Model Answers and Marking Scheme (1/10)
12084

Q-1) A) Attempt any six of the following [12]

a) Define soil

→ As per I.S. - 2809 - 1972 (01)

Soil is the sediments or other unconsolidated accumulation of solid particles produced by physical and chemical disintegration of rock

For Civil Engineering [OR] (01)
Soil is the mixture of minerals and/or rock derived from chemical and mechanical weathering of rock

b) Define voids ratio and porosity [02]

→ The ratio of volume of voids [$V_v = V_a + V_w$], to the volume of solids [V_s] in soil mass is called as void ratio [e]. It is expressed as decimal (fraction)

$$\therefore e = \frac{V_v}{V_s}$$ (01)

Porosity is a ratio of volume of voids [V_v] to the total volume of soil [V]

$$\therefore n = \frac{V_v}{V} \times 100 \text{ percent}$$ — (01)

c) State Darcy's Law [02]

→ It states that "for laminar flow, the rate of flow or discharge per unit time is directly proportional to hydraulic gradient". Written as (01)

$$q = KiA \quad \text{or} \quad V = \frac{q}{A} = Ki$$ (01)

it is for isotropic, homogeneous soils under laminar flow conditions

d) Define shear strength of soil [02]

→ "The property that enables a material (i.e. soil) to remain in equilibrium when its surface is not in level is defined as shear strength". Therefore, shear strength of soil can be defined as the resistance to deformation by continuous shear displacement of soil particles

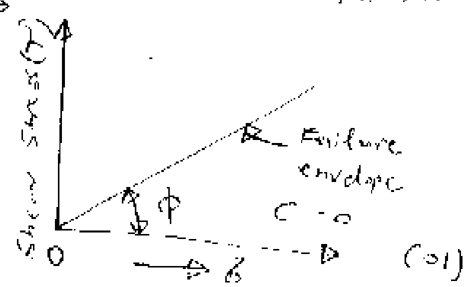
OR

It is the property of soil which enable the soil to remain in equilibrium against sloping surface such as slopes of embankments, earthen dam etc.

[02]

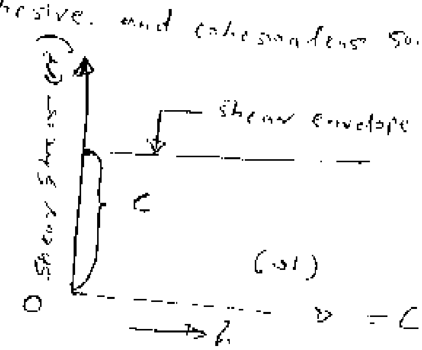
e) Draw Mohr's envelope for cohesive and cohesionless soil

→



Normal stress

Cohesionless soil



= [02]

Normal stress

Cohesive soil (Pure)

f) Define ultimate and safe bearing capacity

→ The ultimate bearing capacity [q_u] is the gross pressure at the base of the foundation at which the soil fails in shear. This is also sometimes called as ultimate bearing value or ultimate bearing pressure. (01)

The safe bearing capacity [q_s] is the maximum pressure which the soil can carry without risk of failure is called safe bearing capacity

$$q_s = \frac{\text{Ultimate Bearing Capacity}}{\text{Factor of Safety}}$$ (01)

[02]

g) State the purpose of compaction

→ 1) To increase shear strength

2) To reduce air voids so porosity decreases which helps for low permeability and water tightness

3) To reduce chances of further settlement

4) To increase the dry density which is caused for increase in bearing capacity

5) Improve engineering properties which helps the structure to have stable and long life span

[any 04 × $\frac{1}{2}$ = 02]

h) State various methods of site investigation

→ The various methods of site investigation (exploration) are

1) Open excavation

2) Boring

3) Sub-surface soundings

4) Geophysical methods

(04 × $\frac{1}{2}$ = 02)

\# Pl. Note that a site investigation is also termed as sub-surface explorations

B) Attempt any two of the following (08) (3/10)

a) Explain Factors affecting Compaction (04)

→ The factors which affect the compaction and hence the dry density of soil are as follows:

1) Water Content – From the laboratory experiments, it is clear that, as the water content increased, the compacted density goes on increasing till maximum dry density is achieved, after further addition of water, decreases the density.

2) Amount of Compaction – The effect of increasing the amount of compaction effort results increase in the ~~dry~~ maximum dry density and decrease in optimum moisture content.

3) Type of soil – Well graded coarse grained soil can be compacted to a higher degree compared to a uniform soil, for same compaction effort. As soil tends towards more & more fine grained nature – OMC increases & MDD decreases for the same compaction effort.

4) Method of compaction – The dry density depend upon method of compaction, manner of operation, time and contact area between the soil and the equipment.

5) Admixtures – Various admixtures like lime, calcium chloride, aggregate in various proportion are utilised to improve the compaction properties. The use and amount of these admixtures depend upon type of soil to be compacted. Certain chemical admixtures like lime can increase the dry density about ~~8~~ 5–10% under the same compaction energy. [any 04 × 01 = 04]

