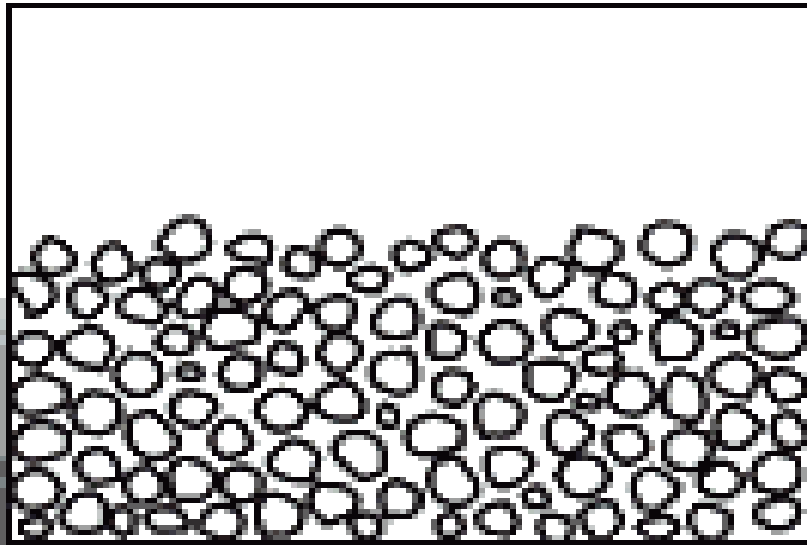


9. COMPACTION OF SOILS

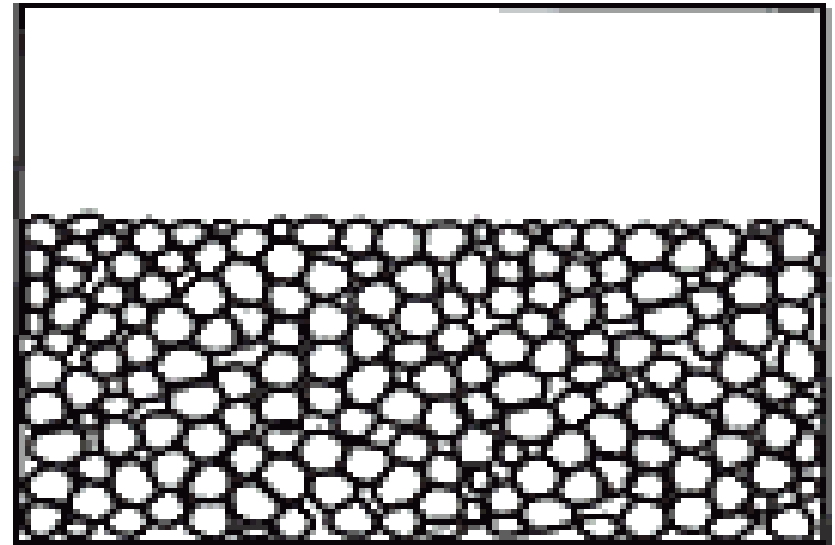


- **Compaction of a soil may be defined as the process of closely packing the soil particles together by reducing the air voids in the soils, by mechanical means.**
- **Compaction of a soil can be achieved by repetitive application of loads. Loads can be applied statically, dynamically, or through**

Soil Density



Loose Soil
(poor load support)



Compacted Soil
(improved load support)

- **The Primary objective of compaction is to improve the engineering properties of the material in any or all of the following ways:**
 - **by increasing the shear strength and thereby improving the stability of embankments and the bearing capacity of foundation and pavement.**
 - **by decreasing the compressibility and thereby reducing settlement.**
 - **by decreasing the void ratio and thereby reducing permeability**

Compaction of a soil is measured in terms of dry density.

$$\gamma_d = \frac{\gamma_t}{1 + \omega}$$

$$= \frac{G_s \gamma_w (1 + \omega)}{1 + e}$$

The moisture content of the soil which gives the maximum dry density is the Optimum moisture content.

