Unit VI – Compaction

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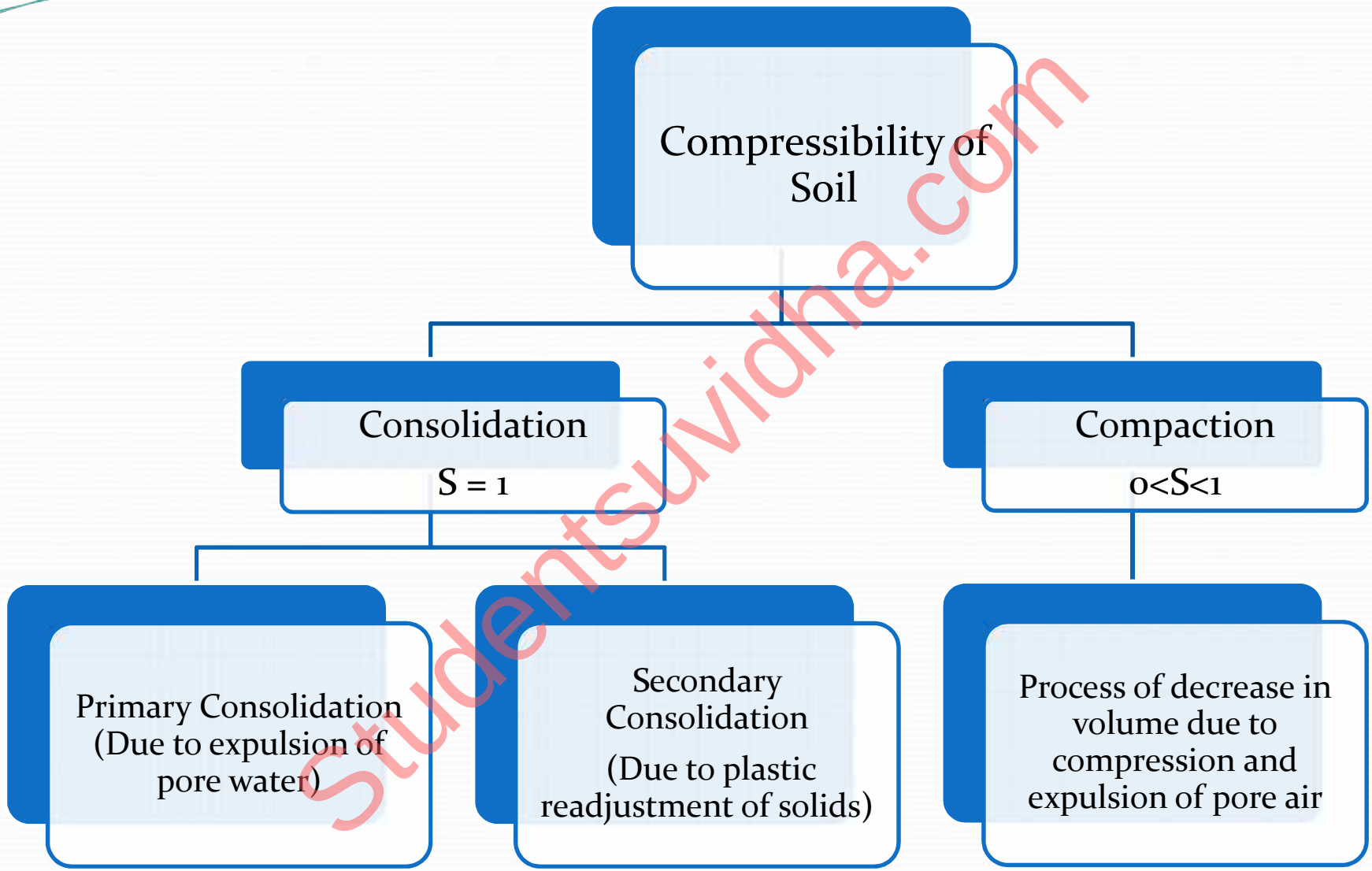
UNIT VI – COMPACTION

