Marwadi
education foundation

CIVIL ENGINEERING

BRANCH CODE: 06

SEMESTER: 5th

SUBJECT: SOIL MECHANICS

SUBJECT CODE: 2150609

OWLEDGE IS THE CURRENCY
THE 21st CENTURY

IMPORTANCE OF BLOOM'S TAXONOMY:

Suggested Specification table with Marks (Theory):

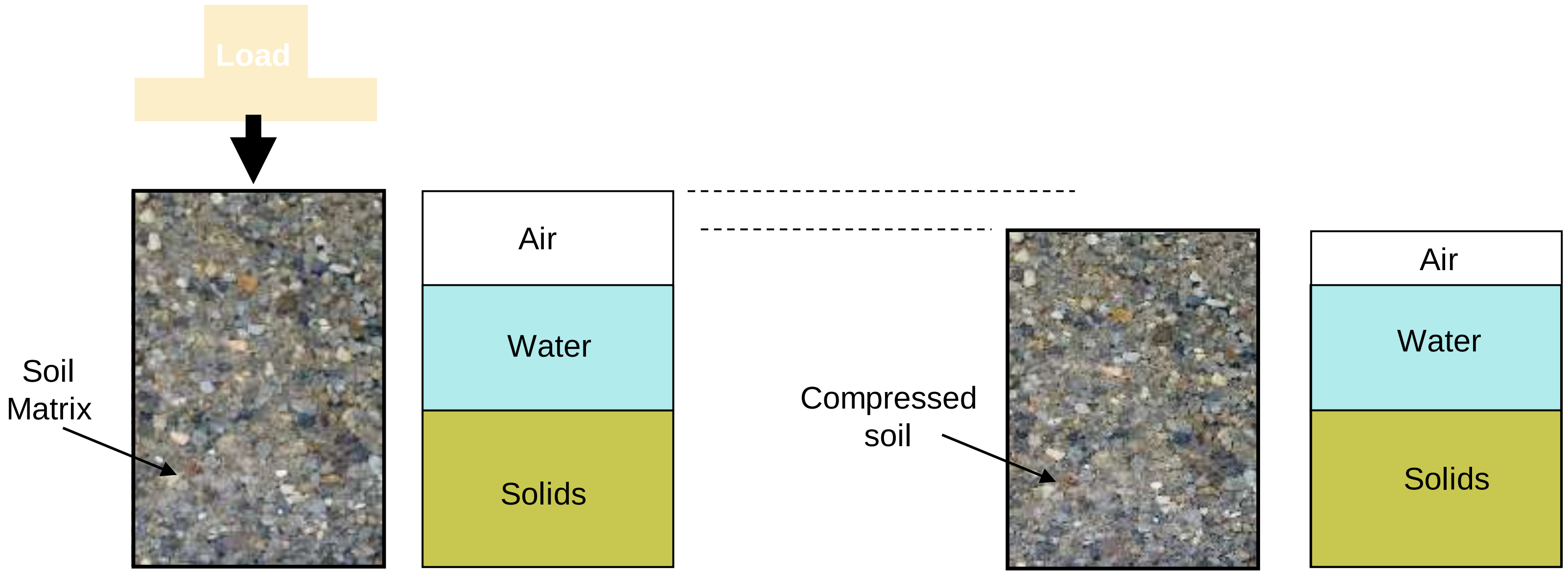
Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
20	**20**	**20**	**25**	**15**	**0**

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Definition:

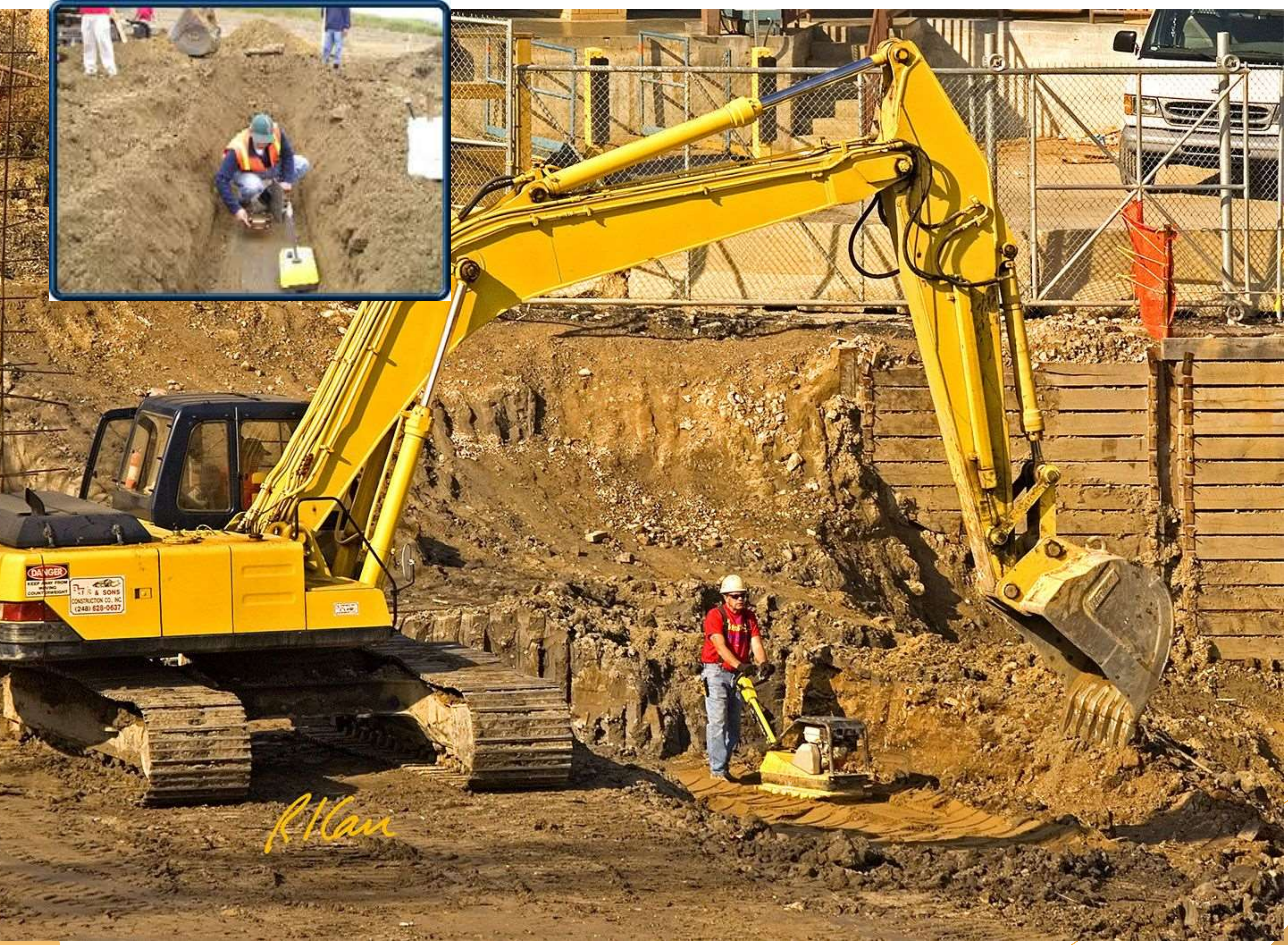
Soil compaction is defined as the method of mechanically increasing the density of soil by reducing volume of air.

$$\gamma_{soil\ (2)} > \gamma_{soil\ (1)}$$



$$\gamma_{soil\ (1)} = \frac{W_{T1}}{V_{T1}}$$

$$\gamma_{soil\ (2)} = \frac{W_{T1}}{V_{T2}}$$



DANGER

COMPACTION

- Compaction is a process by which soil particle are artificially packed together into a closer state by mechanical means in order to decrease the void ratio of the soil and thus increase its dry density.

- Air during compaction is expelled from the voids space in the soil mass and therefore mass density is increased.

- compaction during soil mass is done to improve the its engineering properties.