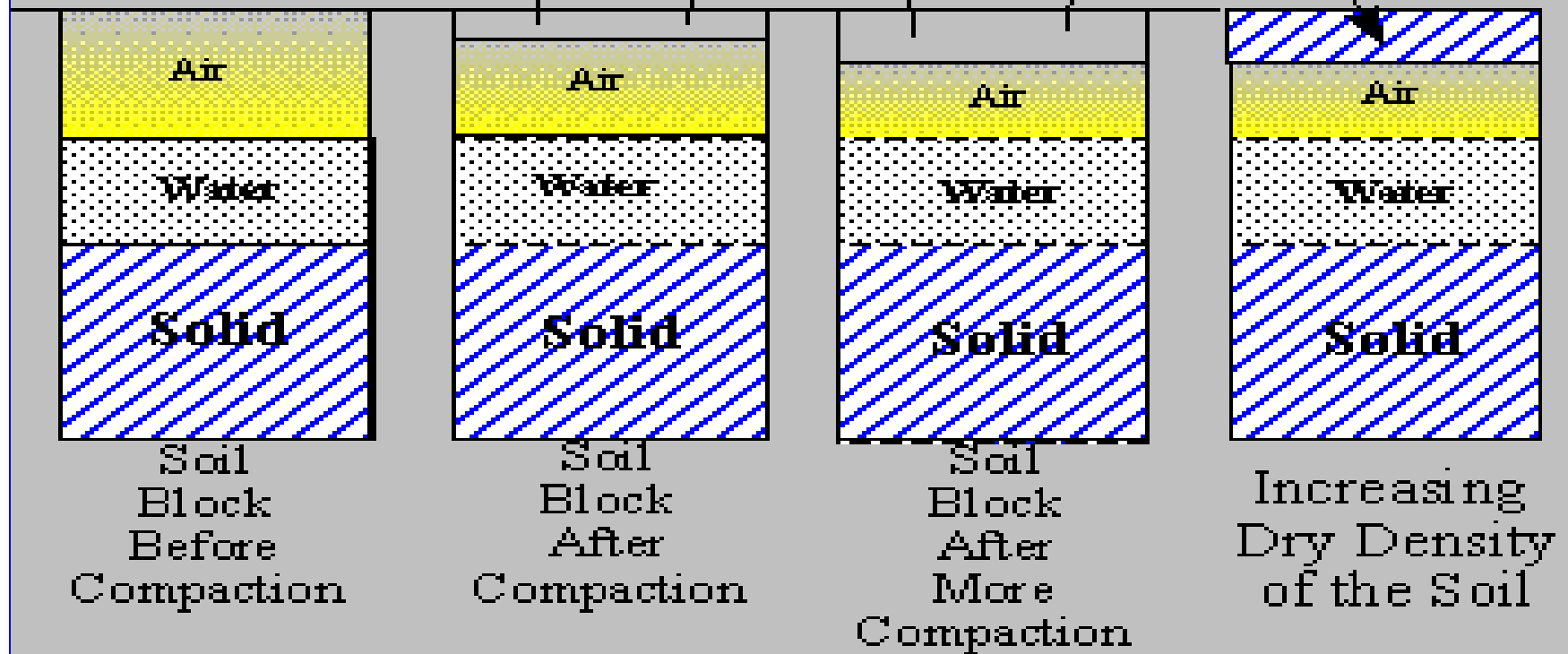
Increase in the dry density of a soil due to compaction is affected by

- The moisture content of the soil**
- The mode and amount of compaction.**
- The type of the soil.**

Applying Load

More Load

Add More
Soil
to the Block



- **LABORATORY COMPACTION TESTS**

(to determine the optimum moisture content and max.dry density)

Two types of compaction procedures (tests) are usually employed in the laboratory

- **Standard proctor compaction test after the name of its originator Proctor (1933)**
- **Modified proctor (or modified AASHO) compaction test. AASHO(American Association of State Highway Officials)**