Hours – 1 Hour

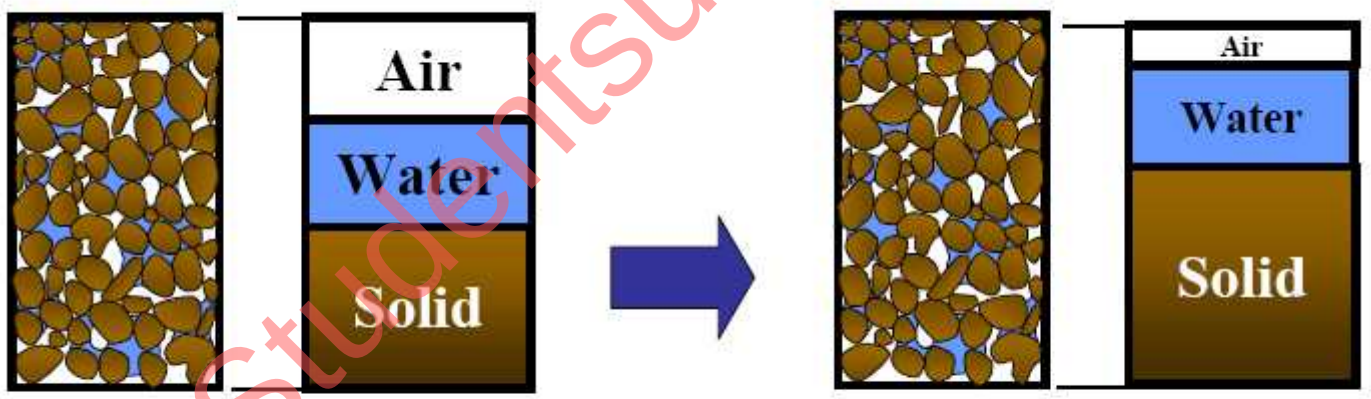
Topics –

- Introduction, role of moisture and compactive effect in compaction,
- laboratory determination of optimum moisture content, moisture density relationship, compaction in field,
- compaction of cohesionless soils, moderately cohesive soils and clays, field control of compaction.



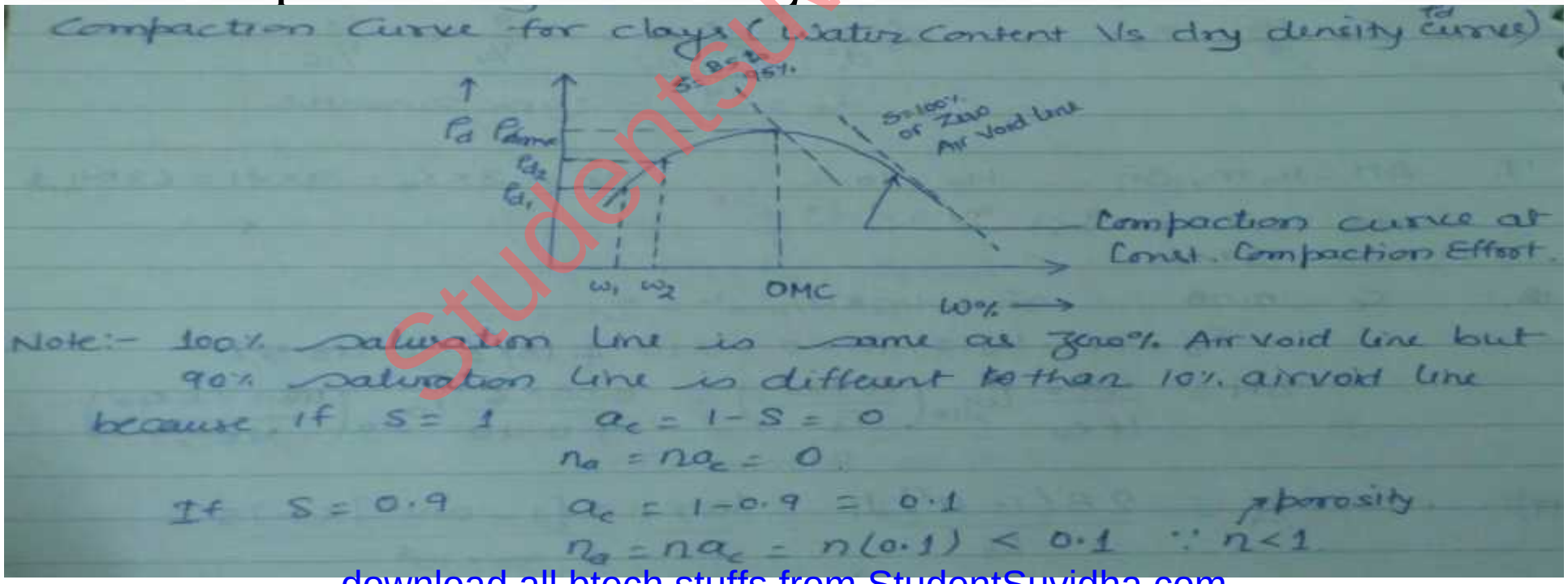
OBJECTIVE FOR COMPACTION

- Increasing the bearing capacity of foundations
- Decreasing the undesirable settlement of structures
- Control undesirable volume change
- Reduction in Hydraulic conductivity