Why Soil Compaction:

- 1- Increase Soil Strength
- 2- Reduce Soil Settlement
- 3- Reduce Soil Permeability
- 4- Reduce Erosion Damage

- **<u>Types of Compaction</u> :** *(Static or Dynamic)*
- 1- Vibration
- 2- Impact
- 3- Kneading
- 4- Pressure

Consolidation

- When the soil is fully saturate, compression of soil mass occurs mainly due to expulsion of water from void under static load. This process is called consolidation.
- Due to escape of water, the solid particles shift from one position to another by rolling and sliding and thus attain a closer state of packing.
- A study of consolidation is extremely useful for forecasting the time of the settlement of the structure.

Compaction	**Consolidation**
Decrease in volume of soil is due to removal of air from void.	Decrease in volume is due to removal of void.
Load is dynamic.	Load is static
The process of compaction is rapid.	The process of compaction is very slow.
Soil is partially saturated.	Soil is fully saturated.
Applies to cohesive as well as cohesionless soil.	Applies to cohesive soil.
Useful primary in construction of earth dam, etc,	Useful in improving the properties of foundation soil.

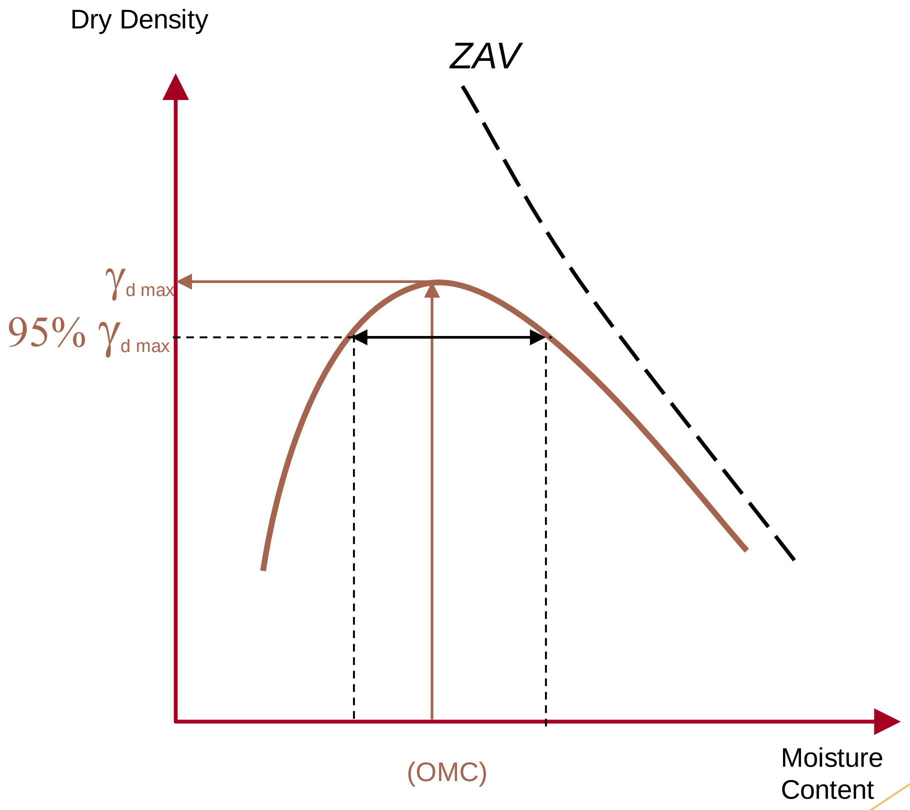
Compaction curve

- In 1933, R. R. proctor showed that there existed a definite relationship between the soil water content and dry density.
- Compaction curve is plotted between the water content as abscissa and dry density as a ordinate.
- It is observed that dry density increases with increase in water content till the maximum density is achieved, with further increase in water content the dry density decreases.

- At low water content, the soil is stiff and has lot of void spaces, and therefore the dry density is low.
- As water content is increased, the soil particle get lubricated and slip over eachother, and move into densely packed positions and dry density is increased.
- However, at a water content more than optimum, additional water reduced the dry density.

