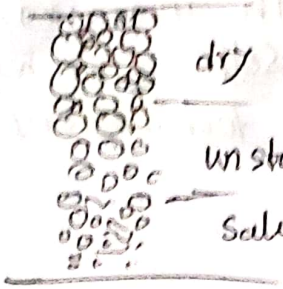
# Soil Compaction




Phases of Dry soil, – Air, Solid – $(V_a, V_s)$

" " unsaturated soil, – Air, liquid, water $(V_a, V_w, V_s)$

" " saturated " – Solid liquid $(V_s, V_w)$

Voids, $V_v = V_a + V_w$

$\therefore$ Porosity, $n = \frac{V_v}{V_T} = \frac{V_v}{V_v + V_s}$

Void Ratio, $e = \frac{V_v}{V_s}$

$\therefore \frac{1}{n} = \frac{V_v + V_s}{V_v}$

$= 1 + \frac{V_s}{V_v}$

$= 1 + \frac{1}{e}$

$= \frac{1+e}{e}$

$\therefore \boxed{n = \frac{e}{1+e}}$

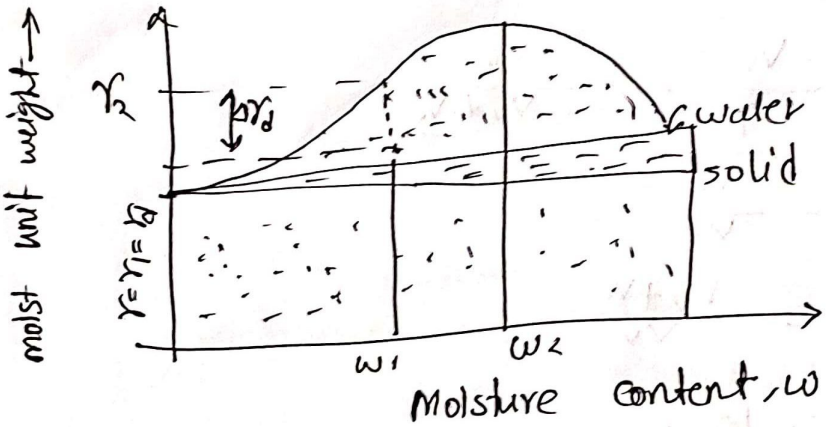
the

Compaction: Compaction is a process in which mechanical energy is applied and air is removed with increased density. Compaction increases strength of soil, which increases the bearing capacity of soil of foundations built over them.

Degree of compaction:

The degree of compaction is measured in terms of its dry unit weight

*** Principles of Compaction:




When water is added during compaction, it works as a softening agent/lubricant.

The dry unit weight first increases as the moisture content increases.

At a moisture content $w=0$, the moist unit weight $\gamma = \gamma_d$ is equal to dry unit weight or dry density.

$$\therefore \gamma = \gamma_d\,(w=0) = \gamma_1$$

When moisture content is increased, the unit weight of soil also increases.

$\therefore$ at $w = w_1$, $\gamma = \gamma_2$

However, the dry unit weight,

$$\gamma_{d\,(w=w_1)} = \gamma_{d(w=0)} + \Delta\gamma_d$$

But after $w=w_2$, the dry unit weight reduces although moisture content is decreased. This phenomenon occurs because the water takes up the spaces of solids.

This moisture content at which dry density is at it's maximum is known as ~~max~~ optimum moisture content.

17 * Why compaction is used in field?
* Objectives of compaction

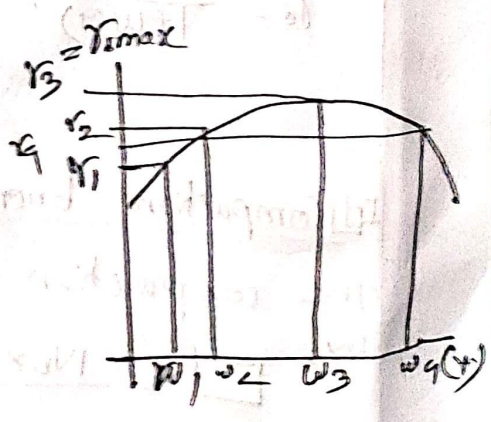
Ans:

(i) To increase shear strength thus increasing bearing capacity

(ii) To increase stiffness, therefore decrease future settlement

(iii) To decrease void ratio. and permeability. thus reducing potential of ~~fr~~ frost heave.