• The Standard Proctor Compaction Test

- The apparatus used for the test consists of a cylindrical mould, with an **internal diameter of 10.16 cm** and an **effective height of 11.643cm**, giving a **volume of 944cc**.
- The mould is placed on a detachable square metallic plate and it carries a detachable collar of **6.35cm height** on its top.
- The
- **ham**
- **dist**



is mould is done with a
(bs) and falls through a

hammer

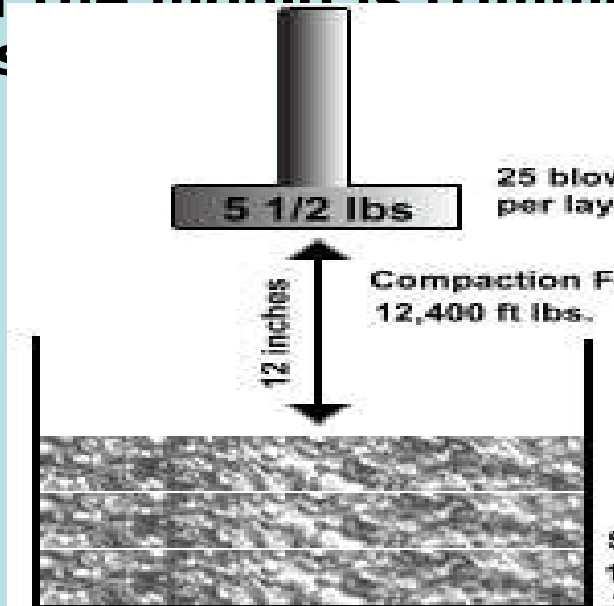
detachable collar

cylindrical mould

square metallic plate

• Test procedure

- Air-dried soil sample passing **sieve No 4** is mixed thoroughly with a measured quantity of water and is compacted in the mould in **three equal layers**.
- Each layer is compacted by **25 blows** of the hammer falling through **12 inches (30.48cm)** during each blow.
- Each compacted layer is raked with a spatula before placing the next layer. This ensures a good bond between the three layers.
- After compaction of the three layers, the detachable collar is removed and the extra soil projecting above the top of the mould is trimmed level the surface.



Standard AASHO



- The net weight of wet soil is determined by subtracting from the total weight of wet soil, mould and the base plate, the weight of empty mould and the base plate.

i.e $W1 = \text{Weight of the wet Soil} + \text{mould} + \text{base plate}$

$W2 = \text{Weight of empty mould} + \text{base plate}$

Net weight of wet soil = $W1 - W2$

- A representative soil samples from top, middle and bottom are taken from this wet soil to determine its average moisture content.