Field Soil Compaction

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



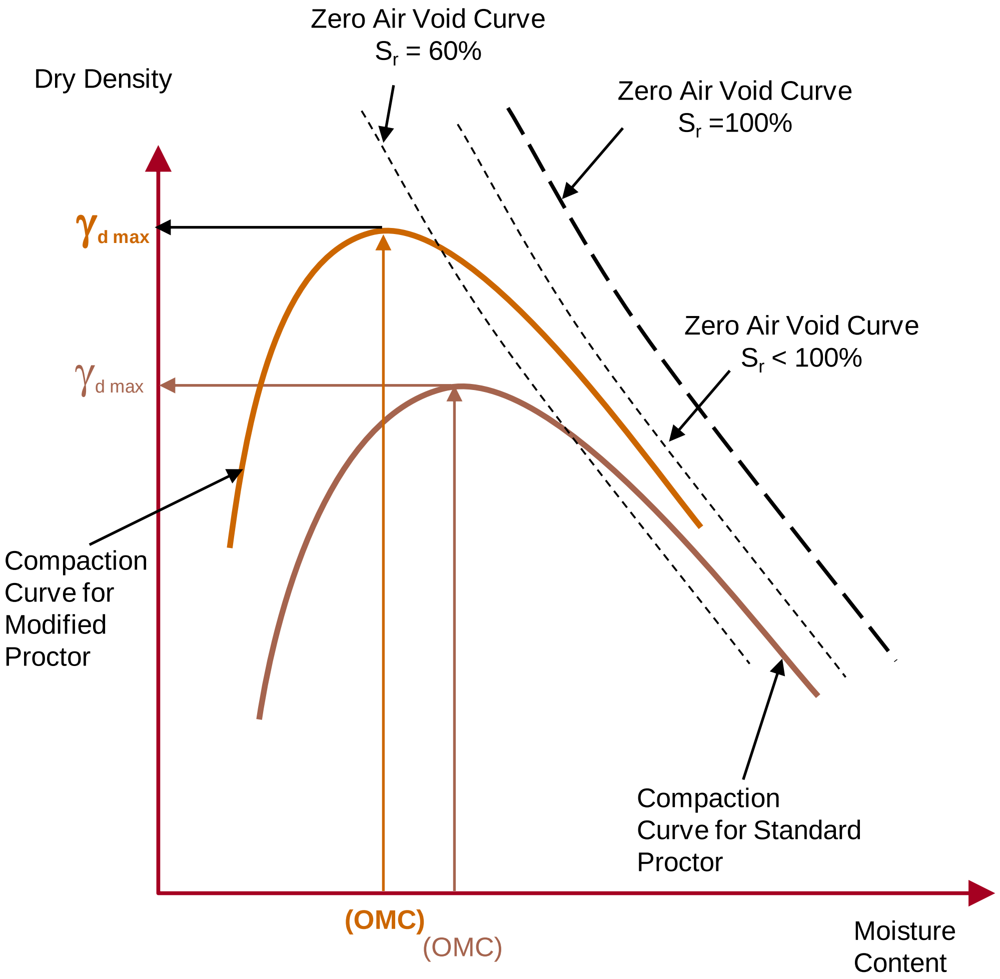
Soil Compaction in the Lab:

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



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

Effects of compaction on soil properties

1. Soil structure

The structure of soil during compaction depends upon,

- Type of soil
- Water content type and amount of compaction
- Water content

- In case of clays, soil compacted at a water content less than optimum water content generally have a flocculated structure.
- Soil compacted at a water content more than optimum water content usually have dispersed structure.

2. Permeability

- The permeability of soil decrease with an increase in water content on the dry side of optimum water content.
- As the dry density increases due to compaction, the void go on reducing and hence the permeability goes on reducing.
- If the compactive effort is increased, the permeability of soil decrease due to increased dry density and better orientation of particles.

3. Shrinkage

- For same density, soil sample compacted dry of optimum shrink less than sample compacted wet of optimum.
- The soil compacted wet of optimum shrink more because the soil particle in dispersed structure have parallel orientation of particles and can pack more efficiently.

