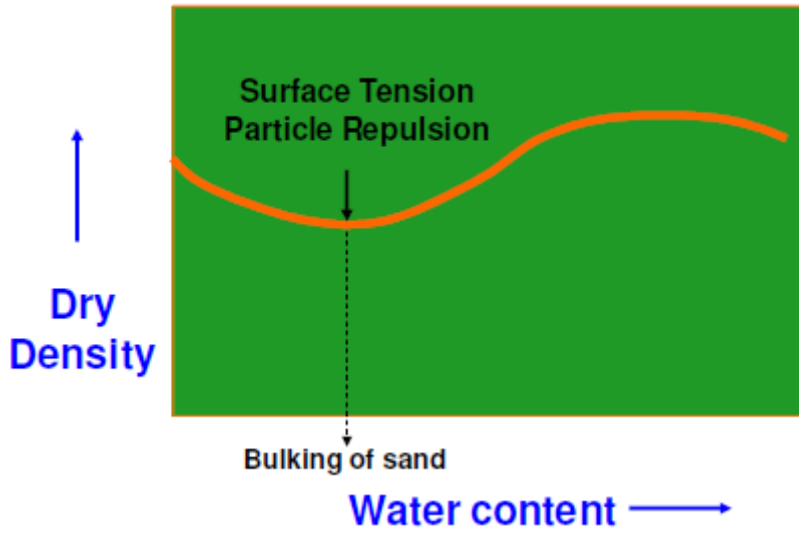


Optimum Moisture Content (OMC) is the moisture content at which the maximum possible dry density is achieved for a particular compaction energy or compaction method. The corresponding dry density is called Maximum Dry Density (MDD). Water is added to lubricate the contact surfaces of soil particles and improve the compressibility of the soil matrix. It should be noted that increase in water content increases the dry density in most soils up to one stage (Dry side). Water acts as lubrication. Beyond this level, any further increase in water (Wet side) will only add more void space, thereby reducing the dry density. Hence OMC indicates the boundary between the dry side and wet side. Hence the compaction curve as shown in figure indicates the initial upward trend up to OMC and the downward trend.

Reasons for the shape of curve

1. On dry side of OMC, clayey soil shows high suction, lumps are difficult to break or compact.
2. Increasing the water content reduces suction, softens lumps, lubricates the grains for easy compaction.
3. As water content increases, lubrication improves compaction resulting in higher dry density.
4. Now nearly impossible to drive out the last of the air – further increase in water content results in reduced dry density (curve follows down parallel to the maximum possible density curve – the Zero Air Voids curve)
5. MDD and OMC depend on the compaction energy and are not unique soil properties.
6. For sand, suction at low water contents also prevents compaction (but not if completely dry)
7. In cohesionless soils, MDD is achieved either when completely dry, or when completely saturated.

8. At low water content, grains are held together by suction (water at grain contacts only)
9. This prevents compaction.
10. Laboratory test for MDD on sand requires fully saturated sample, and involves vibration.



Percent Air Voids:

$$\gamma_d = \frac{(1 - n_a) G \gamma_w}{1 + \omega G}$$

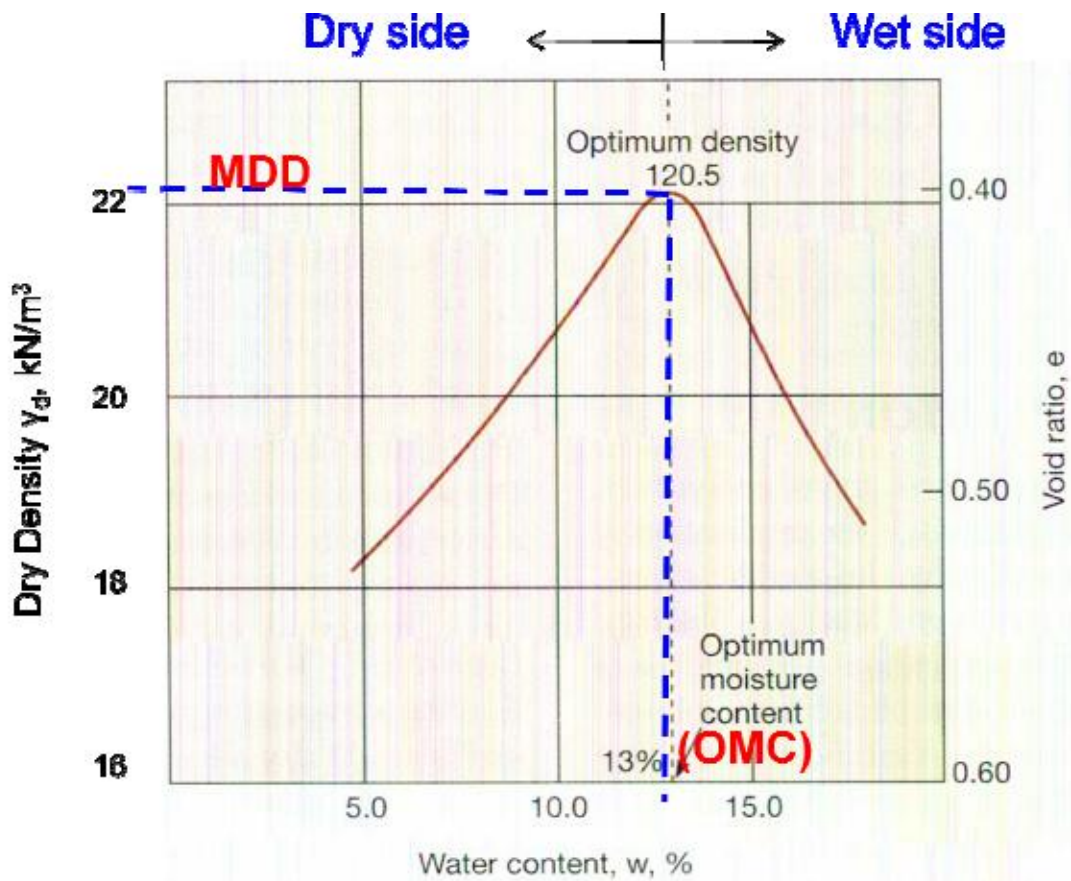
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Factors affecting Compaction-

