1.6 SOIL COMPACTION:

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

Three are two methods of compaction.

* Laboratory methods – It includes the following
    1) Standard proctor test
    2) Modified proctor test
    3) Harvard miniature compaction test
    4) Abbot compaction test
    5) Jodhpur – mini compactor test
* Field methods – It induces the following
    1) Tampers
    2) Rollers
    3) Vibratory compactors

Table 1.4 Difference between compaction and consolidation

Compaction	Consolidation
It is a rapid process of reduction of volume by mechanical means such as rolling, tamping and vibration.	It is a gradual process of reduction of volume under sustained, static loader.
The volume of a partially saturated soil decreases because of expulsion of air from the voids of the unaltered water content.	It eases a reduction in volume of a saturated soil due to squeezing out of water from the soil.

In both the process, cause a reduction in the volume of soil mass takes place.

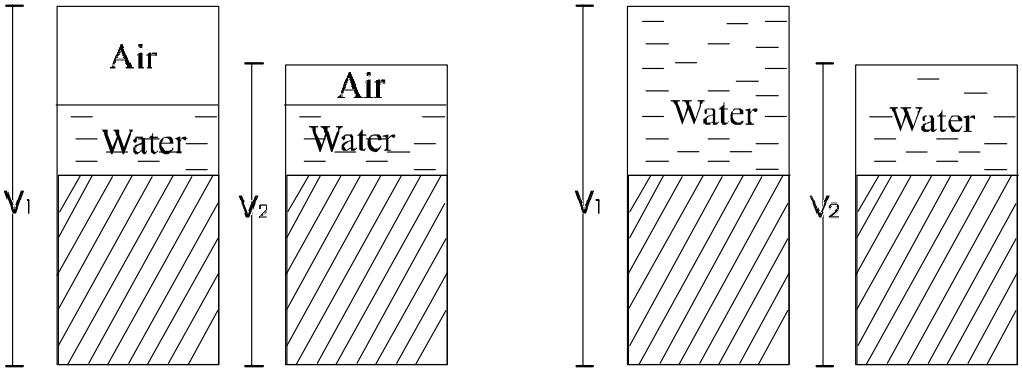


Fig 1.9 volume reduction

1.6.1.1 STANDARD PROCTOR TEST: (IS 2720 Part –VIII)

Equipment Required

(i) Cylindrical mould (metal) of capacity 100ml with an internal diameter of 100mm and internal effective height of 127.3mm mould fixed with a detectable base of removable collar of 60mm height .

(ii) Metal rammer 50mmdia, 2.6kg mass with a free fall of 310mm.

(iii) Mixing equipments, balances, sieves etc.,

Procedure:

1.) About 3kg of air-dried soil passing 4.75mm sieve is taken. Water is added to the soil to bring its water content to about 4% for coarse grained and 8% for fine grained.

2.) The proctor mould is cleaned, dried and greased lightly. The mass of the empty mould with the base plate, but without collar is taken.

3.) The collar is then fitted to the mould. The mould is placed on a solid base and filled with the soil sample to about 1/3 of its height. The soil is compacted by 25 blows of the rammer, with a free fall of 310mm. The blows are evenly distributed.

4.) The soil surface is scratched before the second layer. The mould is filled to about 2/3 height with the soil and compacted again by 25 blows

5.) Likewise, the third layer is placed and compacted. It should project above the top of the mould in to the collar by not more than 6mm.

6.) The collar is rotated to break the bond between the soil and collar. The collar is then removed, and the soil is trimmed off flush with the top of the mould.

7.) The mass of the mould, base plate and compacted soil is taken, and thus the mass of the compacted soil is determined. Calculate the volume of the mould and bulk density of the soil.

8.) Eject out the soil from the mould, cut it in the middle and keep a representative soil specimen for water content determination.

9.) Repeat the process for about five or six times by increasing the water content by 2% for each times.

Bulk density $\rho = \frac{M}{V}$g/cc

Dry density $\rho_d = \frac{\rho}{1+w} g/cc$

w – water content

M_1 – mass of empty mould with base

M_2 – mass of mould + base compacted soil

M – mass of the compacted soil

V – volume of the mould.

