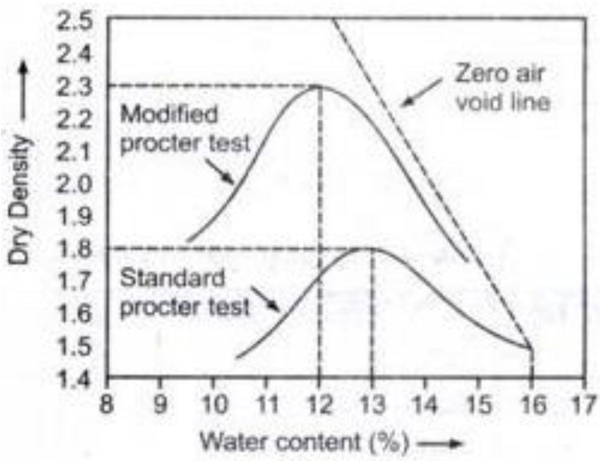
Solution - Internal Assessment Test II – December 2021

1	(a) Differentiate between standard and modified proctor compaction tests.	[06]	CO2	L2

6 differences including figure – 6 marks

Sl No	Description	Standard compaction	Modified compaction
1	No of layers (N_L)	3	5
2	No of blows(N_B)	25	25
3	Mass of rammer, kg (M)	2.6	4.89
4	Height of rammer fall, mm (H)	310	450
5	Compaction energy $= \frac{MHN_LN_B}{Volume\ of\ mould}$ kNm/m^3)	593	2699
6	Practical application	Suitable for embankments	Suitable for airfield pavements

Effect on OMC and MDD



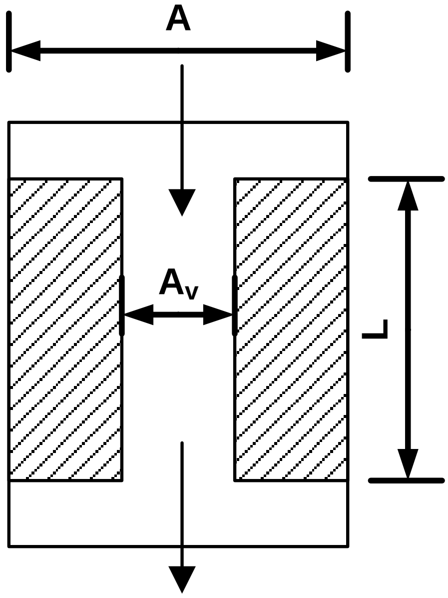
Modified compaction effort increases MDD and decreases OMC when compared to standard compaction effort

(b) Explain the terms superficial velocity and seepage velocity. Derive the relationship between them.	[06]	CO3	L3

Definition – 2

Derivation with sketch - 4

The velocity of water obtained using the total cross-sectional area of the soil is known as discharge velocity or superficial velocity. Since water flows only through voids and not through the total cross-sectional area, the actual velocity of water is much higher than the discharge velocity and that is known as seepage velocity (v_s).



According to the equation of continuity,

$$A \times v = A_v \times v_s$$

Or $v_s = \frac{A \times v}{A_v}$

$$v_s = \frac{(A \times L) \times v}{(A_v \times L)}$$

Where L is the length of the specimen

$$v_s = \frac{V \times v}{V_v}$$

But $\frac{V}{V_v} = \frac{1}{n}$

According to Darcy's law,

$$v = ki$$

$$v_s = \frac{v}{n} = \frac{k \times i}{n}$$

$$v_s = k_p \times i,$$

Where

$k_p = \frac{k}{n}$ and k_p *is called as coefficient of percolation*

(c) The following results refer to compaction test results as per light compaction. [08] CO2 L3

Water content, %	8.5	12.2	13.75	15.5	18.2	20.2
Wt of wet soil, kg	1.8	1.94	2.00	2.05	2.03	1.98

If the specific gravity of soil is 2.7 and volume of compaction mould is 1000 cc. Plot the compaction curve and obtain the maximum dry unit weight and optimum moisture content. Also estimate the degree of saturation at MDD and OMC.