CT 19, 15 * Explain compaction curve.




Ans:

At first when moisture content increaseses $w_1 \rightarrow w_3$ the dry density also increases But after a certain point the dry density decreases. This point is unown of max dry density.

## Lab Compaction test:

or Difference between Standard and Modified Proctor test.

First a mould of 1/30 ft³ and 4" dia is taken

| Item | Standard | Modified |
|---|---|---|
| Layers | 3 | 5 |
| blows/layer | 25 | 25 |
| hammer (wt) | 5.5 Lb | 10 Lb |
| Drop Height | 12" | 18" |
| Energy | 12375 Lbft/ft³ | 56250 ft Lb/ft³ |

for each test, moisture unit weight γ / bulk density is the calculated,

$$\gamma = \frac{W}{V_m}$$ ; W = weight of the compacted soil
$V_m$ = volume of mould = 1/30 ft³

Then for the particular w(%), Dry density is found by

$$\gamma_d = \frac{\gamma}{1+w(\%)}$$

## Compaction Energy of proctor test:

The compaction energy per unit volume is given by,

$$E = \frac{N_b \times N_L \times W_n \times H_d}{V_{(m)}}$$

$N_b$ = No. of blows
$N_L$ = " " layers
$H_d$ = Height of blows
$W_n$ = Weight of hammer

∴ For standard proctor test,

$$E_s = \frac{25 \times 3 \times 12\frac{1}{2} \times 5.6}{1/30} = 12375 \text{ lbft/ft}^3$$

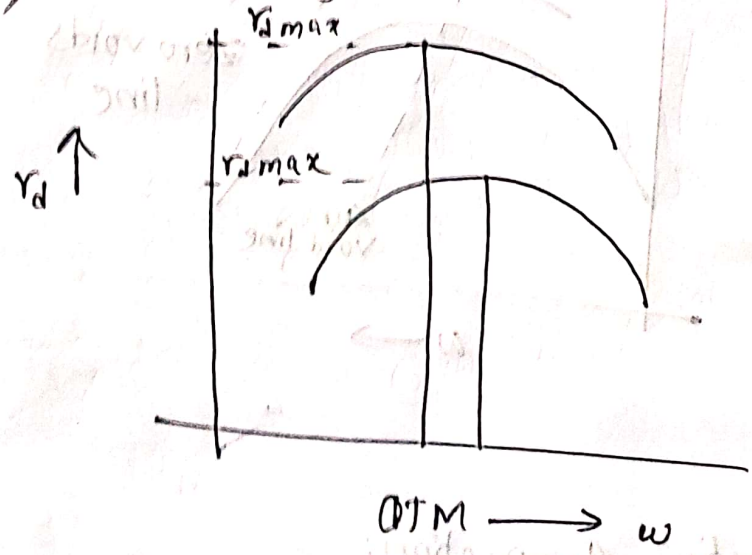
For modified proctor test,

$$E_m = \frac{25 \times 5 \times 12\frac{1}{2} \times 10}{1/30} = 56250 \text{ lb ft/ft}^3$$

$$\therefore \frac{E_s}{E_m} = 0.22$$

(b) **Qualitative Diagram of proctor Test:**

Modified test has an compaction energy 4.55 times than standard test. Thus for the increased energy moisture content optimum moisture content is decreased and dry density is increased.



Air void lines: A line that shows the relationship between dry density and water content for a constant percentage of entrapped air voids is known as Air void line.