COMPACTION

- Definition –
  - Compaction is the process of decrease in Volume due to compression and expulsion of pore air. It is an instantaneous process which is carried out at partially saturated or dry soils.
- Compaction Curve for Clays

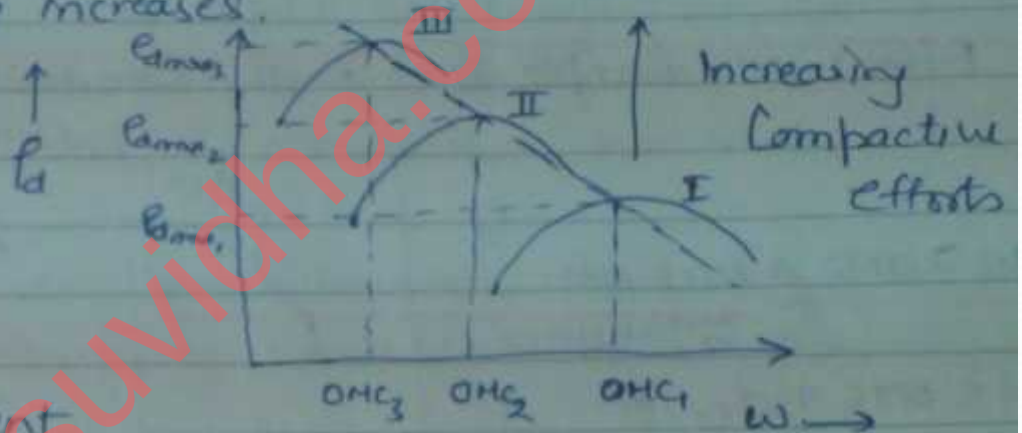


COMPACTION

- In process of compaction of clays, compaction energy is given to the soil due to which pore air is compressed and expelled, with changing water content at equal compaction effort dry density changes.
- Maximum dry density occurs at optimum moisture content (OMC). At this stage, the degree of saturation in the soil will be 85 to 95% because practically it is not possible to remove all the air, as soon as hammer is lifted certain air is entrapped in due to which degree of saturation is less than 100%
- Theoretically maximum dry density will be achieved when all the air is expelled out, it means degree of saturation has reached 100%

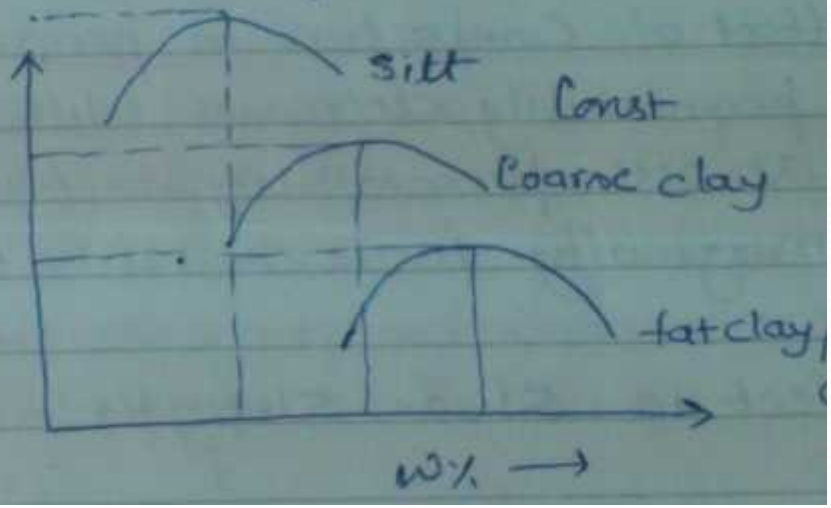
EFFECT OF COMPACTIVE EFFORTS

If Compactive efforts are increased in the same soil, then OMC reduces and dry density increases.