4. Swelling

- A clayey soil sample compacted dry of optimum water content has higher water deficiency and more random orientation and hence exert greater swelling pressure.
- Sample compacted wet of optimum has more swelling.

5. Pore water pressure

- A sample compacted dry of optimum has low water content, and develop lower pore water pressure than sample compacted wet of optimum.

6. Compressibility

- The flocculated structure developed on dry side of optimum offers have greater resistance to compression than the dispersed structure on the wet side.

7. Stress strain relationship

- The soil compacted dry of optimum has a steeper stress-strain curve than those on wet side.

8. Shear strength

- The shear strength of compacted clay depend upon, dry density, water content, soil structure, method of compaction, drainage condition, type of soil.

Definitions:

- OMC: The water content at which dry density is maximum is called OMC.
- MDD: The density corresponding to OMC is called MDD.
- Zero air void or saturation line: Maximum density is obtained when there are no air voids. The line showing the dry density as a function of water content for soil containing no air void is called zero air void.

Light compaction test	Heavy compaction test
Mass of rammer is 2.6 kg.	Mass of rammer is 4.89 kg.
Height of free fall is 31cm.	Height of free fall is 45cm.
Dimension of mould: dia: 100mm, ht: 127.3mm, vol: 1000cm3	Dimension of mould: dia: 100mm, ht: 127.3mm, vol: 1000cm3
Soil is compacted in the 3 layers.	Soil is compacted in the 5 layers.
Each soil layer is subjected to 25 blow.	Each soil layer is subjected to 25 blow.
Compactive effort is 592 kJ/ m3	Compactive effort is 2700 kJ/ m3
It is called standard proctor test.	It is called modified proctor test.

Factor affecting compaction

1. Water content

- As the water content is increased, the soil particle gets lubricated, the soil mass becomes more workable and particles have closer packing.
- Dry density of soil increases with increase in water content till optimum content is reached.
- With further increase in water content, the air void do not decrease, but total (air + void) increase and dry density decrease.

2. Amount of compaction

- The effect of increasing the compactive energy result in an increase in MDD and decrease in OMC.

3. Type of soil

- Coarse grained soil can be compacted to higher dry density than fine grained soil.

4. Method of compaction

- Dry density depends upon the method of compaction.
- For The same amount of compactive force, dry density will depend upon the whether method of compaction utilizes kneading action, dynamic action or stationary action.

5. Thickness of layer

- Normally layer of thickness in laboratory is kept 30 to 40mm while in field thickness is 200 to 300mm.

6. Saturation line

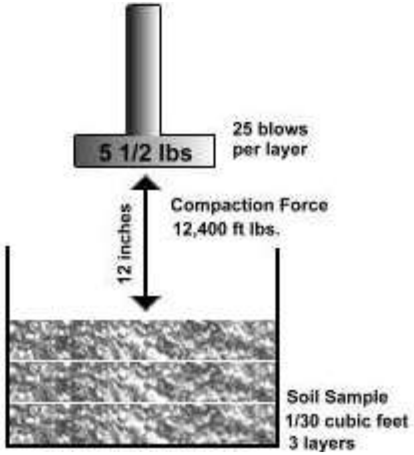
- If all air void removed from soil by compaction, the soil becomes fully saturated and higher MDD is achieved.

7. Admixture

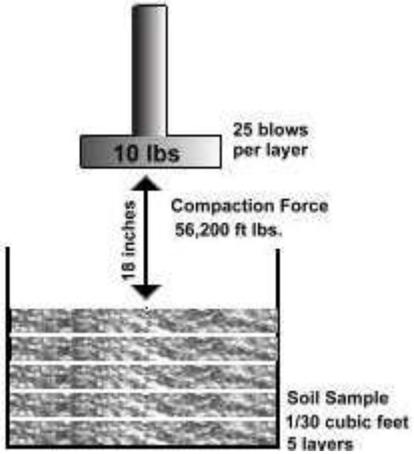
- The most commonly used admixture are lime, cement and bitumen.