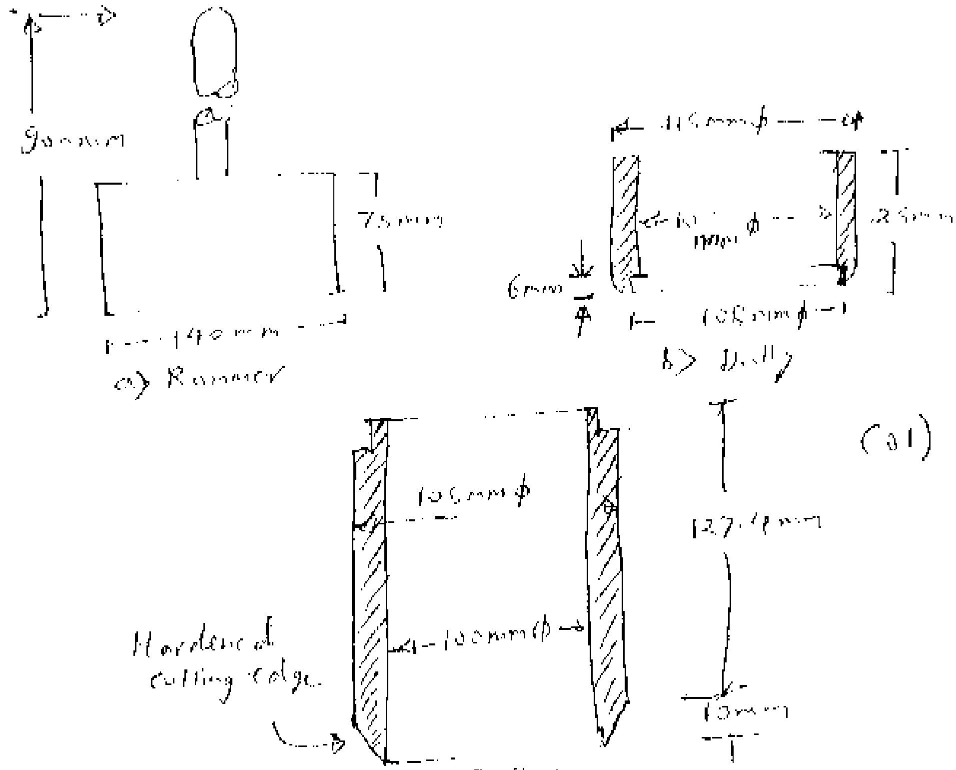
b) Explain soil as a three phase system

The soil mass in general, is a three phase system composed of solid, liquid and gaseous matter. The solid particles are called as solid grains. The void between the solid particles is filled partially with water and partially with air. The liquid phase is generally water that fills partial or wholly the voids. The gaseous phase is usually air which occupies the voids not filled by the water. (01)

These three constituent of soil mass are blended together forming a complex material. They donot occupy separate spaces. The properties of soil mass depends upon the relative percentage of these constituents and their arrangement. Hence, the relative volumetric and gravimetric proportions of the solids, water and air in a soil mass are required to be studied. (01)

(4/10)

Q No 2 - b> Explain determination of dry density by Core cutter method



Cutter

Core cutter apparatus

(01)

Following is the procedure of measuring dry density

1> Measure the inside dimensions of the core cutter and calculate its volume.

2> Weigh the core cutter (without dolly) accurate to 1gm (W_1)

3> Clean the top of soil on the site and level it. Dolly placed on the top of the core cutter and drive in to the soil with the help of rammer until about 10-15mm of dolly remain above the surface.

4> Dig out the container (cutter) which is containing the soil from the ground. Remove the dolly with the help of straight edge, trim flat, the end of the cutter.

5> Weigh the cutter with cutter soil and keep representive specimen soil for water content determination. (W_2)

6> Repeat the test at two to three locations nearby for getting average unit weight

(02)

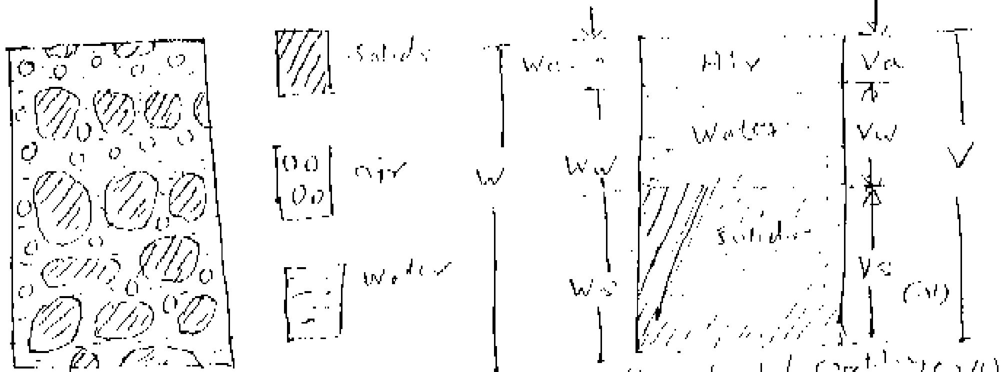
Calculations :- Bulk unit weight, $\gamma = \dfrac{W_2 - W_1}{V}$ (01)

and dry unit weight $\gamma d = \dfrac{\gamma}{1+w}$

[04]

x

Though the different phase present in the soil mass cannot be separated shown in Fig (1), but for a better understanding our soil behaviour, it is helpful to make them separates and study the phase diagram. (01)



a) Natural soil

Partially saturated condition (04)

c) Explain effect of water table on bearing capacity of soil

→ When the water table is above the base of footing, the submerged weight γ' should be used for the soil below the water table for determining the effective pressure of the surcharge. When the water table is located somewhat below the base of footing, when the water table is partly on moist soil and partly on the elastic wedge is partly submerged soil and a suitable reduction factor should be used with the wedge term $\frac{1}{2}\gamma B N_\gamma$ and Terzaghi's ultimate bearing capacity equation. Since it uses effective unit weight. (01)

$$q_f = cN_c + \gamma D N_q + 0.5\,\gamma B N_\gamma$$ may be

modified as

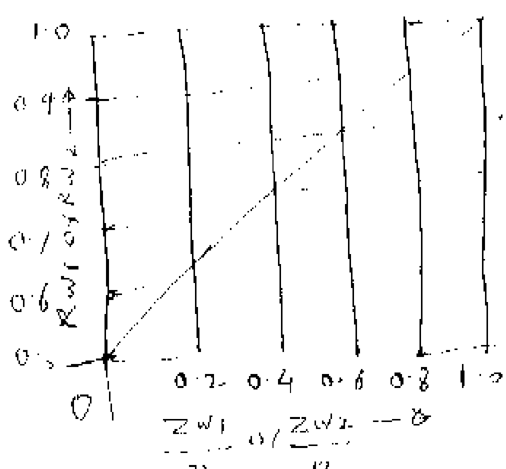
$$q_f = cN_c + \gamma_1 D N_q R_{w1} + 0.5\,\gamma_2 B N_\gamma R_{w2}$$

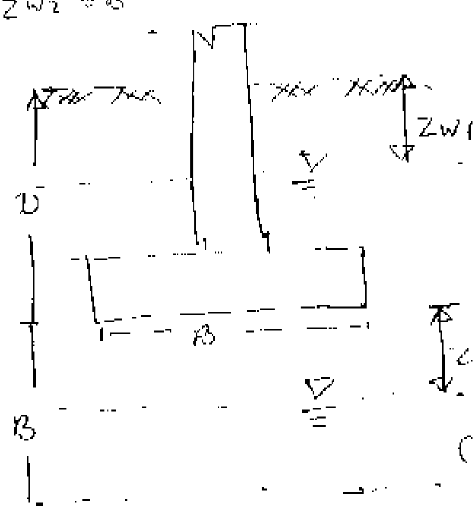
Where R_{w1} and R_{w2} are the reduction factors for water table computed as follows. $R_{w1} = 0.5\left[1 + \frac{Z_{w1}}{D}\right]$

at $Z_{w1} = 0$ $R_{w1} = 1/2$ and $Z_{w1} = D$, $R_{w1} = 1$

and $R_{w2} = 0.5\left[1 + \frac{Z_{w2}}{B}\right]$ (01)

at $Z_{w2} = 0$ $R_{w2} = 1/2$ and $Z_{w2} = B$ $R_{w2} = 2$.