1. Water Content
2. Amount of Compaction
3. Method of Compaction
4. Type of Soil
5. Addition of Admixtures

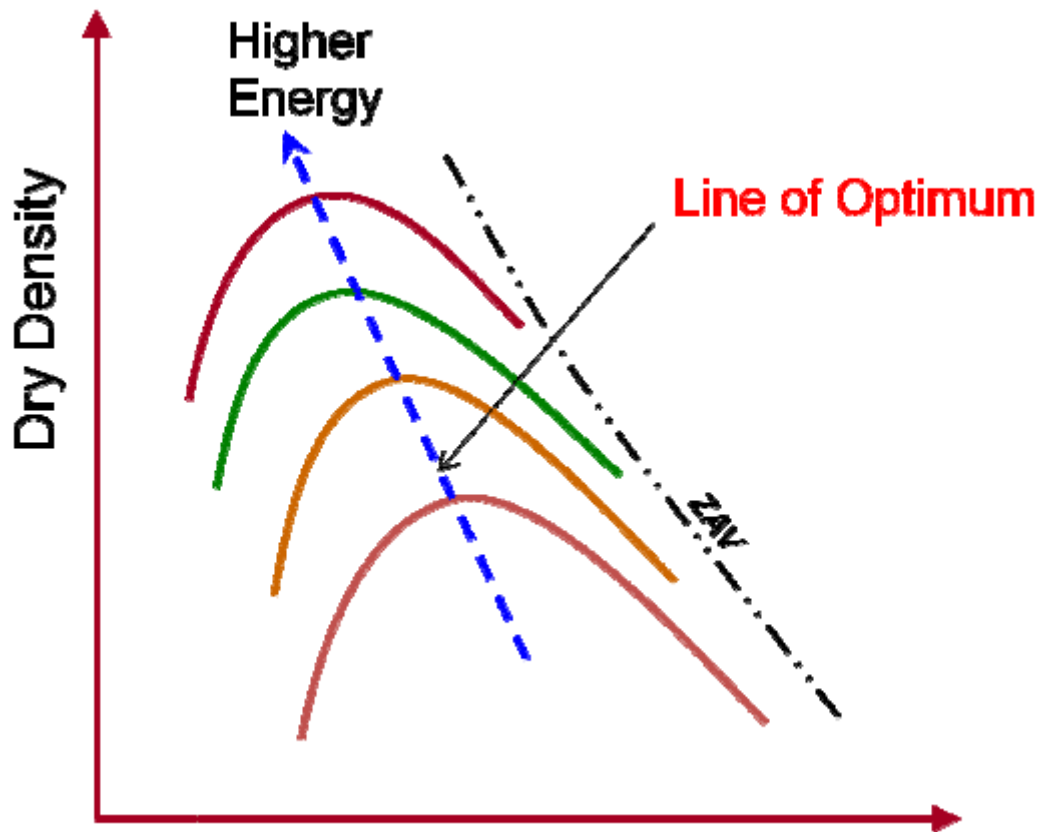
Effect of Water Content-

1. With increase in water content, compacted density increases up to a stage, beyond which compacted density decreases.
2. The maximum density achieved is called MDD and the corresponding water content is called OMC.
3. At lower water contents than OMC, soil particles are held by the force that prevents the development of diffused double layer leading to low inter-particle repulsion.
4. Increase in water results in expansion of double layer and reduction in net attractive force between particles.
Water replaces air in void space
5. Particles slide over each other easily increasing lubrication, helping in dense packing.
6. After OMC is reached, air voids remain constant. Further increase in water, increases the void space, thereby decreasing dry density.



Effect of Amount of Compaction-

1. As discussed earlier, effect of increasing compactive effort is to increase MDD And reduce OMC (Evident from Standard & Modified Proctor's Tests).
2. However, there is no linear relationship between compactive effort and MDD.



Effect of Method of Compaction-

The dry density achieved by the soil depends on the following characteristics of compacting method.

