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CHAPTER: COMPACTION OF SOIL

COMPACTION:

It is the process of bringing soil particles closer to a dense state by mechanical means, thus it is densification of soil by removal of air from the voids. The mechanical means may include rolling, ramming, vibration etc.

ADVANTAGES: (OBJECTIVES):

The main objective of compaction is the improvement of engineering properties of soil which are listed below.

i) To increase shear strain:.
ii) It provides high shear strength for bearing capacity for foundation, higher CBR (California bearing Ratio) for pavements and greater stability against land sliding natural or man made.
2) To lower compressibility and hence smaller settlement of building structures and lesser deformation of earth structure.
3) To lower permeability. It reduces the H_2O absorption and the

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resulting loss of strength. It also reduces water percolation and hence reduces seepage qualities.

4) To lower the frost for susciptibility and hence reduces the risk of frost heave (Rise)

5) To reduce the degree of shrinkage It reduces the possibility of formation of tension cracks.

COMPACTION EFFORT / COMPACTION ENERGY:

Compaction is done when some energy is apply to soil by some mechanical means. The energy applied for unit volume of the soil is called compaction effort and compaction energy.

In the field the compaction energy is imparted / given by rollers and depends upon different parameters of the rollers such as tyre pressure of the rollers, No of pressure etc.

In the lab test compaction energy is imparted to the soil by dropping hammer from certain height. For lab test the compaction energy can be calculated as follows.

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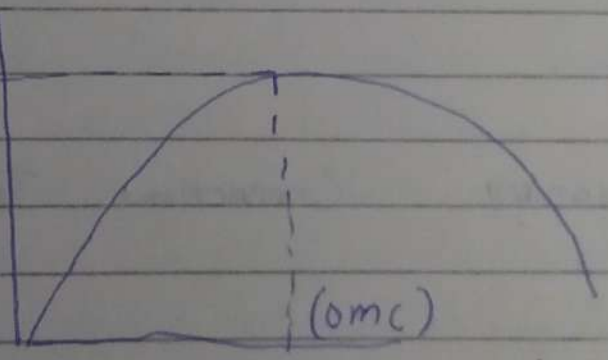
Compaction energy = Number of blows per layer x No of layers x weight of Rammer x Height of drop of Rammer / Volume of mould.

MOISTURE CONTENT - DENSITY RELATION:

For given soil type and compaction energy, the dry density (weight density) first increases with increase in the moisture content reaching to a maximum value at certain moisture content and then decreases with further increase in the moisture content. This is shown in figure.

w	γ_d
2%	γ_{d_1}
4%	γ_{d_2}
8%	γ_{d_3}



The moisture content at which γ_d becomes maximum is called optimum moisture content (omc). The explanation for above moisture content, density relation is that when water is added to the soil during

Compaction, it acts as lubricant causing soil particles to soften and more workable. Due to the film of water surrounding the soil particles, they slide over one another more easily and move into and densily packed position, thus giving high dry density and low air content. When water content is increased beyond omc then the thickness of water film around a particles increases to such an extent that it tends to keep the soil particles apart from one another and thus dry density decreases. This is because the water takes up the space that would have been otherwise occupied by soil particles.

LABORATORY COMPACTION TESTS METHOD:.

In laboratory test soil is compacted in a mould of specific dimensions in several layers by means of hammer of given weight falling from certain known height. The two most common only used labs compaction test are

1) Standard Proctor test:.

In this test soil

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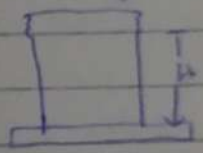
is compacted in a mould having internal diameter of 4 inches and internal height of 4.6" and volume is equal to $\frac{1}{30}$ ft^3.

$$V = \frac{\pi}{4} D^2 \times H$$

During the test the mould is attached to the detachable based plate at the bottom and to a collar (2" height at the top). The soil is mixed initially with some quantity of water and then compacted in the mould for three layers equally. Each layer is given 25 blows of hammer of 5.5 lb in weight and falling freely, from height of 12". Atleast five samples at different moisture content are compacted in the mould. For each sample the bulk density "γ" and dry density "γd" are determined are as follow.



$$\gamma = \frac{W}{V}$$

W = weight of soil in the mould.
V = volume of soil.

For each sample the moisture content is determined by oven drying.

$$w = \frac{W_w - W_d}{W_d}$$

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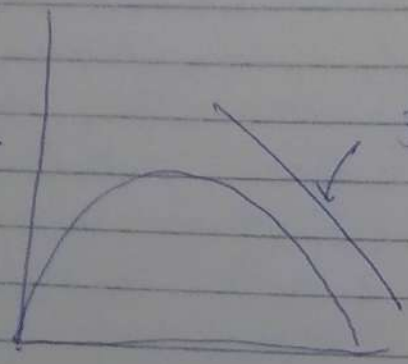
for each sample find $\gamma_d = \frac{\gamma}{1+w}$

⇒ Curve is plotted between m.c and γ_d as shown in figure



⇒ OMC and maximum γ_d are obtained from the compaction curve.
⇒ The compaction energy applied in this test is about 18375 lb ≈ 12400 lb/ft or 600 kN-m

MODIFIED PROCTOR TEST:

This test was developed to obtain higher dry densities. In this test, soil is compacted in the same mould of $\frac{1}{30}$ ft^3 capacity (v) as in standard proctor test. However the soil is compacted in five layers by hammer that has weight of 10 pounds and falling freely from height of 18".