(01)

Water reduction factors

γ_1 = Average unit weight of the surcharge soil situated above the water table.

γ_2 = Average unit weight of the soil in the wedge zone, is situated within a depth B below the base of footing

As a thumb rule this term may be reduced ($\frac{1}{2}\gamma B N_\gamma$) to half (since $\gamma' = \gamma_{sat}/2$) if water table is just at the base of the footing and no reduction to be made if the water table is at a depth equal to width of the footing below the base of footing. For intermediate positions, linear interpolation of the reduction be made as explained above. (01)

[04]

---- x : ------- x ------

Q. 2 → Attempt any four of the following [16]

a) Explain Atterberg's limit of consistency

→ The water content at which the soil passes from one state to next are known as consistency limit. As per Atterberg these limits are liquid limit, plastic limit and shrinkage limit. (01)

1) Liquid limit (WL) – Liquid limit is the water content corresponding to arbitrary limit between liquid and ~~solid~~ plastic state of consistency of soil can be defined as the minimum water content at which the soil is in liquid state but has a small shearing strength against flowing with respect to liquid limit approaches. Liquid limit is defined as the minimum water content at which two parts of soil cut by a standard groove will flow together under impact of 25 number of blows in the Casagrande's liquid limit device. (01)

2) Plastic limit (W_p) – It is the water content corresponding to an ~~arbitrary~~ arbitrary limit between plastic and semi-solid state of consistency of soil. It is defined as the minimum water content at which the soil will just begin to crumble when rolled into a thread of approximately 3 mm diameter. (01)

3) Shrinkage limit (WS) – Shrinkage limit is the water content corresponding to arbitrary limits between solid and semi-solid states of consistency of soil. It is defined as the maximum water content at which a reduction in water content will not cause decrease in volume of soil mass. It is the lowest water content at which the soil can be still completely in saturated condition. (01)

[04]

{please refer page no(4) for Q.2 - b}

c) Explain I.S. classification of soil

→ According I.S 1498, soils are broadly divided into three divisions:

1) Coarse grained soils : In these soils, more than half the total material by mass larger than 75 micron I.S. sieve size.

2) Fine grained soils : In these soils, more than half the total mass of material is smaller than 75 micron I.S. sieve size.

3) Highly organic soils and other miscellaneous soil materials: These soil contain large percentages of fibrous organic matter such as peat, and the particles of decomposed vegetation. In addition, certain soils containing shells, concretions, cinders and other non soil material in sufficient quantities are also grouped in this division. (01)

1] Coarse grained soils :- These are further divided into two sub-divisions

a) Gravels [G] :- In these soils, more than half the coarse fraction [+75 µ] is larger than 4.75 mm I.S sieve size.

b) Sand [S] :- In these soils, more than half the coarse fraction [+75µ] is smaller than 4.75 mm I.S sieve size.

Each of the above subdivisions are further sub-divided into four groups (01)

i) Well graded, clean [W] ii) Well graded with excellent clay binder [C]

iii) Poorly graded, fairly clean [P] iv) not covered in other groups [M]

These symbols are used in combination and designate the type of coarse grained soils. For example, GC means clayey gravels.

2) Fine grained soils :- Fine grained soils are further divided into three subdivisions.

a) Inorganic silt and very fine sands [M] (01)

b) Inorganic clay [C]

c) Organic silt and clays [O]

The fine grained soils are further divided into the following groups on the basis of liquid limit, which is a good index of compressibility

i) Silts and clays of low compressibility, having a liquid limit less than 35% [L]

ii) Silts and clays of medium compressibility, having a liquid limit greater than 35% and less than 50% [I]

iii) Silts and clays of high compressibility, having a liquid limit greater than 50%. [H]

Combination of these symbols indicate the types (01) of fine grained soil. For example CH means Inorganic clay with high compressibility

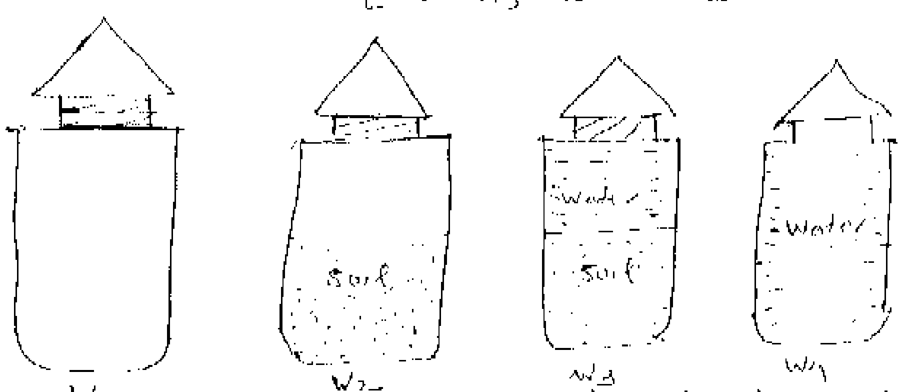
(04)

d) Explain determination of specific gravity of soil by pycnometer method

⟶ The specific gravity of soil using pycnometer can be determined as follows:

1) Dry the pycnometer thoroughly and weigh with its cap tightly screwed on [W_1]
2) Unscrew the cap and put about 200gm of ovendried soil sample passing 4.75mm I.S sieve and weigh again [W_2]
3) Add sufficient water to cover soil about half full, screwed the cap and shake well, so that soil become wet and air shall be removed.
4) Allow air to remove about 20 minutes, then add more water upto top of the cap, use glass rod to remove entrapped air.
5) After removing all entrapped air, again check level of water in pycnometer and water is required to top of cap and wipe off with dry cloth from out side and take weight as [W_3]
6) Clean the pycnometer by washing thoroughly with water (02)
7) Fill the pycnometer with water upto top, screw on the cap and add water upto top of the cap
8) Weigh the pycnometer after drying it on the out side thoroughly [W_4]
9) Repeat the test twice more.