This relationship is produced by,

$$\gamma_d = \frac{(1-n_a) G_s \gamma_w}{1+w G_s}$$

; $G_s$ = s.g of soil

$\gamma_w = 1 g/cm^3$

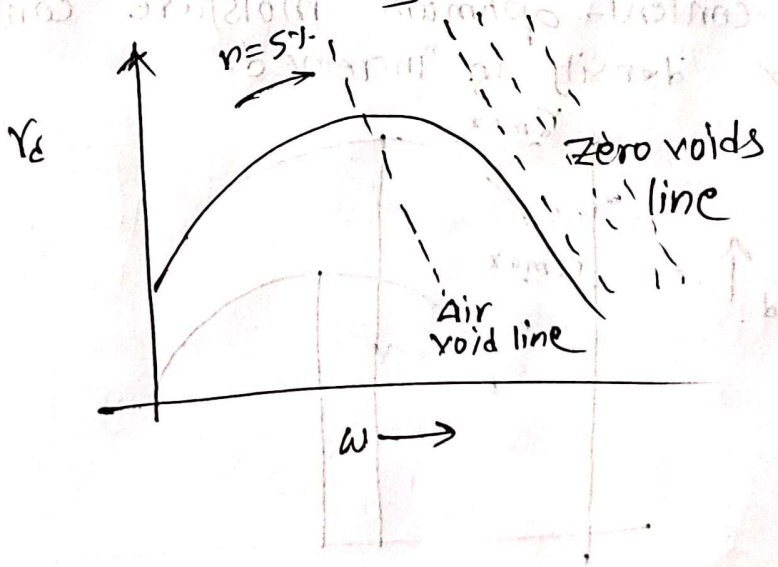
$n_a$ = air void percentage

Zero void lines:

For zero void lines,

$n_a = 0$

$$\therefore \gamma_d = \frac{G_s \gamma_w}{1+\frac{G_s w}{S}}$$

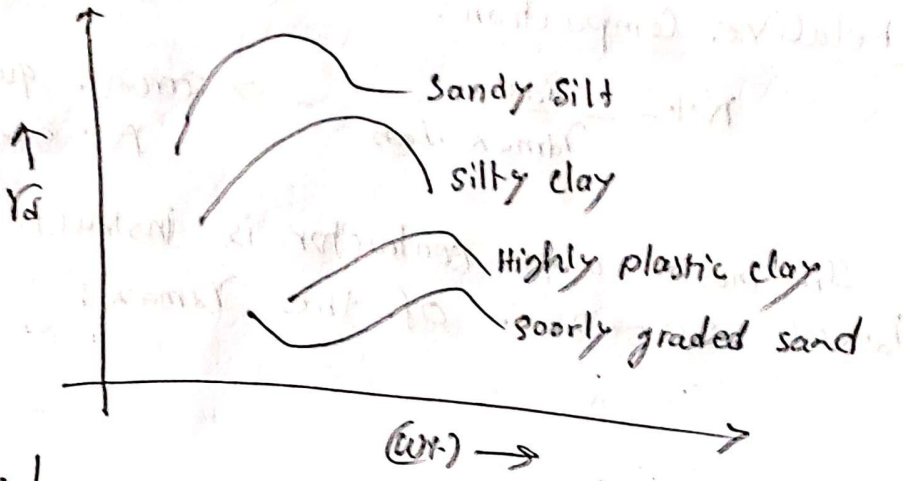


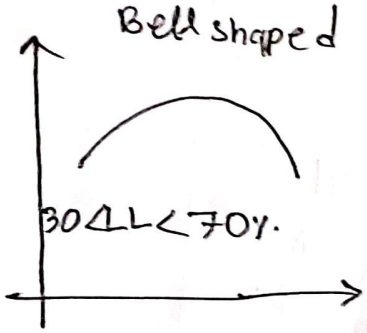

Factors affecting Compaction:

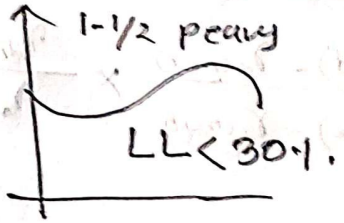
(I) Water content
(II) Soil type
(III) Amount of compaction
(IV) Admixture.

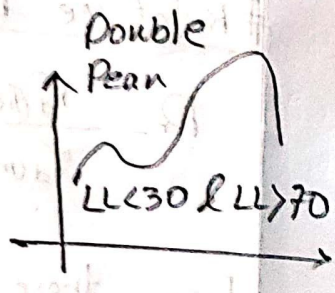
(ii) Soil type:

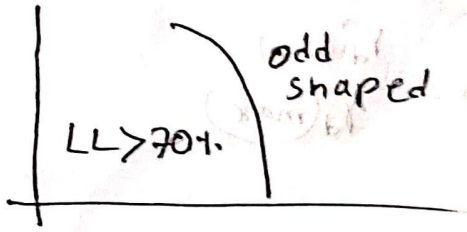
According to grain size distribution



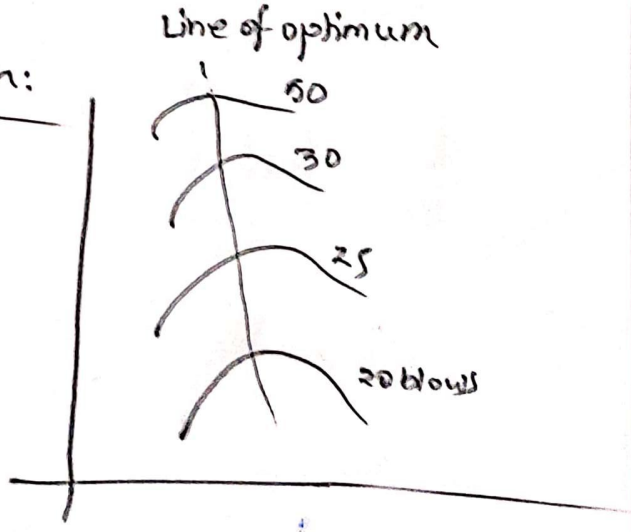




(iii) Amount of compaction:



## Specifications affecting Field Compaction:

### #Relative Compaction:

$$R.C. = \frac{\gamma_{df}}{\gamma_{dmax}} \longrightarrow$$ কাজের quality যত ভালো R.C. তত বেশী

In most cases contractor is instructed to achieve $\gamma_{df}$ of 90 → 95% of the $\gamma_{dmax}$.

### #Relative Density: (For granular Soil)

$$D_r = \frac{\gamma_{d(field)} - \gamma_{d(min)}}{\gamma_{d(max)} - \gamma_{d(min)}} \times \frac{\gamma_{dmax}}{\gamma_{d\,field}}$$

From those two eqn,

$$R = \frac{R_0}{1 - D_r(1 - R_0)} \quad ; \quad R_0 = \frac{\gamma_{d(min)}}{\gamma_{d(max)}}$$

## Specifications affecting Field Compaction:

### Field Compaction:

15 Equipments:

(i) Smooth wheel Rollers (Drum Rollers)
(ii) Pneumatic Rubber tire Rollers
(iii) Sheep foot Roller
(iv) Vibratory Roller

#### (i) Smooth Wheel Roller:

(a) A dram is attached to this equipment.
(b) Used for surface finishing works of sand and clay
(c) Area coverage 100%.
(d) 45~55 psi pressure.

#### (ii) Pneumatic Rubber tire Roller:

(a) 4~6 No. of tires are used
(b) Used for clay and sand soil
(c) 70-80% area coverage
(d) 85-100 psi pressure.

#### (iii) Sheepfoots Roller:

(a) Projections are attached with this drum
(b) used for clay
(c) 100% coverage
(d) 200~1000 psi

... Specification ... Field Compaction:

(iv) Vibratory Rollers:

(a) Vibrators are attached to drum, pneumatic or sheep foot rollers.

(b) Compaction purpose for sandy or granular soil.

(c) The vibration is caused rotating off center weights.

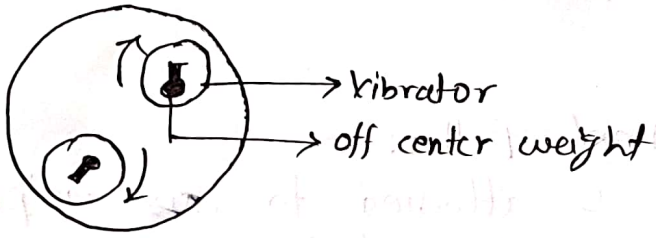



Fig. Principles of vibratory weight

## Field Compaction Control: (B.C Punmia)

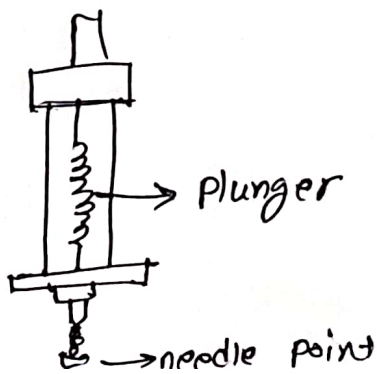
(i) Water Content Control → Calcium Carbide Method