Compaction curve:

A compaction curve is plotted between the w/c as abscissa and the corresponding dry densityas ordinate (see fig).

Note: It is observed that the dry density initially increases with an increase in w/c till the maximumdensity (ρ_d max) is affined. With further increase in w/c ρ_d decreases.

The water content corresponding to maximum dry density is know as optimum water content(OWC) (or) optimum moisture content (OMC).

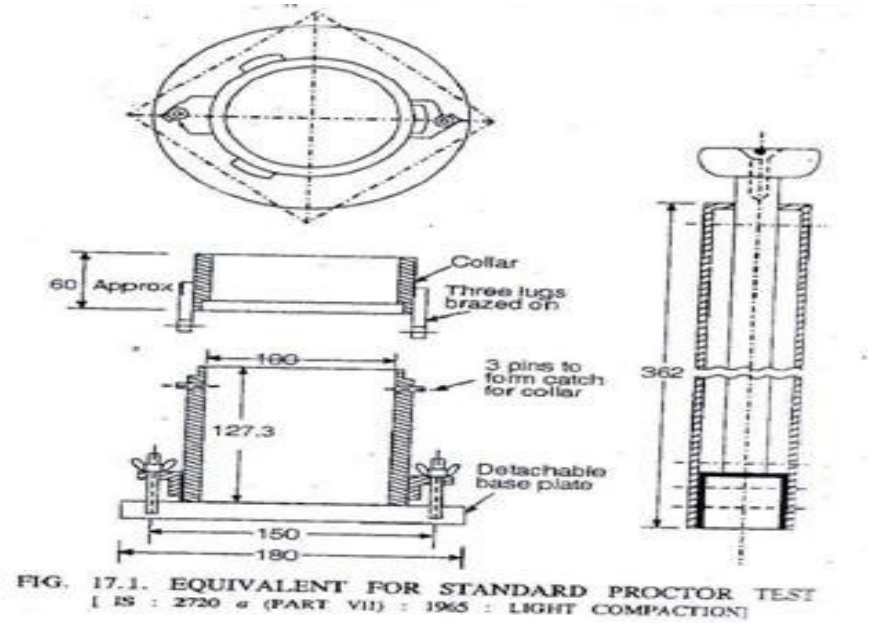


FIG. 17.1. EQUIVALENT FOR STANDARD PROCTOR TEST
[IS : 2720 a (PART VII) : 1965 : LIGHT COMPACTION]

Fig 1.10 Standard Proctor Test

$$\gamma_{ZAV} = \frac{G_s \gamma_w}{1 + \frac{W_c G_s}{S_r}}$$

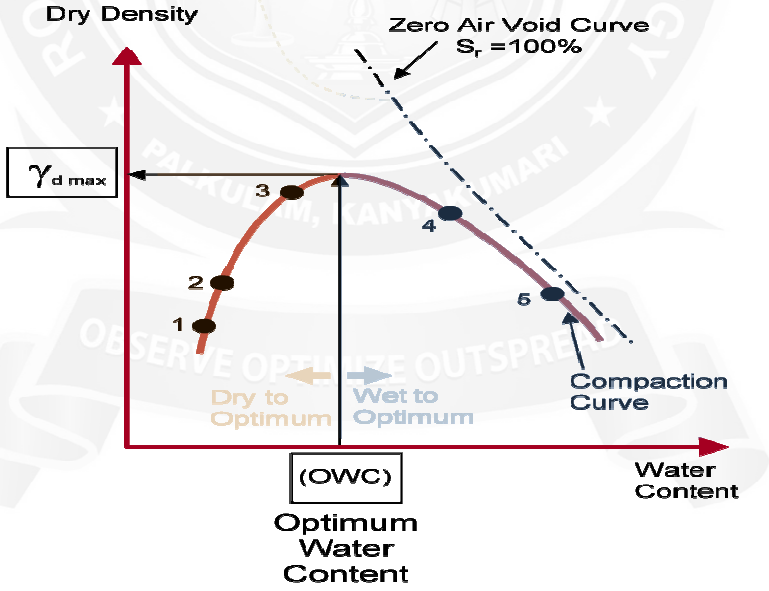


Fig1.11 Optimum water content

AIRVOIDS LINE:

A line which Shows the w/c and dry density relation for the compacted soil containing a content percentage are voids known as Air – voids line and can be established from

$$\rho_d = \frac{(1 - n_a)G\rho_w}{(1 + wG)}$$

1.6.1.2 MODIFIED PROCTOR TEST:

It was developed to simulate the field conditions where heavy rollers are used. The test was standardized by the American Association of State Highway Officials and it therefore, also known as modified AASHO - test. IS – 2720 (Part –VIII) given the specification for heavy compaction bared on this test.

Equipment :

Mould – same as SPT

Man of hammer – 4.89kg. free fall – 450mm

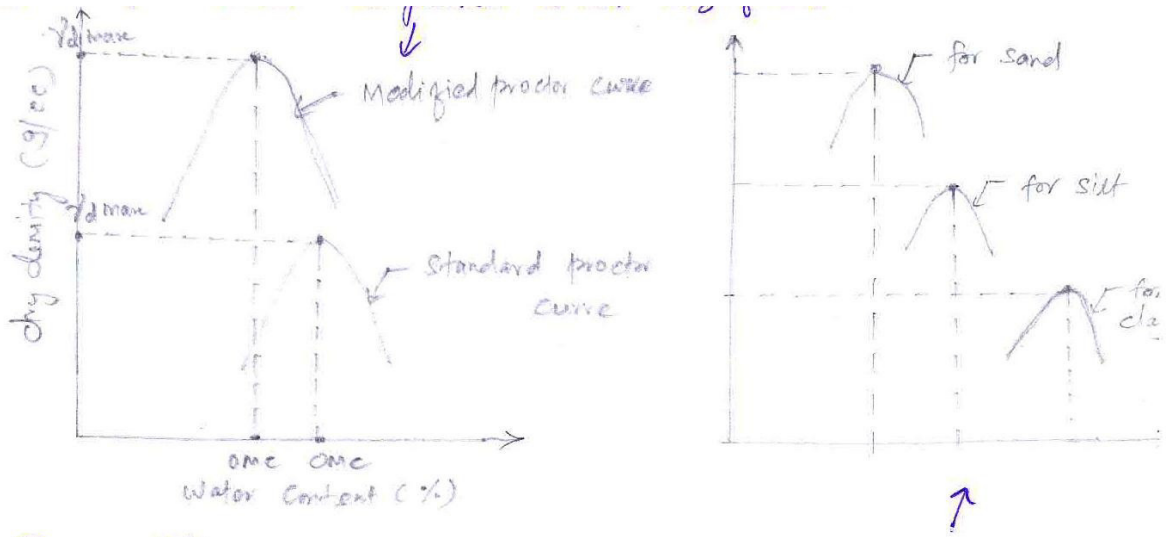
Compaction - 5 equal layers and 25 no. of blows for each. Effort – 4.56 times more than SPT.

Procedure – same as SPT.

In curve – Heavier compaction increases the maximum dry density but decreases the optimummoisture content (one)

FACTORS AFFECTING THE COMPACTION:

1) Water content: When the water content is increases the compacted density goes an increasing till the maximum dry density is achieved after which further addition of water decreases the density. The increase in water content results in an reduction in the net affricative forces blow particles and hence higher density After the optimum water content is reached the air voids approach approximated a constant value as further increase in water contents does not cause any appreciable decrease in them the total voids due to water and air combination goes on increasing with increate of water content, beyond the optional, and hence the dry density of the soils falls.



2) Amount of compaction: The effect of increasing the amount of comp active effort is to increase the maximum dry density and to decrease the OMC (see fig.) At a water content less than the optimum, the effect of increased compaction is more predominant. At a water content more than the optimum, the volume of air becomes almost and the effect of increased compaction is not significant.