Calculations :- $G = \frac{[W_2 - W_1]}{[W_2 - W_1] - [W_3 - W_4]}$ (01)



a) empty pycnometer
b) Pyc + soil
c) Pyc + soil + water
d) Pyc + water

(01)

(04)

c) Explain determination of water content by oven drying method

$\left(\frac{9}{12}\right)$

→ The soil sample is in small, non-corrodible, airtight container. The mass of the sample and that of the container are obtained using weighing balance. The mass of sample should be taken to an accuracy of 0.04%. The quantity of sample to be taken for the test depends upon the gradation and maximum size of the particles and degree of wetness of the soil. The drier the soil, the more should be quantity of the specimen. (01)

The soil sample in the container is then dried, in an oven at a temperature of 110° for 24 hours. The temperature range selected is suitable for most of the soils. The temperature lower than 110° ± 5° C may not cause complete evaporation of water and a temperature higher than this temperature may cause the breaking down of the crystalline structure of the soil particles and loss of chemically bound, structural water. However oven drying at 110° ± 5° C does not give reliable results for soil containing gypsum or other minerals having loosely bound water of hydration. This temperature is also not suitable for soils containing significant amount of organic matter. For all such soils, a temperature of 60 to 80° C is recommended. At higher temperature, gypsum losses its water of crystalline and organic soil tends to decompose and get oxidised. (01)

The drying period of 24 hours has been recommended for normal soils, as it has been found that this period is sufficient to cause complete evaporation of water. The sample is dried till it attains a constant mass. The soil may be deemed to be dry when the difference in successive weighings of the cooled sample. does require drying for a period longer than 24 hours. (01)

The water content of the soil sample is calculated from following equation

$$w = \frac{W_w}{W_s} = \frac{W_2 - W_3}{W_3 - W_1} \times 100$$

(01)

Where W_1 = Weight of container with lid

W_2 = Weight of container with lid & wet soil

W_3 = Weight of container, lid & dry soil

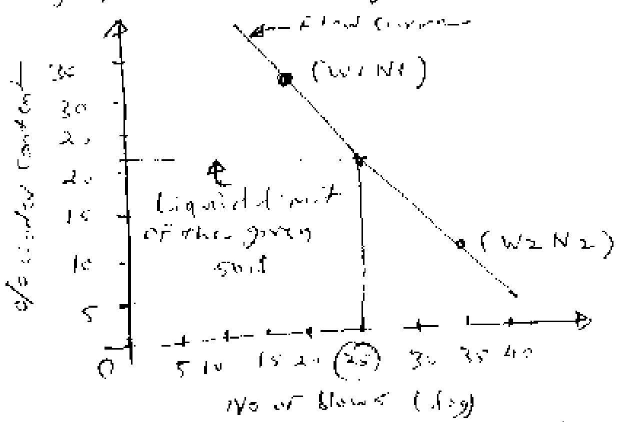
[04]

10/10

1) Explain determination of liquid limit

→ Following is the procedure of Casagrande's method to determine liquid limit

1) Sieve the sample through 425 micron IS sieve.
2) Take 120 gm of soil sample and mix it properly with 20 ml of water. Prepare a soil paste.
3) Spread the paste in the test cup and divide it by standard grooving tool
4) Now, lift and drop the cup to fall on the rubber base with the help of cam operated by handle. The handle is rotated at a rate of 2 revolutions per second untill the two halves of the soil sample in the cup remain contact with each other. The cam lifts the brass cup upto a specific height of one centimeter
5) Record the number of blows require to close the groove. Mix the soil in the cup immediately and repeat the above steps. The number of blows should be same. A difference of 2 or 3 blows indicates poor mixing of the sample.
6) Calculate the moisture content of the same sample
7) Repeat the test with 4 to 5 soil samples with varying moisture content
8) Draw a graph between the log of blows and moisture content.



(01)

9) Calculate the moisture content at 25 blows and record it as liquid limit of the given soil (03)

(04)

Checked PB
14-12-12

Q.3. Attempt any four **(4 x 4 =16)**

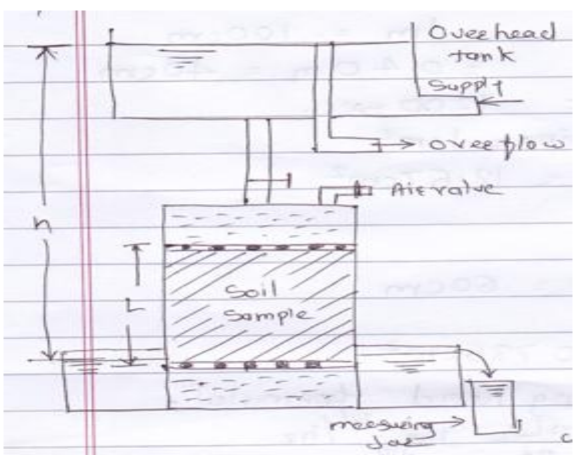
a) Factors affecting permeability of soil.

- Grain size
- Effect of properties of pore fluid
- Void ratio of the soil
- Structural arrangement of the soil particles
- Entrapped air and foreign matter
- Absorbed water in clayey soils
- Degree of saturation
- Shape of particles **(8 x 1/2 = 04)**

b) Characteristics of flow net **(any four)**

- Flow lines and equipotential lines meet at right angles to each other.
- The fields are approximately square.
- The quantity of water flow through each channel is same.
- Smaller the dimensions of the field, greater will be the hydraulic gradient and velocity of flow.
- Every transition in the shape of the curve is smooth, being either elliptical or parabolic in shape. **(4 x 1 = 04)**

c) Explain determination of coefficient permeability by constant head method.



(02)

Diagram shows the diagrammatic view of constant head test, water flow from overhead tank consisting of three tubes. The inlet tube, the overflow tube & the outer tube. The constant hydraulic gradient I causing the flow is the head h (i.e. difference in the water level of the overhead and bottom tank.). Divided by the length L of the sample. If the length of sample is large, the head lost over length of specimen is measured by inserting piezometric tubes. **(01)**

If Q is the total quantity of flow in a time interval t, we have from Darcy's law

$$q = Q/t = kiA$$

$$k = Q/t \;\; 1/1A = Q/t \;\; L/h \;\; 1/A$$

Where A= total c/s area of sample. **(01)**

d) Given

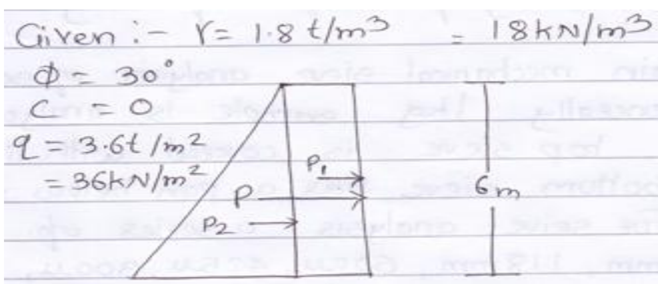
dia of soil sample = 4 cm
Length of soil sample = 18 cm
Initial head of soil sample = 1 m = 100 cm
Final head of soil sample = 0.40 m = 40 cm
t = 20 min = 1200 Sec.
Dia of stand pipe = 1 cm^2
A = $\pi/4 \times 4^2 = 12.57\ cm^2$ (01)