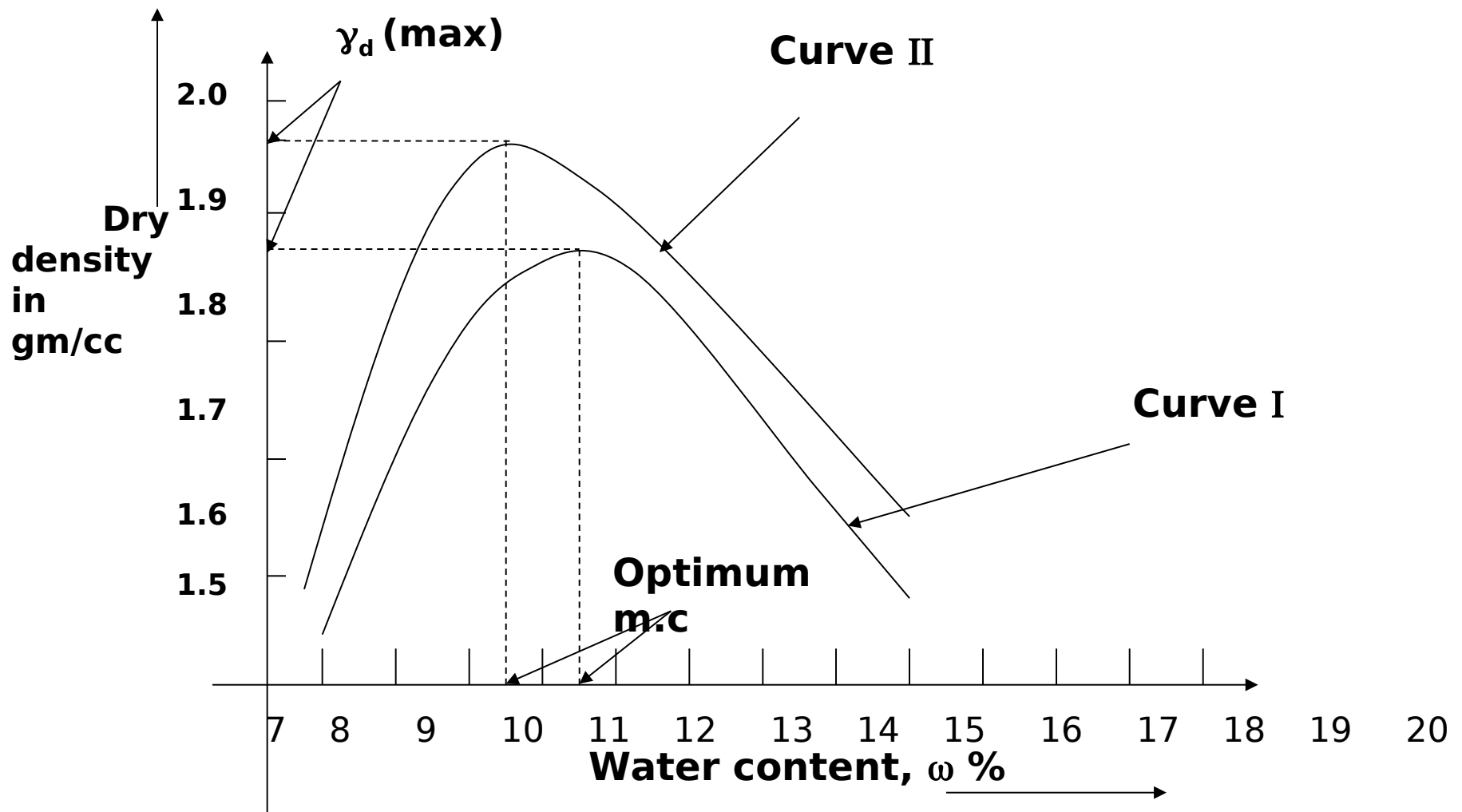
- (i.e $\omega =$ Wet unit weight of the soil, $\gamma_t =$

$$\frac{W_1 - W_2}{V}$$

Dry unit weight of the soil

$$\gamma_d = \frac{\gamma_t}{1 + \omega}$$

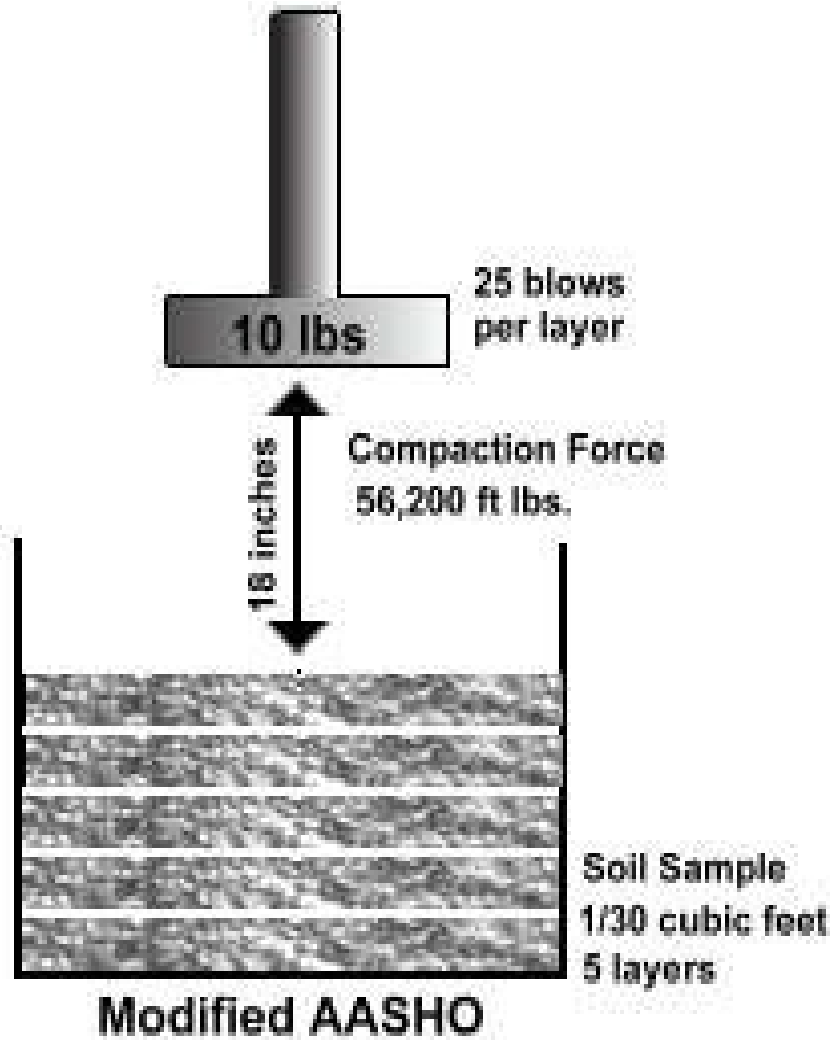
- **A number of such tests are conducted with soil samples having different moisture contents and γ_d worked out for all tests.**
- **From all these tests data, the moisture content-dry density curve is drawn and the peak of this curve gives the optimum moisture content and the corresponding maximum dry density.**