Data set + Compaction curve – 5

Identification of OMC and MDD -1

Calculation of S - 2

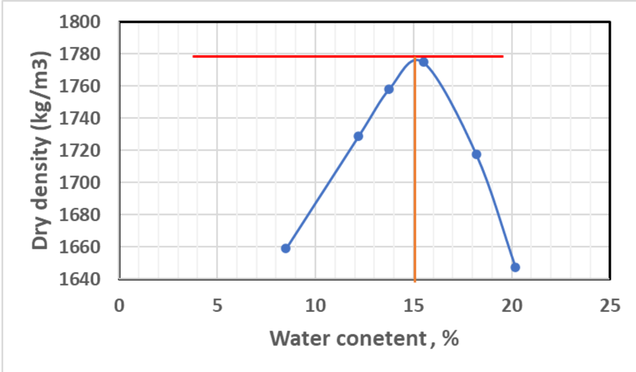
Water content, %	8.5	12.2	13.75	15.5	18.2	20.2
Wt of wet soil, kg	1.8	1.94	2	2.05	2.03	1.98
Density (kg/m3)	1800	1940	2000	2050	2030	1980
Dry density (Kg/m3)	1658.986	1729.055	1758.242	1774.892	1717.428	1647.255

OMC = 15 %
MDD = 1780 kg/m^3

$$\rho_d = \frac{\rho_w G}{1+e}$$

$$1780 = \frac{1000 \times 2.7}{1+e}$$

e = 0.516
eS = wG
S = 0.15 × 2.7/0.516
S = 78.5 %

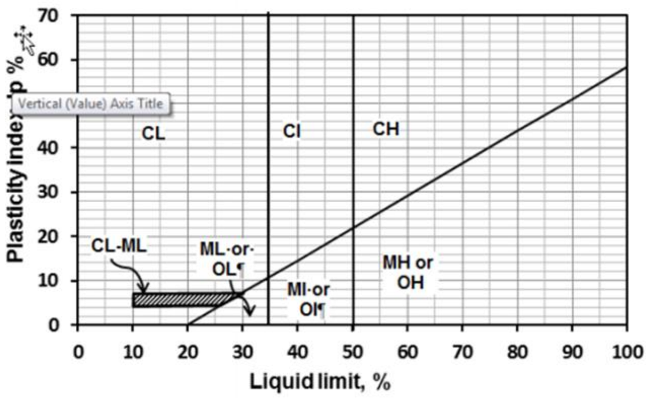


2	(a) Explain the use of plasticity chart. A fine-grained soil has a liquid limit of 54% and a plastic limit of 30%. Classify the soil as per IS classification.	[06]	CO1	L3

Plasticity chart -2
Description – 2
Classification - 2

Fine-grained soils are those for which more than 50% of the material has particle size less than 0.075 mm. A plasticity chart is a chart with liquid limit (W_L) on X-axis and plasticity index (IP) on Y-axis. According to IS classification, fine grained soils are classified into 9 groups using A-line whose equation is given as IP= 0.73 (W_L- 20)

Ip on A – line = 0.73 (54-20) = 24.82 %
Obtained Ip = 54 – 30 – 24 % its below A -line, hence its silt.
Since liquid limit is greater than 50%, its MH.



Ip above A-line	Wl<35	CL
Ip above A-line	Wl between 35 and 50	CI
Ip above A-line	Wl>50	CH
Ip below A-line	Wl<35	ML or OL
Ip below A-line	Wl between 35 and 50	MI or OI
Ip below A-line	Wl>50	MH or OH
Ip above A-line	Ip between 4 and 7	CL-ML

	(b) If during variable head permeability test on a soil sample, equal time intervals are noted for drops of head from h_1 to h_2 and again from h_2 to h_3. Find the relationship between h_1, h_2 and h_3.	[06]	CO3	L4

$Expression - 2$

Simplification – 2

Final expression - 2

$$t = 2.303\frac{aL}{Ak}log\frac{h_1}{h_2} = 2.303\frac{aL}{Ak}log\frac{h_2}{h_3}$$

$$log\frac{h_1}{h_2} = log\frac{h_2}{h_3}$$

$$\frac{h_1}{h_2} = \frac{h_2}{h_3}$$

$$h_2^2 = h_1.h_3$$

$$h_2 = \sqrt{h_1.h_3}$$

	(c) List and explain the various factors that affect the permeability of soil	[08]	CO3	L3

Any 5 major factor and 1 minor factor – 1.5×5 +0.5 for sketches

In soils, the interconnected pores provide passage for water. A large number of such flow paths act together, and the average rate of flow is termed the coefficient of permeability, or just permeability. It is a measure of the ease that the soil provides to the flow of water through its pores.