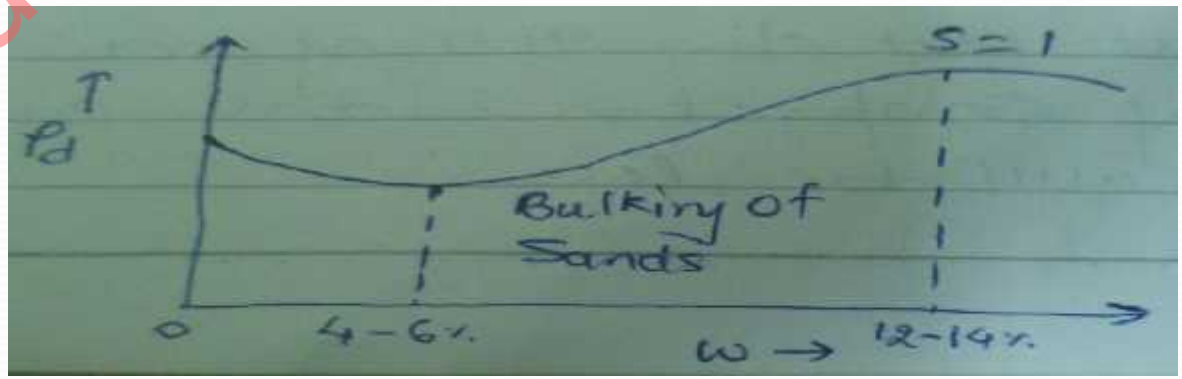
Dry density Vs Water content Curve for various soils at Const Compactive Effort.

Coarser the soil small is the OMC and greater is the dry density ρ_d



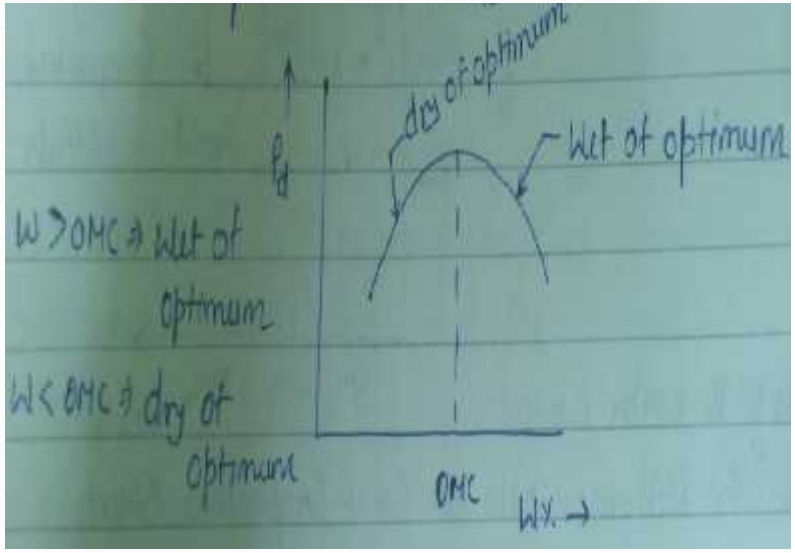
DRY DENSITY AND WATER CONTENT FOR SANDS

- Behavior of sands is different than for clays'.
- The sandy soils are best compactive at full saturation and best method of compaction is vibration
- When water content is 12-14% then degree of saturation in sands is 1, It means flooded sands will be most compacted
- When water content is 4-6% then sands are least compacted, At 4-6% water content, a thin film of water is formed between the solids which has repulsive effect due to which the density achieved is minimum, such an stage is called bulking of sands
- It means it is not a good idea to buy sand at 4-6% water content



EFFECT OF COMPACTION IN THE SOILS

- Effect of compaction in permeability
  - On dry side of OMC permeability decreases with increase in water content and at OMC permeability is minimum. On wet side of OMC permeability marginally increases with increase in water content
- Effect in shear strength
  - The dry compacted soil have more shear strength than the wet compacted soil
- Effect on Swelling
  - If compaction is done at dry side of OMC then swelling will be more & if compaction is done on wet side of OMC then swelling will be less
- Effect on Shrinkage
  - If compaction is done on dry side of OMC then shrinkage will be less on drying the soil. If compaction is done on wet side of OMC then shrinkage will be more on drying the soil



SELECTION OF COMPACTION

- The field compaction of soil is done at a particular Moisture content which may be on dry side or wet side of OMC
- Core of Earth Dam
  - It is compacted on wet side of OMC in order to reduce permeability and to prevent cracking in the core
- Homogeneous Earth Dam
  - It is compacted at water content on dry side of OMC so as to have stronger soil (more shear) and to prevent built up of high pore water pressure
- Subgrade of Pavements or highways
  - These are compacted on wet side of OMC so as to limit swelling pressure and volume change that may occur during mansoon season

RELATIVE COMPACTION

- Relative Compaction
  - Relative compaction is defined as the ratio of dry unit weight at the field to the maximum dry unit weight obtained in the laboratory for same soil
- Problem :- The insitu void ratio of a granular soil deposit is 0.5, the maximum and minimum void ratio obtained for same soil in the lab are 0.75 and 0.35 resp. If specific gravity of solids is 2.67 then find relative density and relative compaction
- Answer – Relative density – 62.5%