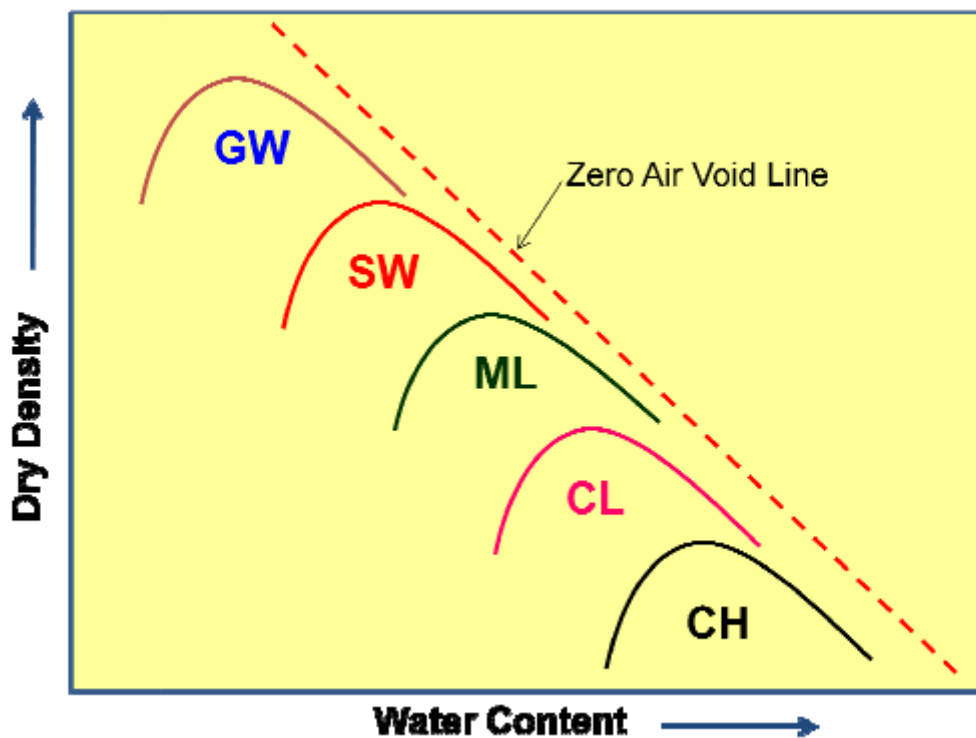
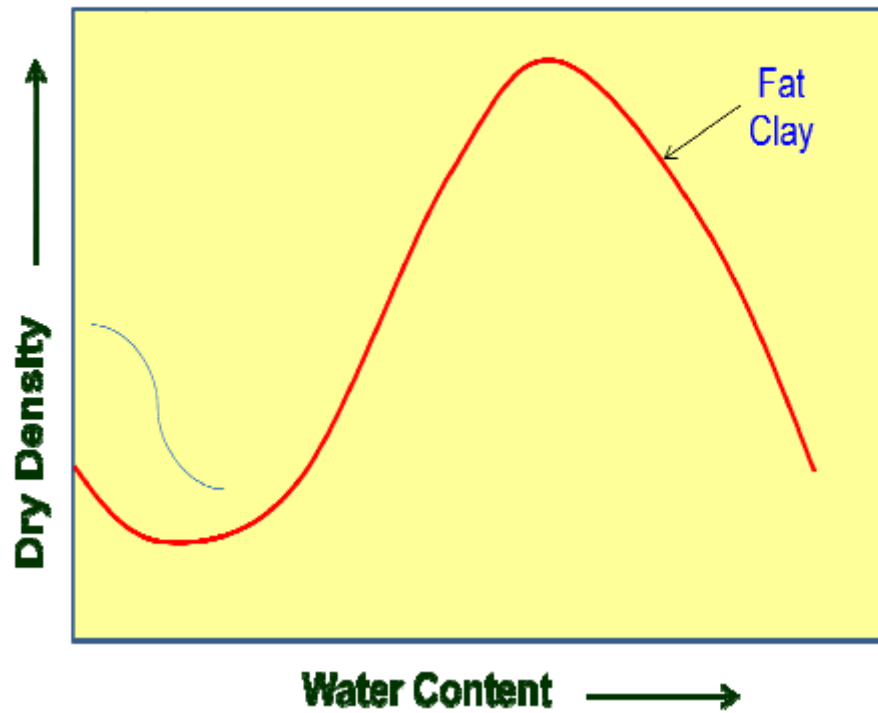
1. Weight of compacting equipment
2. Type of compaction
3. Area of contact of
4. Time of exposure
5. Each of these approaches will yield different compactive effort.

Further, suitability of a particular method depends on type of soil.

Effect of Type of Soil

1. Maximum density achieved depends on type of
2. Coarse grained soil achieves higher density at lower water content and fine grained soil achieves lesser density, but at higher water content.

Typical Compaction Curve for Fat Clay



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Effect of Addition of Admixtures-

1. Stabilizing agents are the admixtures added to soil.
2. The effect of adding these admixtures is to stabilize the soil.
3. In many cases they accelerate the process of densification.