The different factors affecting permeability are

(a) Particle size
(b) Structure of soil mass
(c) Shape of particles
(d) Void ratio
(e) Properties of water
(f) Degree of saturation
(g) Adsorbed water
(h) Impurities in water

For a laminar flow, coefficient of permeability of soil can be given as

$$k = C\left[\frac{\gamma_w}{\mu}\right]\left[\frac{e^3}{1+e}\right]D2$$

This expression can be used to explain the different factors affecting permeability.

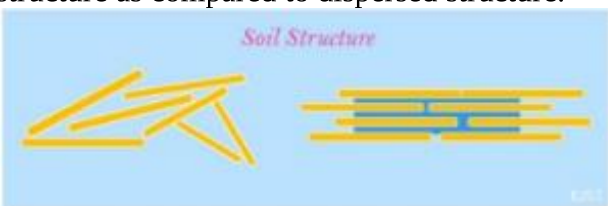
i. **Particle size:**

Coefficient of permeability varies approximately as the square of the grain size. It depends on the effective diameter of the grain size i.e., D_{10}.

$K=CD_{10}^2$

ii. Structure of soil mass:

The coefficient C, takes into account the shape of flow passage. The size of flow passage depends upon the structural arrangement. For the same void ratio, the permeability is more in case of flocculated structure as compared to dispersed structure.



iii. **Shape of particles**

Angular particles have greater specific surface area as compared to rounded particles. For the same void ratio, angular particles are less permeable than those with rounded particles as the permeability is inversely proportional to specific surface.

iv. **Void ratio**

$$k \ \alpha \ \frac{e^3}{1+e}$$

Greater the void ratio, greater is the permeability.

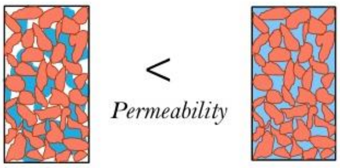
v. **Properties of water**

$$k \ \alpha \ \frac{\gamma_w}{\mu}$$

Coefficient of permeability is directly dependent on unit weight of water and inversely proportional to its viscosity. Since viscosity is dependent upon temperature, coefficient of permeability is dependent upon temperature.

vi. **Degree of saturation**

Presence of air in soil causes blockage to the flow of water. So if the soil is not saturated, coefficient of permeability decreases.



vii. **Adsorbed water**

Fine grained soils have a layer of adsorbed water around it and this will not mover under gravity. It causes an obstruction to flow passage. Thus coefficient of permeability decreases with presence of adsorbed water.

viii. Impurities in water

Foreign matter has a tendency to block the flow passage and reduce the effective voids. Thus coefficient of permeability decreases if impurities are present in water.

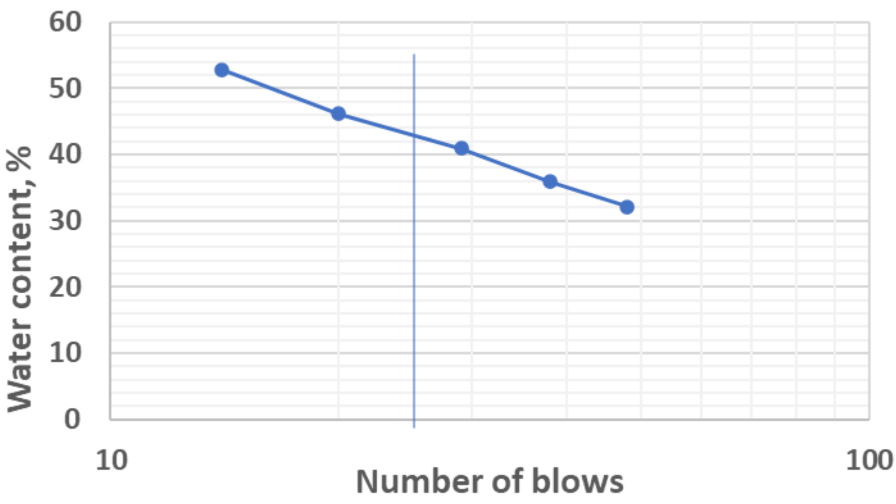
3 (a) The results of a liquid limit test are given below. The plastic limit of soil is 23%. Plot the flow curve and determine: [06] CO1 L3