Soil Compaction in the Lab:

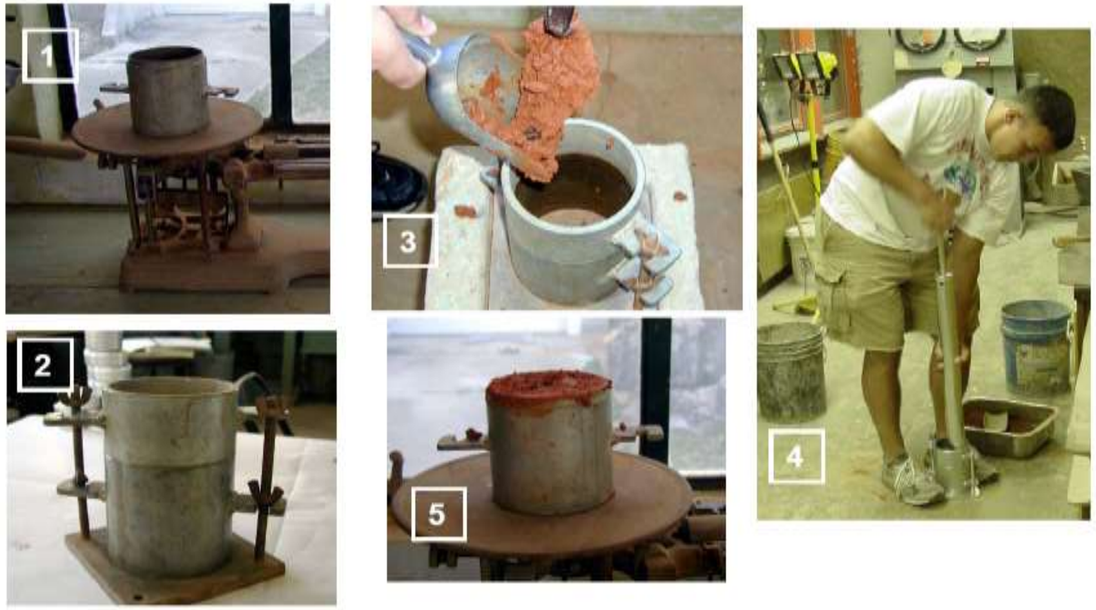
1- Standard Proctor Test
2- Modified Proctor Test



Standard Proctor Test



Modified Proctor Test



Compaction Equipment

- Sheepfoot compactor
- Smooth Drum
- Vibratory
- Rubber Tire
- Jumping Jacks
- Plates
- Trench Compactors

Compaction Equipment

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Field Compaction Operations

- Primary Factors:
  - Equipment
  - Lift Thickness
  - Soil Moisture

Field Compaction Operations

- Heavier equipment is better
- However - heavier must be translated to contact area (intensity of pressure)
- Track equipment - dozers, excavators, are heavy, but don't compact
- Why?

Methods of field compaction

- The various methods of field compaction are:

Rolling

The compaction depends upon the following factor:

- Contact pressure
- Number of passes
- Layer of thickness
- Speed of roller

Ramming

Vibrations

- Different types of roller used are:

Smooth wheel roller

Types of smooth rollers:

- Conventional three wheel type: (weight 2 to 15 ton)
- Tendem rollers: (weight 1 to 14 ton)
- Three axel tendem: (weight 12 to 18 ton)

<u>Pneumatic tyred roller</u>: Vibratory rollers are used to compact all types of soil.

It is suitable for cohesive as well as for cohesionless soil.

Sheep foot roller:

- This roller is consist of a hollow drum with a large numbers of projections on its surface.
- These projections penetrate the soil during the rolling and cause compaction.
- The drum is filled with water or soil to increase its mass.
- This sheep foot roller is ideally suitable for compaction of cohesive soil.

Vibratory roller:

- These roller are available as a both vibratory and smooth wheel type.

FIELD COMPACTION TEST

The field compaction control consist of determination of:

Dry density

- The degree of compaction achieved in the field is measured by relative compaction.

Relative compaction:

δd in the field / δd in the laboratory

Water content:

- Oven drying method
- Calcium carbide method
- Proctor needle