16th Sept,
TUESDAY

12. COMPACTION

- Compaction of soil is due to compression and escape of air.
- It is a quick process.
- under short term loading, moving loads etc

→ Effect of Compaction:

- shear strength increases.
- compressibility decreases
- permeability decreases.

⊙ During compaction, some amount of water is generally added to have a lubrication effect b/w the particles to facilita easy compaction.

→ Compaction Tests:

The purpose of compaction test is :

- to find OMC
- to find compactive energy.

1. IS Light Compaction Test (Std. Proctor's test)
   This test is performed for ordinary roads, earthen dams.

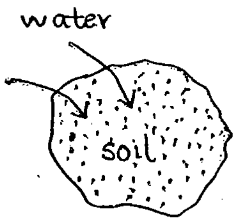
2. IS Heavy Compaction Test (Modified Proctor's test
   This test is performed for expressways, runways e

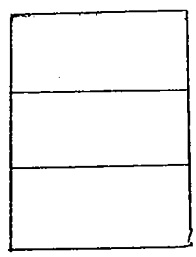
	Wt. of Rammer	Ht. of fall	No. of blow per each layer	No. of Layers
Heavy test	4.90 kg	45 cm	25	5
Light test	2.60 kg	31 cm	25	3

- Total energy ratio $= \dfrac{4.90 \times 45 \times 25 \times 5}{2.60 \times 31 \times 25 \times 3} = \underline{\underline{4.55}}$

- Mould Capacity = 1 L generally or 2.25 L.
  (if soil has % retc
  on 4.75 mm > 20%)

For 1 L mould → 25 blows per each layer
For 2.25 L mould → 56 blow per each layer
} for both tests.

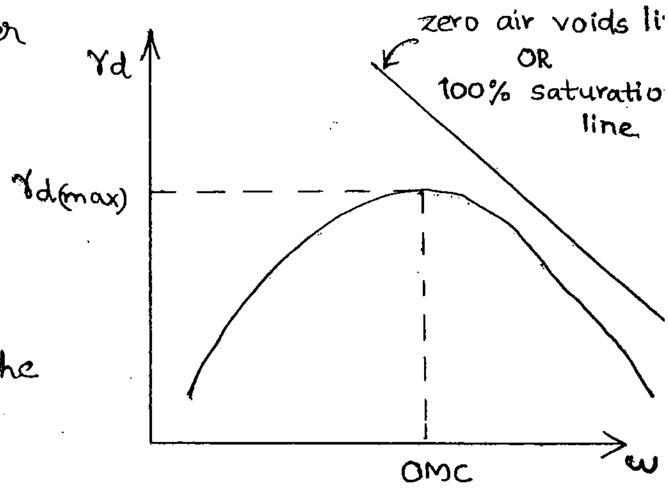




Mould.

W = wt. of soil
V = vol. of soil.
$\gamma = \frac{W}{V}$
ω → obtained by over drying.
$\gamma_d = \frac{\gamma}{1+\omega}$

The test is repeated for diff water contents and γ_d is obtained in each case. A graph is plotted b/w γ_d & ω.



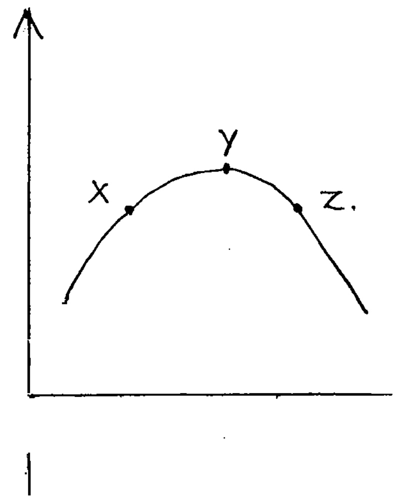
compaction curve

OMC:— Optimum Moisture Content is the water content at which max. dry density is obtained.