$h_1 = 100$ cm
$h_2 = 100 - 40 = 60$ cm
a= = $\pi/4 \times 1^2 = 0.785\ cm^2$ (01)
by falling head formula,
K = 2.303 (aL/At) $\log_{10} h_1/h_2$ (01)
= 2.303 0.785 x 18/12.57 x 1200 $\log_{10}^{100/60)}$
K= 4.786×10^{-4} cm/s (01)

e) Assumption made in Rankine's theory of earth pressure.

i) The soil moss is semi-infinite, homogeneous dry and cohesionless.
ii) The ground surface is plane which may be horizontal or inclined
iii) The back of wall is vertical and smooth.
iv) The wall yields about the base and thus satisfies the deformation condition for plastic eauillbeium. (1 x 4 =04)

f)



Ka = (1 – Sin Ø) /(1 + Sin Ø) **(01)**
= 1/3

i) Lateral pressure intensity due to the surcharge **(01)**
P1 = Ka . q = 1/3 x 36 = 12 kN/ m2

ii) Pressure intensity due to back fill at
depth H= 6 cm
= p2 = Ka.rH
= 1/3. 18x6
= 36 kN/ m2 **(01)**

iii) Total pressure intensity at the base of wall
Pa = P1 + P2
Pa = 48 kN/ m2 **(01)**

Q.4 Attempt any four of the following **(16)**

a)

i) Explain mechanical sieve analysis of soil.
Generally 1 kg sample is analyzed. The top sieve is covered with lid& the bottom sieve has a pan below it.

ii) For sieve analysis a series of 4.75mm 2.36mm, 1.18mm, 600u 425u 300u 150u & 75 µ sieves are used.

iii) These sieves are arranged & the sample from the pan is shaken for ten minutes then weight of soil retained on each sieve is then recorded.

iv) The soil particles passing through the 75 µ sieve are collected in the pan.

v) From observation table plot percentage finer against cumulative percentage finer on semi log graph paper. This gives particle size distribution curve which determine the character tics of the soil **(02)**

Observation table :-

IS sieve.	Mass retained	% retained	Cummulative % retaind	Cummulative % finer
4.75 mm				
2.36 mm				
1.18 mm				
600 µ				
425 µ				
300 µ				
150 µ				
75 µ				

(02)

c) Determination of plastic limit of soil:

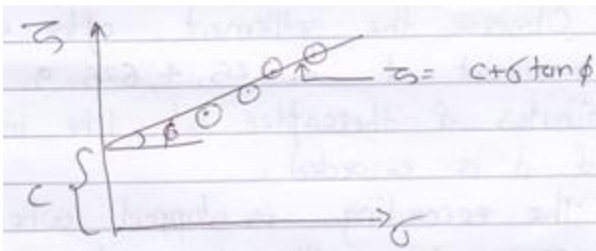
i) Take 15 gm of air dried soil passing through 1S sieve 425u & is mixed with sufficient quantity of water which would enable the soil mass to become plastic enough to be easy shaped into a ball.
ii) A portion of is taken & rolled on a glass plate with a palm of hand in to a thread of a uniform diameter.
iii) When a diameter of 3 mm is reached the sol is remolded in to a ball
iv) The process of making the thread & remolding is continued till the diameter of 3 mm just starts crumbling.
v) Some of the crumbled pieces are then taken for water content determination
vi) The water content is nothing but the plastic limit of the soil sample. **(04)**

c) Concept of shear strength of soil:

Shear strength of soil is the resistance to deformation by continuous shear displacement of soil particle. All stability analysis in soil mechanics involve a basic knowledge of the shearing properties & shearing resistance of the soil. **(02)**
The shearing resistance of soil is constituted basically of the following components:
1) The structural resistance of displacement of the soil because of the interlocking of the particles.
2) The frictional resistance to translocation between the individual soil particles at their contact points.
3) Cohesion or adhesion between the surface of the soil particles. **(02)**

d) Description of direct shear test of shear strength of soil.

i) The soil specimen is confined in a metal box of size 60 mm^2 & 50 mm deep so the sample of size 60x60x24 mm may be tested. The metal box is split horizontally.
ii) A pressure pad is placed on top & the entire box is placed in a trolley.
iii) Shear plates & porous stones are placed above & below the specimen.
iv) The upper half of the box is fixed to a support through a proving ring & the lower half of the box is pushed at constant strain rate. A vertical load is applied on the pressure pad. At the time of failure, shear stress is measured by the proving ring.
v) Normal load I varied from 0.5 Kg/cm^2 & 2 Kg/cm^2.
vi) Test is repeated for different normal stress.
vii) By dividing normal load & corresponding shear load at failure by the internal horizontal area of the shear box, the normal & shear stress values can be obtained.
viii) From these values, plot between normal stress Vs Shear stress gives the strength envelope from this C & Q can be determined. **(03)**



(01)

e) Explain plate load test as per IS 1888.

Plate load test is useful for determination of bearing capacity of soil by observing settlement of plate under load increments.

i) The site where testing is to be done is selected.
ii) A test pit at least 5 times the diameter or width of the plate & up to the depth of proposed foundation level is excavated.
iii) The plate is seated firmly at the centre of the pit.
iv) The dead load of all the equipment ball & socket, steel plate, loading column, jackets – is recorded before application of the load increments.
v) A min seating pressure of 70 gm/cm^2 is applied & removed before actual starting of the load test.
vi) A min load is applied to soil, in cumulative increment up to 1 Km/cm^2 or 1/5 of the estimated ultimate bearing capacity whichever is lower.
vii) Observe the settlement after each load increment at 1, 1.25, 4, 6.25, 9, 16, 30 minutes & thereafter at 1 hour intervals & it is recorded.
viii) The recording is stopped when the increase in settlement is only 0.02 mm.
ix) The procedure is repeated after every increment in load.
x) The observations are plotted on a log-log scale. The settlement against load is plotted.
xi) From this plot, ultimate bearing capacity is determined. The load increment can either by applied through gravity method or by reaction of truss method. **(03)**

(01)

Q.5.

a) Lime Stabilization of soil: Lime stabilization has been used for stabilizing the road bases and sub grades. Hydrated (or slaked) is very effective in treating heavy, plastic clayey soils. Lime may be used alone, or in combination with cement, bitumen or fly ash. Sandy soils can also be stabilized with these combinations.