- **Modified Proctor [AASTHO] Test**
- The standard proctor compaction test is performed where ordinary compaction equipment is to be used in the field.
- However, in some types of constructions it is required to use heavy compacting equipments; then in order to get better comparable results; this test is performed with some modifications.
- In this modified test, the testing equipment is similar to the one used in the standard proctor's test except that the **weight of hammer is 10lbs** and its **fall is 18 inches**.

- The testing procedure is also similar except that the soil is compacted in **5 equal layers**, using **25 blows of the hammer for each layer**, the hammer falling through 18 inches during each blow.
- The calculations of dry density and moisture content are identical with the ones described in the proceeding test.
- The compactive energy transmitted by the modified AASHO test is about 4.5 times the energy transmitted by the standard proctor test

$$\left[\frac{5layers}{3layers} \times \frac{10lb}{5.5lb} \times \frac{18'}{12'} \times \frac{25blows}{25blows} = 4.5 \right]$$



- **COMPACTION OF SOIL IN THE FIELD.**

- A number of different types of equipment are available for compacting soils.



Smooth Roller



Sheep foot roller



Vibratory plate



Rammer

- **Compaction Control in the Field.**
- **In the field when the compaction is being carried out, it is essential to check the dry density and the moisture contents so as to control the progress of the work.**
- **The following two methods are more commonly used to determine the in-situ density of soil.**