  Relative Compaction – 90%

COMPACTION TEST

- Standard Compaction Test/Light compaction Test
  - Volume of Mould 1/30cubic feet (942cc)
  - Weight of hammer 5.5 pounds (2.495kg)
  - Height of free fall 12 inches (304.8mm)
  - Soil is filled in three layers and each layer is compacted by 25 blows of free fall of hammer
- Modified procter Test/ Heavy Compaction Test
  - Volume of mould 1/30 cubic feet
  - Weight of hammer 10 pounds (4.54kg)
  - Height of free fall of hammer 18 inches (457.2mm)
  - No. of layers 5
  - No of blows to each layer 25

COMPACTION TEST

- Indian Standard Light Compaction Test
  - Volume of Mould 1000cc
  - Weight of hammer 2.6kg
  - Height of free fall 310mm
  - Soil is filled in three layers and each layer is compacted by 25 blows of free fall of hammer
- Modified procter Test/ Heavy Compaction Test
  - Volume of mould 1000cc
  - Weight of hammer 4.9kg
  - Height of free fall of hammer 450mm
  - No. of layers 5
  - No of blows to each layer 25

FACTORS AFFECTING COMPACTION

- Water content
  - On dry side of OMC density increases with increase in water content whearas on wet side of OMC density decreases with increase in water content
- Compactive Effort
  - Due to increase in compactive effort, Maximum dry density increase and OMC reduces
- Type of Soil
  - The granular soil have greater dry density at lower OMC. For thick clays (fat clay) dry density is less and OMC is more
- Method of Compaction
  - Sandy soils are best compacted at full saturation due to vibration. In cohesive soils maximum dry density is achieved at 85-90% degree of saturation

QUALITY CHECK OF FIELD COMPACTION

- Quality of field compaction can be checked by test of field density
- Core cutter Method
  - Core cutter is a cylindrical vessel open at top and bottom with sharp edges, the ground is prepared, leveled and core cutter is punched in. The soil filled core cutter is taken out and leveled at top and bottom
  - This method is suitable for moist clays and is not applicable for boulder, gravel and sandy strata
- Sand Replacement method
  - A small hole or pit is made on the ground and weight of excavated soil is taken. The pit is filled by sand and the volume of sand required is measured through a calibrated cone.
  - This method is widely adopted in construction of roads and highways and suitable for gravel, boulder and sandy strata

FIELD TEST

- Water Displacement Method
  - It is suitable for highly sticky, plastic and cohesive soils. A small sample of soil is taken. The soil is coated with thin layer of parafin wax. The weight of wax coated sample is again taken
  - The wax coated sample of soil is immersed in a water filled cylinder which displaces the volume of water
- Procter Needle Method
  - This method is used to determine field density and water content both

METHODS OF FIELD COMPACTION

- Rollars
  - Smooth wheel rollers :- these are suitable for gravels and boulders and are used for construction of roads
  - Pneumatic Tyred Rollers :- These have kneading action which may convert flocculent structure to dispersed structure. These are suitable for cohesive soils but may be also used for silts and sands. These are used for compaction of embankments and sub-base of highways and earthen dams
  - Sheep-foot Rollers :- These are suitable only for cohesive soils and are used for compaction of core of earth dam.
  - Grid Rollers :- Suitable for silts and clays
- Rammers
  - Dropping Weight :- These are used to remove voids. These can be used for all type of soil specially when area is confined
- Vibrators
  - These are suitable for cohesionless soils

PROBLEM

Qus A cohesive soil has maximum dry density of 1.8 gm/cc at an OMC of 16% during the standard proctor test. If the value of specific Gravity for solids is 2.65 what is the degree of saturation. What is the max. theoritical dry density to which soil can be further compacted at same water content.

Ans $\rho_d = 1.8$ gm/cc w% = 16% $\Rightarrow w = 0.16$.

$G = 2.65$

$\rho_d = \frac{G\rho_w}{1+e} \Rightarrow e = \frac{2.65}{1.8} - 1 \Rightarrow e = 0.472$

$Se = wG$

$S \times 0.472 = 0.16 \times 2.65$

$S = 0.898$

$S = 89.8\%$

At max. theoritical ρ_d all the air will be expelled out

$S = 1$

$Se = wG$

$e = \frac{0.16 \times 2.65}{1} = 0.424$

$(\rho_d)_{max} = \frac{G\rho_w}{1+e} = \frac{2.65 \times 1}{1+0.424} = 1.861$ gm/cc