$\gamma_d = \dfrac{(1-n_a)G\gamma_w}{1+\omega G}$; n_a = % air voids → Equation of Compaction cur

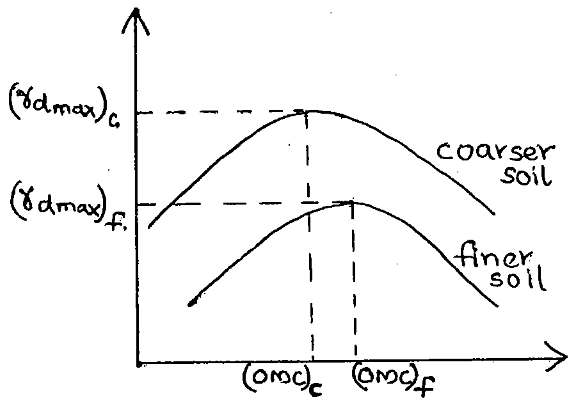
$(\gamma_{dmax})_{theo.} = \dfrac{G\gamma_w}{1+\omega G}$ → Equation of Zero Air Voids line

- Zero air voids line is used to compare and understand the level of compaction.



- K at Y is least (as least no. of voids due to optimum compaction)
- K at Z is relatively less than K at X.

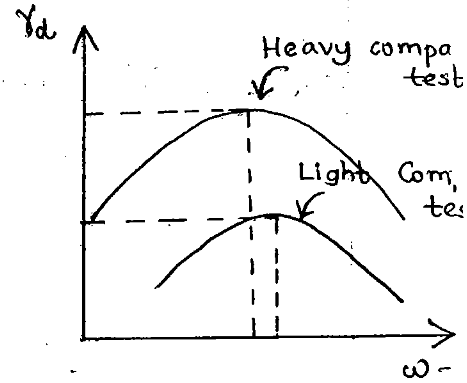
* Same Test but Soils are Different



Finer soil has relatively more OMC and less $(\gamma_d)_{max}$ compared to coarser soil.

Finer soils have more surface area and hence more OMC. Also, $\gamma_d = \frac{G\gamma_w}{1+e}$ $\Rightarrow$ finer soils having larger void ratio (e) will be having lesser $(\gamma_d)_{max}$.

* Same soil but tests are Different.



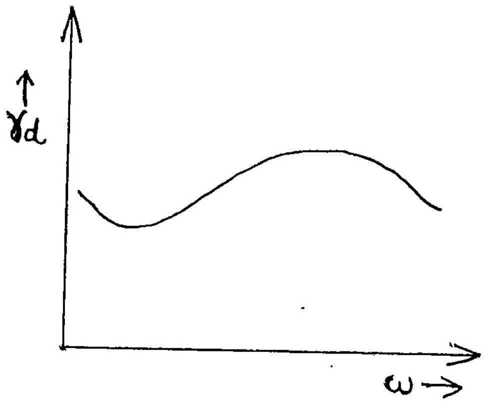
As the compactive energy increases, γ_{dmax} increases but OMC decreases.

→ Factors affecting Compaction:

- water content (w.c)
- compactive energy
- type of soil.

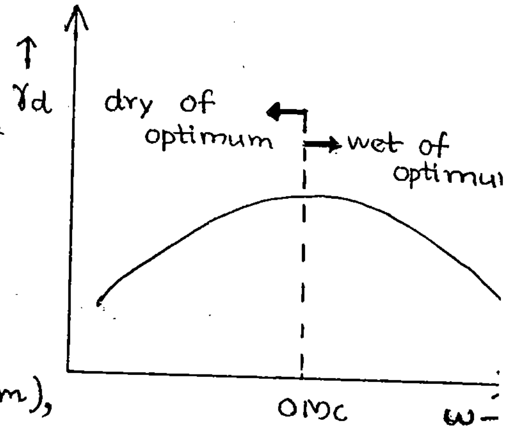
In the case of pure sand without fines, there is no well defined OMC and the curve is shown below.