3) Type of soil:

The dry density achieved depends upon the type of soil in general, carves – grained soils can be compacted to high air voids. These soils attain a relatively lower maximum dry density as compared with cohesion laws soils. Such soils regret more water for lubrication than cohesion less soils and therefore the optimum water content is high (refer fig, above)

4) Method of compaction:

The dry density achieved depends upon not only the amount of compactive effort bolt also on the method of compaction. For the same amount of comp active effort, the dry density will depends upon whether the method of compaction utilizes kneading action, dynamic action (or) static action.

5) Addition of Admixtures:

The compaction characteristics of the soils are improver by adding other materials, known as admixtures the most commonly used admixture are lance, cement and bitumen. The dry density achieved defends upon the type and amount of

admixtures. For example, addition of lime, cement and solid waste will improves the compaction characteristics (ρ_d max &OMC) of expansive solids.

1.6.1.3 FIELD COMPACTION METHODS AND MONITORING:

Several methods are used for compaction of soil in the field the choice of the method will depends upon the soil type, the maximum dry density required, and economic consideration. The following are more commonly used conventional method.

1) Tampers:

A hand – operated tamper (or rammer) consists of a block of iron (or stone) about 3 to 5kg in mass, attached to a wooden rod. The tamper is lifted for about 0.3m and dropped on the soil to be compacted . A mechanical rammer is operated by compressed air (or) gasoline power.

They are used to compact soils adjacent to existing structures where other methods of compaction cannot be used they are not economical where large quantities of soils are involved Itcan be used for all types of soils.

2) Rollers:

Rollers of different type are used for compaction of soils the compaction depends upon the factors such as.

* Contact pressure – It increases, the compaction also increases
* Number of passes – for economy consideration, restricted blow 5 to 15
* Layer thickness – compaction increases the compaction.
* Speed of roller – compunction depends on it of the layer.

Types of Rollers:

a) Smooth – Wheel Rollers:

It generally crests of three wheels, Another type, consists of only two drums, one in the rear and one in the front, the mass of a smooth – wheel rollers generally varies blow 2 to 15mg

They are useful for finished operations after compaction of fills and for compaction granular back courses of highways.

There are not effective for compaction of deep layers of soils, as the results compaction pressure induced are low.

b) Pneumatic tyred rollers :

This type of rollers generally consists of 9 to 11 wheel fixed on two axles, with the pneumatic tires so speed that a complete coverage is obtained. With each pass of the rollers the gross mass of the roller varies between 5 to 200mg compressed air is used for operation.

These rollers are effective for compacting cohesive as well as cohesion soils light rollers are effective for soil layers of small thickness up to 15cm, where as heavy rollers are useful for layers of thickness up to 30cm.

C) Sheep – foot rollers:

In ancient time before the advent of the rollers, it was useful proactive to pass a flock a shape on the newly formed soil fill to cause its compaction. The same principle is used for the design of shape – foot rollers.

The sheep foot rollers consists of a hollow drum with a lave number of small projections on its surface the projections penetrate the soil layers during the rolling operation and cause compaction.

The drums are mounded on a steed frame the .drum eon be filled with water or ballast to increase the mass the contact pressure is generally between food to 4200 kN/m^2 the roller may since in to the soil if the contact pressure is more than the bearing capacity of the soil It is ideally suited for cohesive soils the depth of layer that can be compacted depends upon the length of the projection andweight of the roller.

d) Vibratory compactors:

In vibratory compactors, vibrations are induced in the soil during impaction the compactors, if the vibrator is mounted on a drum it is called a vibrators roller. It is available in a variety of forms.

Smooth – wheel type roller – compacting sandy soil unto 1m thickness Pneumatic – typed compactor – compacting sandy soil upon 30cm thickness Vibrating Plate – there are number of small plates Each plate is operated by a separate Vibrating unit Hand operated Vibrating placates are also available.

SUITABILITY OF ROLLERS:

For cohesive soils – sheep fort rollers

Cohesion less soils – smooth wheel rollers

For both soils – pneumatic tyred rollers.

1.6.2 DIFFERENT FIELD COMPATION METHODS:

Based on the principles of vibration, the compaction methods are clarified as,

* TERRAPROSE METHOD
* VIBROFLOTATION
* COMPACTION PILES
* COMPACTION BY EXPLOSIVES