(i) Liquid limit (ii) Plasticity index (iii) Flow index

Number of blows	48	38	29	20	14
Water content, %	32.1	35.9	40.9	46.1	52.8

Graph + liquid limit - 3

Calculation - 2



Liquid limit = 43%

Plasticity index = 43 – 23 = 20 %

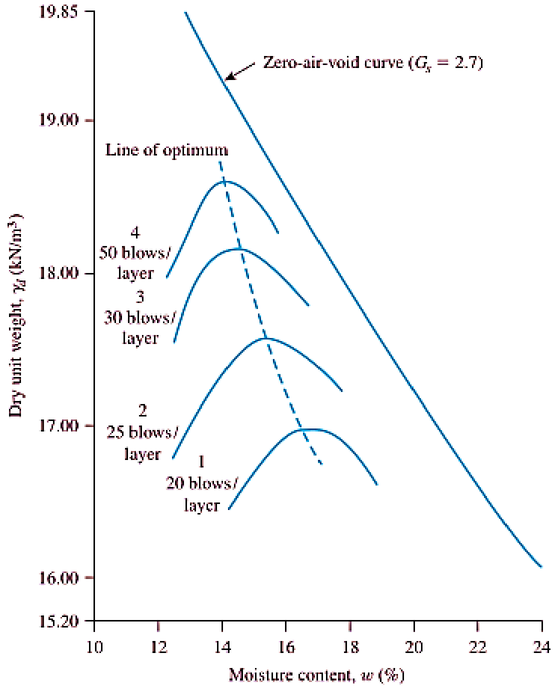
Flow index = (40 – 20)/ log(47.35/35.43)= 1.6

(b) Explain how water content and compactive effort affect compaction	[04]	CO2	L2

Each factor + sketch - 2×2 = 4

Amount of compaction

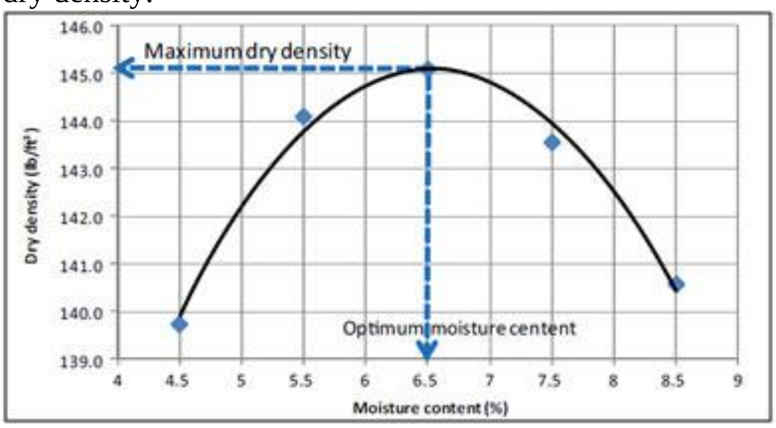
This is dependent on the type of compacting equipment, layer thickness, layer lifts, roller passes etc. Greater the compactive effort, greater will be the compaction energy, greater will be the extent of compaction. Type of compaction equipment to be used is mainly dependent upon the type of soil to be compacted.



Sandy clay: Liquid limit = 31 Plastic limit = 26

Moisture content/ water content

Proper control of moisture content in soil is necessary for achieving desired density. Maximum density with minimum compacting effort can be achieved by compaction of soil near its OMC (optimum moisture content). Relative compaction is the ratio of field dry density to laboratory dry density.



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