On addition of lime to soil, two main types of chemical reactions occurs: i) Alteration in the nature of the absorbed layer through base exchange phenomenon and ii) cementing or puzzolanic action.

The amount of lime required may be used on the unconfined compressive strength or the CBR test criteria. Normally, 2 0r 8% of lime may be required for coarse grained soils, and 5 to 10% for plastic soils.
Following are some factors which affecting soil lime stabilization: Types of soil, lime content, amount of compaction, curing, additives. **(02)**

Advantages of Lime stabilization: Cheap, easy availability and expert supervision is not required. **(01)**
Disadvantages of Lime stabilization: No drastic alterations in properties and suitable only for plastic clay. **(01)**

b)

Compaction	Consolidation
It is defined as the process of increasing the unit weight of soil by forcing the soil solids to move closer due to the expulsion of air from the voids and this is accomplished by rolling or tamping.	The process of gradual reduction in the volume of a partially or fully saturated soil mass due to expulsion of water from the pores of the soil, under a long term static load is called consolidation
Settlement is prevented due to compaction	Settlement takes place due to consolidation.
Compaction is artificial process.	Consolidation is a natural process.
Compaction is fast process.	Consolidation is a slow process.
Compaction is carried out before construction of structure.	Consolidation takes place after construction of structure.
Dynamic loading is given in the process of compaction.	Consolidation takes place under static loading.
Compaction process is carried out for improving soil properties.	Consolidation does not improve soil properties.
Pore water pressure is not important in compaction.	Pore water pressure is more important in the process of consolidation.

(8 x ½ = 04)

c) Significance of CBR: The California bearing ratio is defined as the ratio of the test load to the standard load expressed as percentage, for a given penetration of the plunger.

$$CBR = (\text{Test Load}/\ \text{Standard load}) \times 100$$

The thickness of the different elements comprising a pavement is determined by CBR values.

- The CBR values are usually calculated for penetrations of 2.5 mm and 5mm.
- Generally the CBR values at 2.5 mm penetration will be greater than that of 5 mm penetration and in such a case the former is to be taken as the CBR values for design purposes.
- If the CBR value corresponding to a penetration of 5 mm exceeds that for 2.5mm, the test is repeated.
- After repeating the test, if identical results follow, the bearing ratio corresponding to 5mm penetration is taken for design. (4 x 1 = 04)

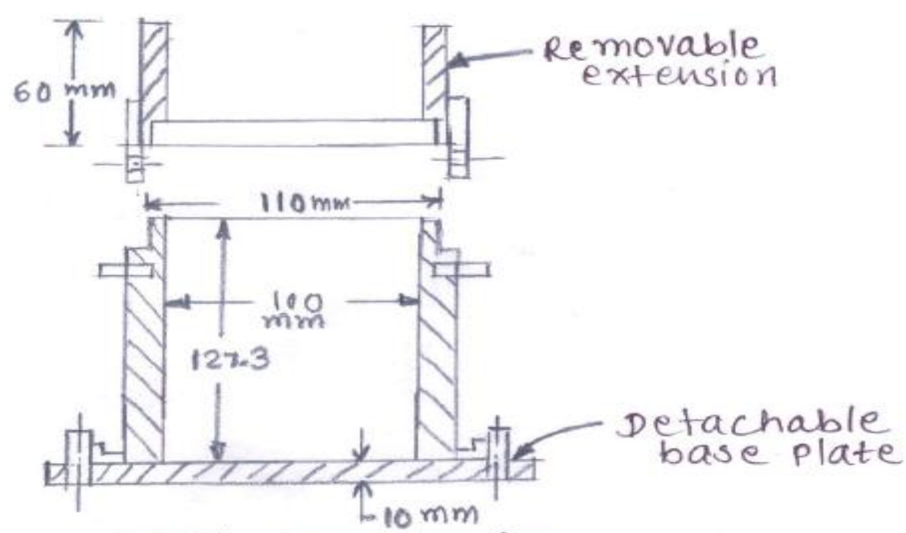
d) Standard Proctor Test for compaction of soil: A cylindrical mould of 1000 ML volume is filled with a soil sample in three layers, each layer being compacted by 25 blows of a free fall of standard dimension hammer of 2.6 kg mass and drop height of 310 mm. The excess material projecting outside the mould is then trimmed and weighed, hence giving bulk density of soil. The moisture content of the soil is determined and hence the dry density. Soil with different water content is compacted and dry density corresponding moisture content in each case is plotted. From the plot, O.M.C. and corresponding maximum dry density can be found. Bulk density ρ and dry density ρ_d for the compacted soil are determined by the relations. (02)

$$\rho = \frac{m}{v}\ (\text{g/cm}^3)$$

m = mass of compacted soil (gm), v = volume of mould.

$$\text{Dry density} = \frac{\rho}{1+w}\ (\text{g/cm}^3)$$ (01)

Where ρ = bulk density and w = water content.



mould for compaction

(01)

e) **Vane shear test**: The apparatus consists of four stainless steel blades fixed at right angle to each other and firmly attached to a high tensile steel rod. The length of the vane is usually kept equal to twice its overall width. The diameter and length of the stainless steel rod were limited to 25 mm and 60 mm respectively. **(01)**

Let C_u= Unit shear strength of the soil.

τ = maximum torque at failure in kg-cm.

H = height of vanes in cm.

Shear strength at failure along the cylindrical surface = π d H C_u

$$C_u = \frac{T}{\pi d^2 \left(\frac{H}{2} + \frac{d}{6}\right)} \qquad \textbf{(1/2)}$$

If the top of the vane is above the soil surface and depth of vane inside the sample is H_1, then

$$C_u = \frac{T}{\pi d^2 \left(\frac{H_1}{2} + \frac{d}{12}\right)} \qquad \textbf{(1/2)}$$

Following steps are involved:

- Push into the clay, the vane and rod below the bottom of the bore hole, ensuring the verticality of the central rod.
- Rotate the vanes at a constant speed of 1^0 per minute by suitable equipment.
- The test can be conveniently used to determine the sensitivity of the soil. (01)