Core cutter method



Sand-replacement

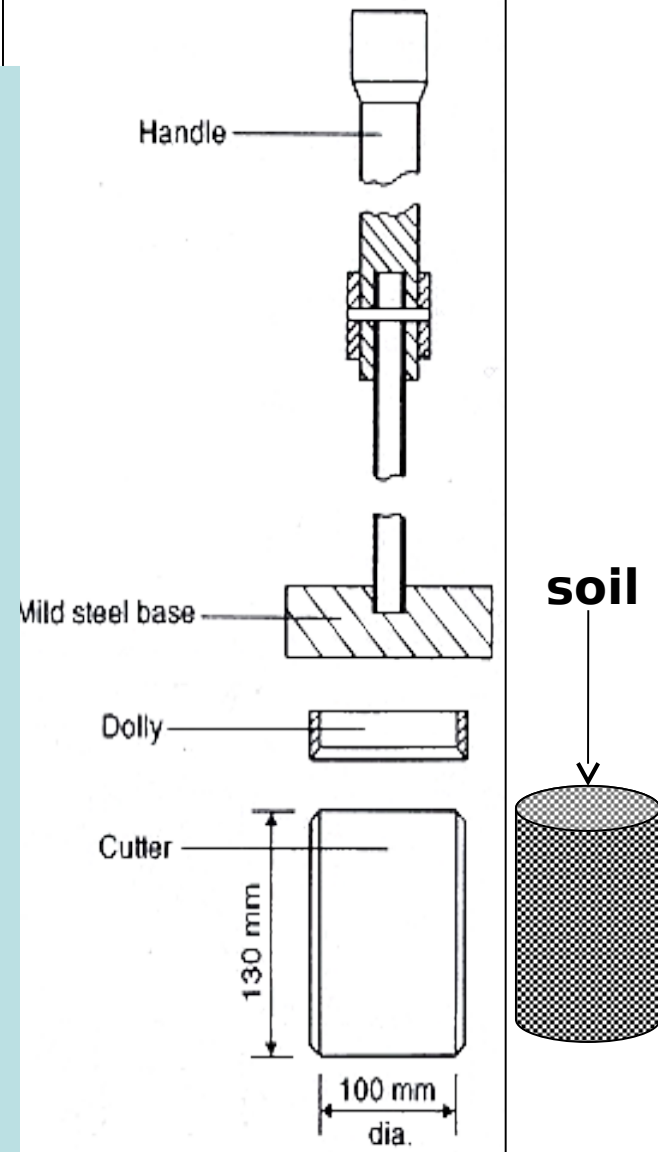
method

- **Core cutter method**

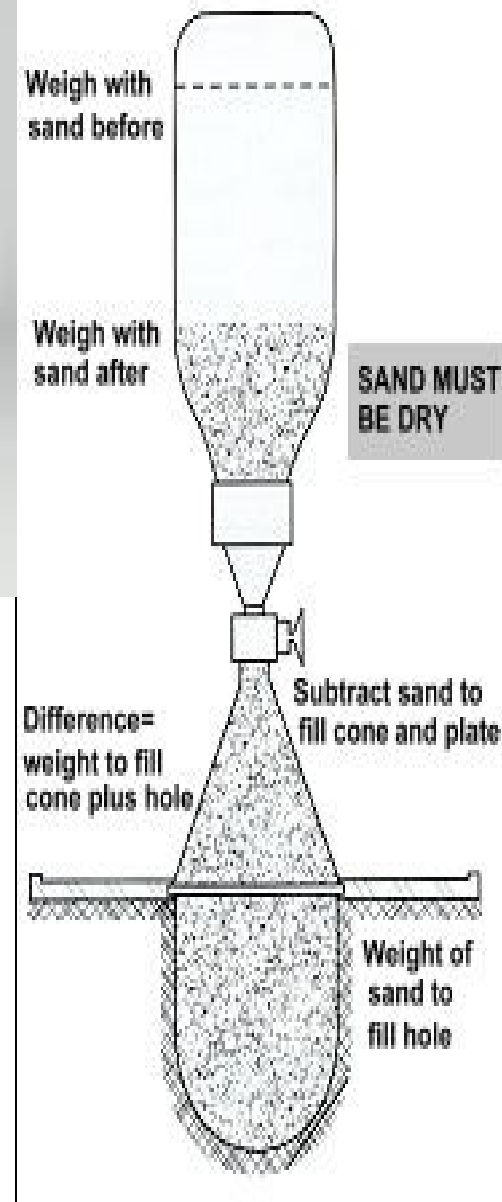
- ❖ After the cutter has been first pressed into the soil and then dug out, the soil is trimmed to the size of the cutter and both cutter and soil are weighed (W_1); knowing the cutter weight (W_2) and cutter dimensions (V), the bulk and dry density of the soil are obtained.

$$\gamma_t = \frac{W_1 - W_2}{V} \Rightarrow \gamma_d = \frac{\gamma_t}{1 + \omega}$$

-
- ❖ This apparatus is more suitable for soft cohesive soils but cannot be applied to stiff clays; sand soils, and soils containing too many stones that can damage the cutting edge.



- ***Sand replacement method.***
- A small round hole (about 100mm diameter and 150mm deep) is dug and the mass of the excavated material is carefully determined.
- The volume of the hole thus formed is obtained by pouring into it sand of known density from a special graduated container; knowing the weight of sand in the container before and after the test, the weight of sand in the hole and hence the volume of the hole can be determined.
- This method can be used for any type of soil.



Compaction Control Test