Effect of compaction on soil properties-

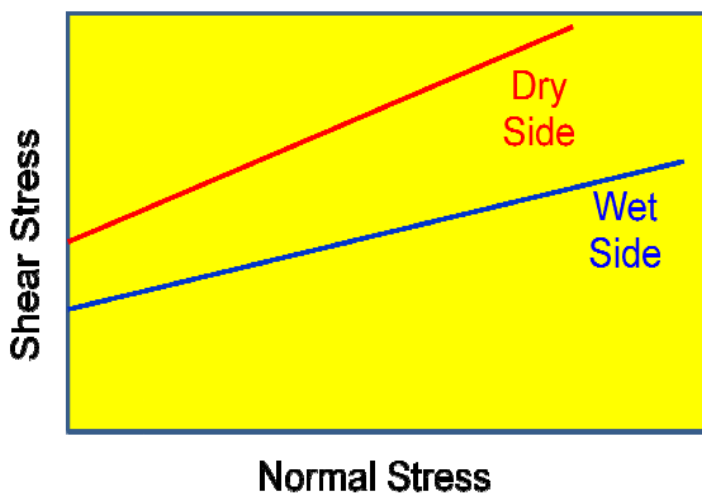
1. Density
2. Shear strength
3. Permeability
4. Bearing Capacity
5. Settlement
6. Soil Structure
7. Pore Pressure
8. Stress Strain characteristics
9. Swelling & Shrinkage

Influence on Density:

Effect of compaction is to reduce the voids by expelling out air. This results in increasing the dry density of soil mass.

Influence on Shear strength:

Increase the number of contacts resulting in increased shear strength, especially in granular soils. In clays, shear strength depends on dry density, moulding water content, soil structure, method of compaction, strain drainage condition etc. Shear strength of cohesive soils compacted dry of optimum (flocculated structure) will be higher than those compacted wet of optimum (dispersed structure).



Effect of compaction on permeability

1. Increased dry density, reduces the void space, thereby reducing permeability.
2. At same density, soil compacted dry of optimum is more permeable.
3. At same void ratio, soil with bigger particle size is more permeable.
4. Increased compactive effort reduces permeability.

Effect on Bearing Capacity

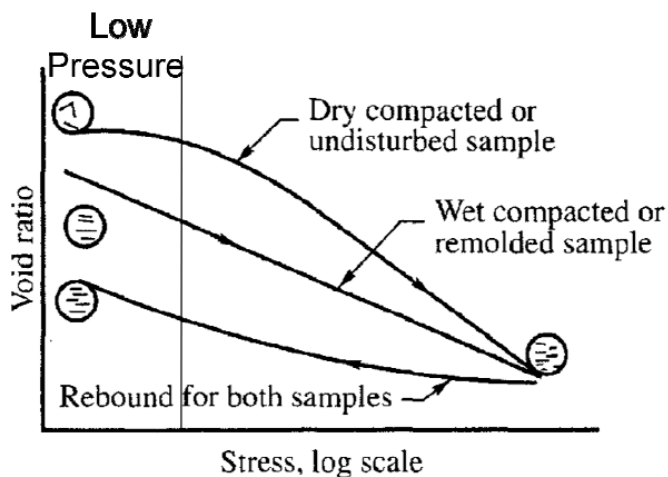
1. Increase in compaction increases the density and number of contacts between soil particles.
2. This results in increased
3. Hence bearing capacity increases which is a function of density and

Effect on Settlement

1. Compaction increases density and decreases void ratio.
2. This results in reduced settlement.
3. Both elastic settlement and consolidation settlement are reduced.
4. Soil compacted dry of optimum experiences greater compression than that compacted wet of optimum.

Effect on Compressibility

Optimum shows more compressibility than that on dry side. But at higher pressure, behavior is similar.



Effect on Soil Structure

In fine grained soil

1. On dry side of optimum, the structure is flocculated. The particles repel and density is less.
2. Addition of water increases lubrication and transforms the structure into dispersed structure

In coarse grained soil, single grained structure is maintained

In composite soil, behaviour depends on composition.