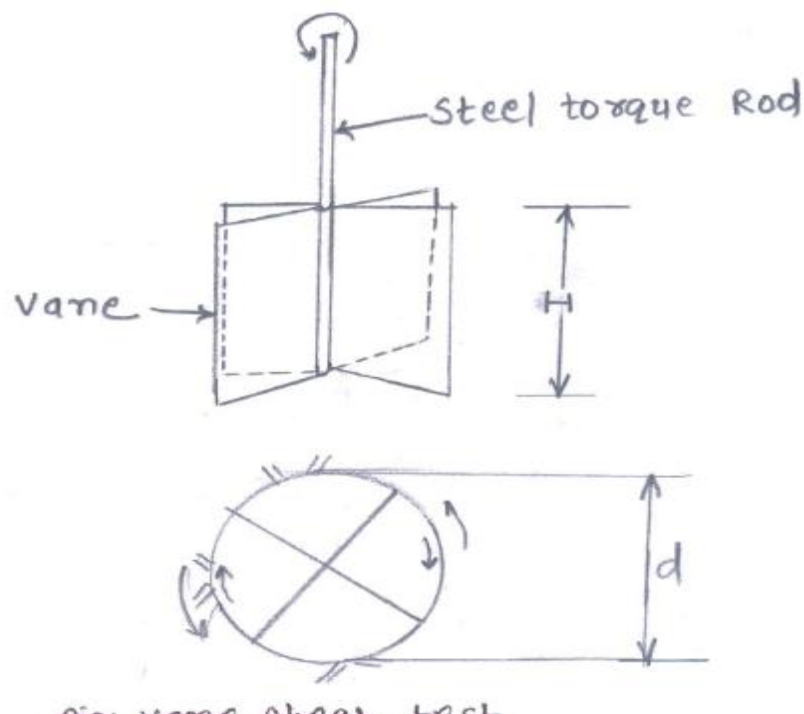


fig: vane shear test

Advantages:

- Test is simple and quick
- It is ideally suited for the determination of the undrained shear strength of non fissured, fully saturated clay.

Disadvantages:

- The test cannot be conducted on the clay containing sand or silt laminations or the fissured clay.
- The test does not give accurate results when the failure envelope is not horizontal. **(01)**

Q.6.

a). Field Methods of Compaction: Various types of soil can be compacted in the field by three methods: rolling, ramming and vibration.

i) Rolling: The rolling equipments are of five types: smooth wheel rollers, pneumatic tyred rollers, sheep foot rollers, lorries, track laying vehicles. In this method, various rollers are used to compact soil.

ii) Ramming: Ramming equipments consists of three types: dropping weight type, internal combustion type and pneumatic type. Rammers or tampers are used to compact the soil.

iii) Vibration: The vibrating equipment, mounted on screeds, plates or rollers are of two types: a) Dropping weight type and b) pulsating hydraulic type. By giving vibration to soil, soil particles are packed together and compaction of soil is achieved. **(04)**

b) Determination of CBR of soil: The CBR test is done as follows:

Equipments and tool required:

1. Cylindrical mould with inside dia 150 mm and height 175 mm, provided with a detachable extension collar 50 mm height and a detachable perforated base plate 10 mm thick.

2. Spacer disc 148 mm in dia and 47.7 mm in height along with handle.

3. Metal rammers. Weight 2.6 kg with a drop of 310 mm (or) weight 4.89 kg a drop 450 mm.

4. Weights. One annular metal weight and several slotted weights weighing 2.5 kg each, 147 mm

in dia, with a central hole 53 mm in diameter.

5. Loading machine. With a capacity of atleast 5000 kg and equipped with a movable head or base that travels at an uniform rate of 1.25 mm/min. Complete with load indicating device.

6. Metal penetration piston 50 mm dia and minimum of 100 mm in length.

7. Two dial gauges reading to 0.01 mm.

8. Sieves. 4.75 mm and 20 mm I.S. Sieves.

9. Miscellaneous apparatus, such as a mixing bowl, straight edge, scales soaking tank or pan, drying oven, filter paper and containers.

DEFINITION OF C.B.R.

It is the ratio of force per unit area required to penetrate a soil mass with standard circular piston at the rate of 1.25 mm/min. to that required for the corresponding penetration of a standard material.

C.B.R. = (Test load/Standard load) x 100 **(01)**

Procedure for Penetration Test:

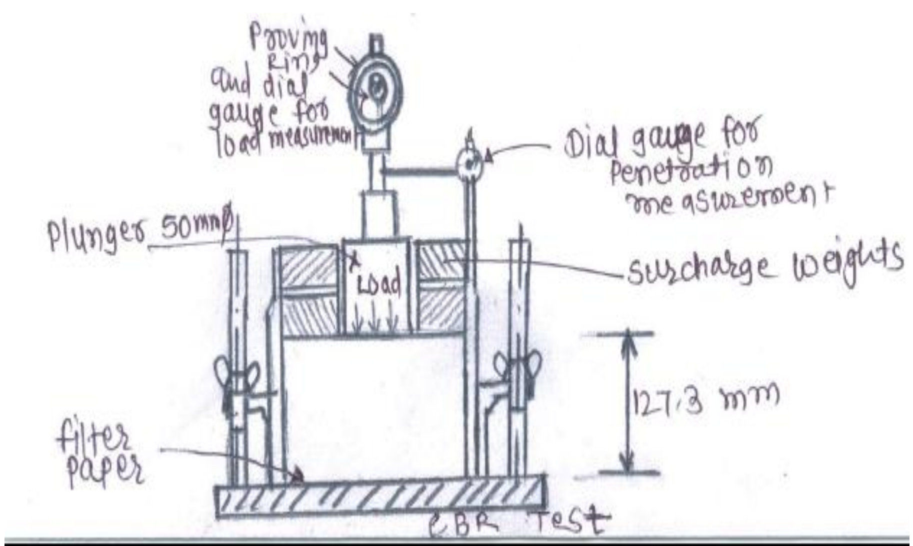
Place the mould assembly with the surcharge weights on the penetration test machine.

Seat the penetration piston at the center of the specimen with the smallest possible load, but in no case in excess of 4 kg so that full contact of the piston on the sample is established.

Set the stress and strain dial gauge to read zero. Apply the load on the piston so that the penetration rate is about 1.25 mm/min.

Record the load readings at penetrations of 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 4.0, 5.0, 7.5, 10 and 12.5 mm. Note the maximum load and corresponding penetration if it occurs for a penetration less than 12.5 mm. **(02)**

Detach the mould from the loading equipment. Take about 20 to 50 g of soil from the top 3 cm layer and determine the moisture content.