∴ For the above soil, the compaction curve is not useful.



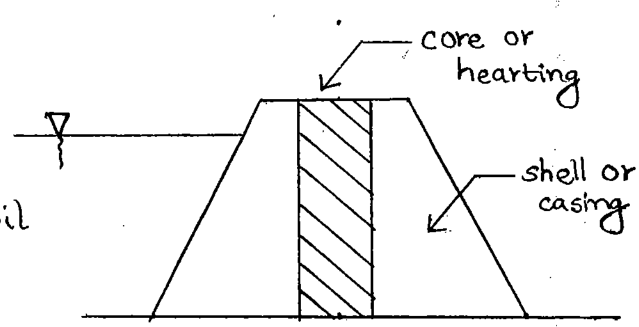
Relative density (or density index) is used to indicate the level of compaction achieved.

Dry of Optimum	Wet of Optimum
- Flocculent struct.	- dispersed struct.
- more shear strength	- less shear strength
- more swelling type	- less swelling type.



- To avoid swelling of soil (below the floors, pavements, core of earthen dam), soil is compacted wet of optimum.
- To have more strength (road embankments & casing of earthen dams), the soil is compacted dry of optimum.
- Placement water content :- w/c actually used at site

→ Earthen Dam:



* Core :-
  - to check seepage
  - made up of impermeable soil (clay)
  - wet of optimum
* Shell :-
  - to provide stability
  - made up of soil other than clay.
  - dry of optimum.

→ Compaction Equipment :

- Tampers → manual compaction (for inaccessible areas: trenches, behind retain walls
- Smooth wheel roller → to have smooth surface.
- Pneumatic Tyred roller → for all soils
- Sheep foot roller. → best suitable for clays
- vibratory roller → best suitable for sands

Kneading action : best for compaction of clay.

Vibratory : best for compaction of sand.

→ Relative Compaction

$$\text{Relative compaction} = \frac{\gamma_d \text{ of field}}{\gamma_{d\,max} \text{ in lab}} \times 100$$

Generally 90-95% is acceptable.

→ Proctor's Needle

To measure in-situ w.c and γ_d (approximate)

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01. $\gamma_d = 1.8$ g/cc ; $w = 16\%$; $G = 2.65$

$$\gamma_d = \frac{\gamma_w G}{1+e}$$

$$1.8 = \frac{2.65}{1+e} \Rightarrow e = 0.472$$

$$e = \frac{wG}{S_r} \Rightarrow 0.472 = \frac{0.16 \times 2.65}{S_r}$$

$$\therefore S_r = \underline{\underline{89.7\%}}$$

$$a_c + S_r = 100\%$$

$$\therefore a_c = \underline{\underline{10.3\%}}$$

$$n_a = n a_c$$

$$= \frac{e}{1+e} \cdot 10.3 = \underline{\underline{3.27\%}}$$

$(\gamma_{d max})_{theo.} = \frac{G\gamma_w}{1+wG} = \underline{\underline{1.86\ g/cc}}$

2. Vol. of soil = volume of cutter

$= \frac{\pi}{4} d^2 h =$

wt. of soil $= 30.10 - 10.8 = 19.30$ N.

$= 0.0193$ KN

$\gamma_d = \frac{\gamma}{1+w} = \frac{W/V}{1+w} = \frac{13.65}{1+0.122}$

$= 12.16$ kN/m³.

$\gamma_d = \frac{G\gamma_w}{1+e}$

$12.16 = \frac{2.65 \times 9.81}{1+e} \Rightarrow e = \underline{\underline{1.136}}$

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- 100% (S_r) saturation line & 0% (n_a) air voids line are same.
- 95% (S_r) saturation line & 5% (n_a) air voids line are different.

$\underline{\underline{S_r + a_c = 100\%}}$