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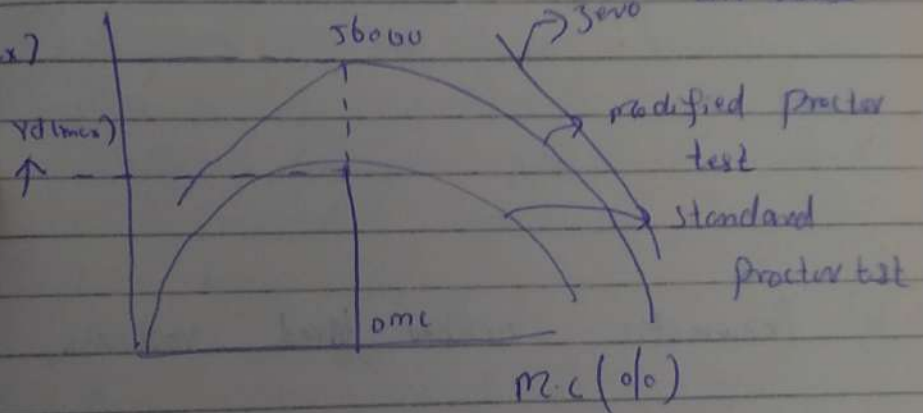
The no of blows given to each layer is kept at 25 as in case of S.Proctor test. The compaction energy for this test is about 56000 lb/ft³ or 2700 kN-m/m³. γ, γd and Moisture content are for different samples are determined in the same way as in standard Proctor test. Compaction curve is plotted between γd and w to find omc and γd (max).



FIELD COMPACTION METHOD / FIELD COMPACTION EQUIPMENTS

In the field, soil can be compacted by any one of the following three method.

1) COMPACTION ROLLING:

In this method rollers are used as a compaction equipment. The most commonly used rollers are
i) Smoth wheel rollers (smoth drum rollers)
There are several types of this

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rollers but most common type of consist of three wheels. Two large smooth face steel wheels in the rear and one smaller smooth faced drum in the front, having a weight of 20 to 150 KN. These rollers are used are for compacting all type of soil except when large boulders are present. It provides 100 % coverage under the wheel and the ground contact pressure as high as 45-55 Psi. They are not suitable for producing higher densities when used on thicker layer.

b) Pneumatic rubber tyred rollers:

In these rollers, the tyres are closely spaced and mounted (Fixed) on serval axles, commonly two axles. The rear wheels overlap the lines of the front wheels to ensure complete coverage of the soil surface. The tyres are sometime misaligned vertically (wobbly wheel) to provide a kneading action on the soil. In these rollers compaction is done both by combination of pressure and kneeding action. These rollers can be used

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for compaction of both sandy and clay soil. The contact pressure under tyres can range from 85-100 psi. These rollers are better in many respect from the smoth wheeled rollers.

c) Sheep foot rollers:-

These rollers consists hollow drums with large number of feet projecting outward from their surfaces. The drums can be filled with water or sand. The feet usually ranges from 200-350mm in length and area of projection of feet may range from 35-85 cm². These rollers are most effective in compacting clay soil. The contact pressure under the projection ranges from 200-1000 psi. Due to penetration of feet in the soil excellent bonding is produced between the successive soil layers.

d) VIBRATORY ROLLERS:-

Vibratory rollers are very effective in compacting granular soil. Power driven vibrations mechanism (vibrators) can be attached to smoth wheeled rollers, Pneumatic rubber tyre

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rollers and sheep's feet rollers to provide vibratory effect to the soil

2e) Compaction by Ramming:-

This method is used for limited area. In this method manually control Power rammers are used for the compaction of small areas where access is difficult or where the use of larger equipment would not be justified. These are extensively used for the compaction of back fill trenches.

3) Compaction By Vibration:-

This method is also used for limited area where rollers cannot be used. In this method vibrating plates are used. Vibrating plates consist of steel plates with upturned edges on which vibrators are mounted. Vibrating plates are commonly used for effective compaction of granular soils. even limited area The vibrating units propels itself slowly over the surface of soil under manual guidence.

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FACTORS EFFECTING COMPACTION:.

Various factors which effects compaction.

i) WATER CONTENT:.

For other factors being same, the compacting density increases with increase in water content, reaching to a maximum value at OMC and then decreases with further increase in water content. Therefore for the given compaction method, the water content of the soil should be ~~kept~~ as ~~near~~ ~~flows~~ close as possible to OMC.

2) AMOUNT OF COMPACTION (Compaction energy):.

The amount of compaction greatly effect the compaction. For the other factors being constant, increase ~~this~~ in compaction energy results in an increase in maximum dry density and decreasing in OMC.

3) Thickness of lift (Layer) and speed of equipment:.

The compaction increases with decrease in the thickness of lift. The speed of equipment also effect the compaction. For efficient compaction, generally

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the rolling speed for soil compaction is 5 km/hr.

4) TYPE OF SOIL:-

The type of soil also effect compaction. For given compaction energy, well graded soil attain a much higher density and lower optimum moisture content than poorly graded soil and fine grained soil.

5) METHOD OF COMPACTION:-

The dry density obtained by compaction depends to some extent on the method of compaction. For same amount of compaction energy, the dry density will be different for different method of compaction.

6) USE OF ADMIXTURE:-

The dry density achieved by given compaction depends upon the amount and type of admixtures (such as lime, bitumen, cement etc). added to soil.