(01)

c) Dilatancy Test: Make a sample of soft putty consistency in your palm. Then observe the reaction during shaking, squeezing (by closing hand) and vigorous tapping. The reaction is rapid, slow or none. During dilatancy test, vibration densifies the silt and water appears on the surface. Now on squeezing, shear stresses are applied on the densified silt. The dense silt has a tendency for volume increase or dilatancy due to shear stresses. So the water disappears from the surface. Moreover, silty soil has a high permeability, so the water moves quickly. In clay, we see no change, no shiny surface, in other words, no reaction. **(02)**

Plasticity (or Toughness) Test: Roll the samples into a thread about 1/8" in diameter. Fold the thread and reroll it repeatedly until the thread crumbles at a diameter of 1/8". Note (a) the pressure required to roll the thread when it is near crumbling, (b) whether it can support its own weight, (c) whether it can be molded back into a coherent mass, and (d) whether it is tough during kneading. (d). A low to medium toughness and non-plastic to low plasticity is the indication that the soil is silty; otherwise the soil is clayey. **(02)**

d) Boring criteria for deciding the location and no. of test pits for a cluster of buildings and dam:

According to IS 1892-1979 gives guidelines as follows:

- Site area about 0.4 hectares, one bore hole or trial pit at center and one at each corner of plot. **(01)**
- For smaller or less important buildings, only one trial pit or bore hole is sufficient. **(01)**
- For larger area, it may be useful to perform sounding test or cone penetration tests at a spacing of 50 m to 100m by dividing the area in grid pattern. **(01)**

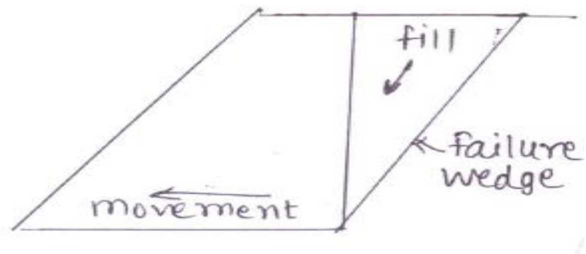
Following table gives the commonly used depth and spacing of 50 to 100m by dividing the area in grid pattern.

Following Table gives the commonly used depth and spacing of borings for cluster of building and dam. **(01)**

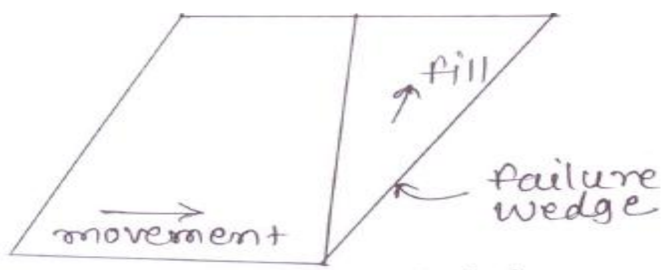
Type of Structure or Project	Boring Spacing in ft.	Depth of boring in ft.
i) Cluster of building	75-100	20 ft to 30 ft. below foundation
ii) Earth dams	100	40 to 50 ft. minimum or 10 ft. into sound rock, whichever comes first.

e) **Active and passive earth pressure of soil**:

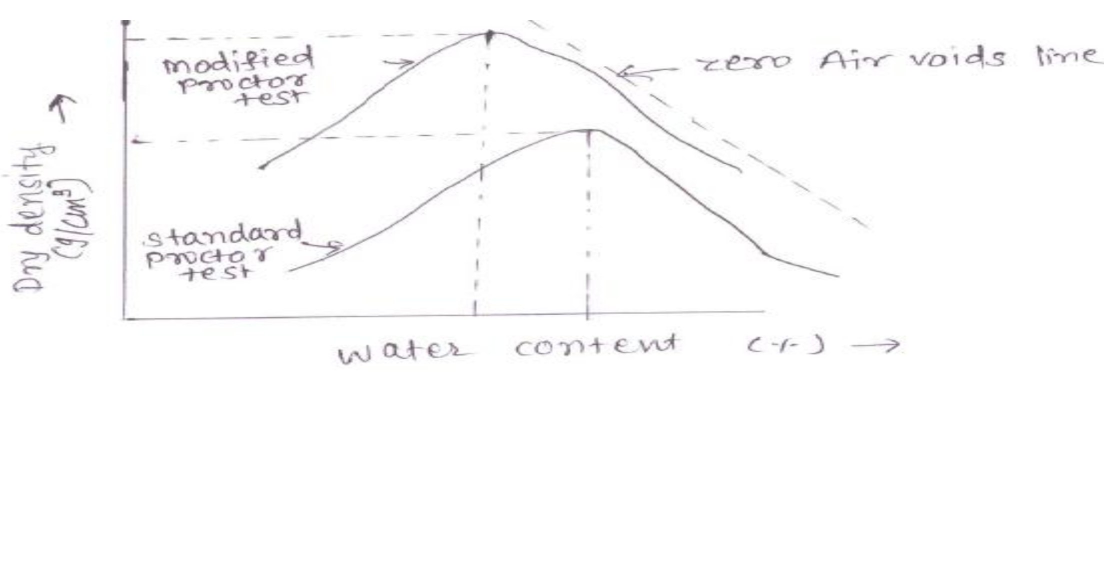
i) Active earth pressure: Due to excessive pressure of the retained soil, the retaining wall tends to move away from the back fill. Consequently, a certain portion of back fill located immediately behind the retaining wall, gets separated from the rest of the soil mass and hence the earth pressure on the retaining wall decreases. The wedge shaped portion of the back fill tending to move with the wall, is called a failure wedge. The retaining wall is kept in equilibrium by the resisting force developed due to shear strength of the soil along the plane of failure wedge in a direction away from the retaining wall. There is a limit with which the retaining wall may move away from the back fill, thereby limiting the pressure. The minimum wall pressure exerted by the soil on the retaining wall is called active earth pressure. **(02)**



iii) **Passive earth pressure:** Whenever the retaining moves towards the back fill due to any natural cause, the earth pressure increases because the taining soil gets compressed and resulting shearing strength develops along the plane of the failure wedge in the direction towards the retaining wall. The pressure reaches a maximum limit when the shearing resistance of the soil has been fully mobilized. The maximum earth pressure due to maximum shear stress on the retaining wall is called passive earth pressure. **(02)**



f) **Modified Proctor Test for Compaction of soil**: Higher compaction is needed for heavier transport. The modified proctor test was developed to give higher standard of compaction. In this test, the soil is compacted in the standard proctor mould in five layers. Each layer being given 25 blows. Compactive energy given t the soil in this test is 2674 KJ/m^3 of the soil which is about 4 ½ times that of standard proctor test. IS: 2720 (Part VII) – 1962 recommends the use of 4.89 kg rammer with a drop of 45 cm for heavy compaction. In the modified proctor test, the water content dry density curve lies above the standard proctor test curve as shown in figure. From the graph, it can be seen that for a same soil, the effect of heavier compaction is to increase in the maximum dry density and to decrease the optimum water content. **(03)**



(01)