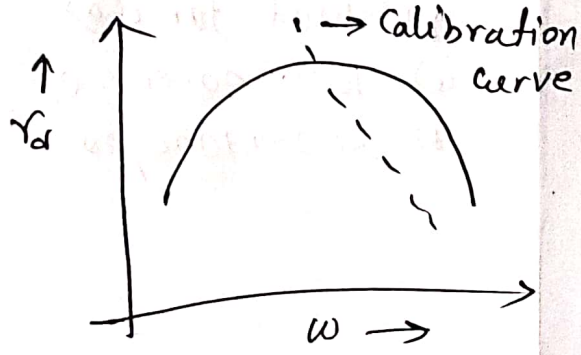
(ii) Compaction Control → Proctor Needle

## Proctor Needle Method:

→ 1" Insertation

→ Pressure of the Insertation is known as "Penetration Pressure."



Ex. 6.1 Results of a proctor test is given below:

a) Determine max dry unit weight of compaction and the optimum moisture content.

b) Calculate the ~~moisture content~~ $\gamma_d$ for degree of saturation, S = 80, 90 and 100%. Given $G_s = 2.7$

Solution: (a)

| Volume of Mould (cc) | weight of moist soil (N) | MOC w (%) | Dry density ($\gamma_d$) kN/m3 |
|---|---|---|---|
| 944 | 16.81 | 10 | 16.18 |
| 944 | 17.84 | 12 | 16.87 |
| " | 18.41 | 14 | ~~16.81~~ 17.10 |
| " | 18.33 | 16 | 16.73 |
| " | 17.84 | 18 | 16.01 |
| 944 | 17.35 | 20 | 15.31 |

Bulk density/moisture density, $\gamma = \frac{W}{V_m}$

Dry density, $\gamma_d = \frac{\gamma}{1 + w(\%)}$

∴ Optimum moisture content ⟶ 14%.

Max Dry Density, $\gamma_d$ ⟶ 17.10 kN/m3

(b) ans:

We know for a given moisture content w and a degree of saturation S, dry density or dry unit weight of zero air voids,

$$\gamma_d = \gamma_{zav} = \frac{(1-n_a) G_s \gamma_w}{1 + \frac{w G_s}{S}}$$

$$= \frac{G_s \gamma_w}{1 + \frac{w G_s}{S}} \quad \because \gamma_w = 9.800 \text{ kg/m}^3$$

$\gamma_d = \gamma_{zav}$

| w → | S = 80% | S = 70% | S = 100% |
|---|---|---|---|
| 10 | 17.78 | 20.35 | 20.83 |
| 12 | 18.83 | 19.45 | 19.78 |
| 14 | 17.76 | 18.63 | 19.20 |
| 16 | — | ⋮ | ⋮ |
| 18 | — | | |
| 20 | — | | |

$$\gamma_d = \left( \frac{G_s \gamma_w}{1 + \frac{w G_s}{S}} \right) \times \frac{1}{1000} \Rightarrow KN/m^3$$

→ needle point

Last Year Qushions:

Chapter: Soil compaction

CT

*** Define compaction and explain principle of compaction.

** Define some work sites where the compaction is needed.

* Draw the qualitative diagrams of standard and modified proctor test results on a single sheet.

* Write the equation of Brown's Stability Number

CT item * In a laboratory test, " Dry density of soil increases with the increase of moisture content up to a certain limit and after that dry density of soil decreases with the increase of moisture content beyond this point. " why?

* Briefly explain the factors affecting compaction with figures.

* A soil having specific gravity 2·70 was compacted by standard Proctor test with 15% water content (degree of saturation 90%) and found maximum dry density 1·8 g/cm³. Calculate the percent air content present in the specimen.

Semfinal:

17 * Difference beluceen Stanturd and Modified Proctor test.

V * Typical compaction test curve and explain

* A labrotary compaction test on soil having 3.G equal to 2.66 gave a max dry density of 1.8 g/cm³ for a water conlent of 15%. Determine

(i) Degree of saturation

(ii) Percentage of Air voids.

2018 * Why soils are compacted? How is the degree of compaction is ensued in field

2017 * factors Influenig compaction with curve

17 *

15 * Briefly discuss equipments of compaction

15 * Explain compaction curve